

Low Temperature Physics Division Fachverband Tiefe Temperaturen (TT)

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Overview of Invited Talks and Sessions

(Lecture halls HSZ/0003, HSZ/0101, HSZ/0103, HSZ/0105, CHE/0089, and CHE/0091; Poster P1 and P4)

Invited Talks

TT 27.1	Tue	9:30–10:00	HSZ/0105	Simulating high-temperature superconductivity in a triangular moiré lattice — •KIN FAI MAK
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Topical Talks in Focus Sessions

Topical Talks of the Focus Session “New Routes to Localization and Quantum Non-Ergodicity” (joint session TT/DY)

TT 1.1	Mon	9:30–10:00	HSZ/0003	Eigenstate thermalization in thermal first-order phase transitions — •MAKSYM SERBYN
TT 1.2	Mon	10:00–10:30	HSZ/0003	Stabilizing Floquet orders to infinite time — •ANUSHYA CHANDRAN
TT 1.3	Mon	10:30–11:00	HSZ/0003	Dynamical landscape of out of equilibrium emergent lattice gauge theories in two dimensions — •NILOTPAL CHAKRABORTY
TT 1.4	Mon	11:15–11:45	HSZ/0003	Interference, topology, and new Hilbert-space routes to quantum non-ergodicity — •YI-PING HUANG
TT 1.5	Mon	11:45–12:15	HSZ/0003	Fock-space cages and their spectral signatures — •CHERYNE JONAY

Topical Talks of the Focus Session “Tunable Correlations in van der Waals Quantum Materials” (joint session TT/DS/HL)

TT 12.1	Mon	15:00–15:30	HSZ/0003	Charge confinement in twisted bilayer graphene — •CHRISTOPH STAMPFER
TT 12.2	Mon	15:30–16:00	HSZ/0003	Tuning Coulomb interactions and Hubbard bands in 1T-TaS₂ — •ANNA GALLER
TT 12.3	Mon	16:00–16:30	HSZ/0003	Optical signatures of interlayer electron coherence in a bilayer semiconductor — •NADINE LEISGANG
TT 12.4	Mon	16:45–17:15	HSZ/0003	Faithful modeling of quantum geometry and electronic correlations in van der Waals heterostructures — •AMMON FISCHER
TT 12.5	Mon	17:15–17:45	HSZ/0003	Mesoscale Atomic Engineering in a Crystal Lattice — •JULIAN KLEIN

Topical Talks of the Focus Session “Relaxation Timescales in Open Quantum Systems” (joint session TT/DY)

TT 18.1	Mon	15:00–15:30	CHE/0089	Markovian and non-Markovian approaches to quantum relaxation — ●HEINZ-PETER BREUER
TT 18.2	Mon	15:30–16:00	CHE/0089	Asymptotic relaxation in quantum Markovian dynamics — ●SUSANA HUELGA
TT 18.3	Mon	16:00–16:30	CHE/0089	Floquet engineering of open quantum Systems — ●ANDRÉ ECKARDT
TT 18.4	Mon	16:45–17:15	CHE/0089	Nonequilibrium thermodynamics of time-dependent quantum transport — ●JANINE SPLETTSTOESSER
TT 18.5	Mon	17:15–17:45	CHE/0089	Connecting time-nonlocal and time-local quantum master equations — ●MAARTEN WEGEWIJS

Topical Talks of the Focus Session “Quantum Sensing with Solid State Spin defects” (joint session TT/MA)

TT 24.1	Tue	9:30–10:00	HSZ/0003	Exploring nanoscale van der Waals magnetism using single spin microscopy — ●PATRICK MALETINSKY
TT 24.2	Tue	10:00–10:30	HSZ/0003	Optically addressable spin defects in two-dimensional materials — ●VLADIMIR DYAKONOV
TT 24.3	Tue	10:30–11:00	HSZ/0003	Nitrogen vacancy centers in diamond as novel sensing and imaging tool for magnetic nanostructures, in life science and chemistry — ●ELKE NEU-RUFFING
TT 24.4	Tue	11:15–11:45	HSZ/0003	Electron spin, nuclear spin, and optical properties of transition-metal defects in silicon carbide with perspectives for quantum technologies — ●GUIDO BURKARD
TT 24.5	Tue	11:45–12:15	HSZ/0003	Statics and dynamics of complex magnetic states in microstructures — ●AURORE FINCO

Topical Talks of the Focus Session “Nickelate Superconductivity: Insights into Unconventional Pairing and Correlation Effects” (joint session TT/DS/MA)

TT 39.1	Wed	9:30–10:00	HSZ/0003	Unconventional Superconductivity in Infinite-layer Samarium Nickelates — ●DANFENG LI
TT 39.2	Wed	10:00–10:30	HSZ/0003	Recent insights into infinite-layer nickelate heterostructures from x-ray spectroscopy — ●EVA BENCKISER
TT 39.3	Wed	10:30–11:00	HSZ/0003	Theory of infinite-layer nickelate superconductors — ●KARSTEN HELD
TT 39.4	Wed	11:15–11:45	HSZ/0003	Disorder and distortions: what electrons tell us about nickelate superconductivity — ●BERIT H. GOODGE
TT 39.5	Wed	11:45–12:15	HSZ/0003	Superconducting gap structure and bosonic mode in $\text{La}_2\text{PrNi}_2\text{O}_7$ thin films at ambient pressure — ●HAI-HU WEN

Topical Talks of the German-French Focus Session “Superconducting Junctions and Quantum Circuits”

TT 50.1	Wed	15:00–15:30	HSZ/0003	Josephson Quantum Tunneling at Odd Parity — ●JULIA S. MEYER
TT 50.2	Wed	15:30–16:00	HSZ/0003	Superconducting qubits and amplifiers resilient to Tesla-scale magnetic fields — ●IOAN POP
TT 50.3	Wed	16:00–16:30	HSZ/0003	Josephson metamaterials as near-quantum-limited microwave amplifiers — ●NICOLAS ROCH
TT 50.4	Wed	16:45–17:15	HSZ/0003	Second Order Topological Insulators probed with mesoscopic physics — ●SOPHIE GUERON
TT 50.5	Wed	17:15–17:45	HSZ/0003	Proximity superconductivity in chiral Kagome antiferromagnets — ●PIET BROUWER

Topical Talks of the Focus Session “High-Temperature Superconductivity in Hydride Materials at High Pressures” (joint session TT/DS)

TT 80.1	Thu	15:00–15:30	HSZ/0003	Computational searches for conventional high temperature superconductivity — ●CHRIS PICKARD
TT 80.2	Thu	15:30–16:00	HSZ/0003	High-pressure synthesis of hydrides and their characterisation by single-crystal X-ray diffraction — ●NATALIA DUBROVINSKAIA
TT 80.3	Thu	16:00–16:30	HSZ/0003	Electrical Transport Studies in bulk and thin-film hydride high-temperature superconductors — ●SVEN FRIEDEMANN
TT 80.4	Thu	16:45–17:15	HSZ/0003	Near room-temperature conventional superconductivity in hydrogen-rich compounds at high pressures: Experimental evidences — ●VASILY MINKOV
TT 80.5	Thu	17:15–17:45	HSZ/0003	Predictive T_c Calculations in Hydride Superconductors — ●CHRISTOPH HEIL

Invited Talks of the joint Symposium SKM Dissertation Prize 2026 (SYSD)

See SYSD for the full program of the symposium.

SYSD 1.1	Mon	9:30–10:00	HSZ/0002	Stochastic-Calculus Approach to Non-equilibrium Statistical Physics — ●CAI DIEBALL
SYSD 1.2	Mon	10:00–10:30	HSZ/0002	Nonuniform magnetic spin textures for sensing, storage and computing applications — ●SABRI KORALTAN
SYSD 1.3	Mon	10:30–11:00	HSZ/0002	Anomalous Quantum Oscillations beyond Onsager’s Fermi Surface Paradigm — ●VALENTIN LEEB
SYSD 1.4	Mon	11:00–11:30	HSZ/0002	Coherent Control Schemes for Semiconductor Quantum Systems — ●EVA SCHÖLL
SYSD 1.5	Mon	11:30–12:00	HSZ/0002	On stochastic thermodynamics under incomplete information: Thermodynamic inference from Markovian events — ●JANN VAN DER MEER

Invited Talks of the joint Symposium Designing Quantum Materials with Light: From Floquet to Cavity Engineering (SYFC)

See SYFC for the full program of the symposium.

SYFC 1.1	Mon	9:30–10:00	HSZ/AUDI	Subcycle videography of strong-field controlled band structures — ●RUPERT HUBER
SYFC 1.2	Mon	10:00–10:30	HSZ/AUDI	Engineering Quantum Materials through Structured Cavity Vacuum Fluctuations — ●ANGEL RUBIO
SYFC 1.3	Mon	10:30–11:00	HSZ/AUDI	Floquet engineering of quantum materials: from semiconductors to semimetals — ●SHUYUN ZHOU
SYFC 1.4	Mon	11:15–11:45	HSZ/AUDI	(Quantum) Light Control of Materials — ●DANTE KENNES
SYFC 1.5	Mon	11:45–12:15	HSZ/AUDI	Lightwave-driven electrons in a Floquet topological insulator — ●PETER HOMMELHOFF

Invited Talks of the joint Symposium Fluids with Broken Time-Reversal Symmetry: Odd/Hall Viscosity between Active Matter and Electron Flows (SYBS)

See SYBS for the full program of the symposium.

SYBS 1.1	Tue	9:30–10:00	HSZ/AUDI	Odd viscosity in three-dimensional fluids: flows, wakes, and eddies — ●TALI KHAIN
SYBS 1.2	Tue	10:00–10:30	HSZ/AUDI	Odd viscosity in two-dimensional hydrodynamic electron transport — ●IGOR GORNYI
SYBS 1.3	Tue	10:30–11:00	HSZ/AUDI	Odd slip on chiral active surfaces — ●ANDREJ VILFAN
SYBS 1.4	Tue	11:15–11:30	HSZ/AUDI	Parity-odd transport in electron fluids — ●JOHANNA ERDMENGER
SYBS 1.5	Tue	11:30–11:45	HSZ/AUDI	Curved Odd Elasticity — ●PIOTR SURÓWKA

Invited Talks of the joint Symposium Interacting Degrees of Freedom in Ultrathin Quantum Films (SYQF)

See SYQF for the full program of the symposium.

SYQF 1.1	Fri	9:30–10:00	HSZ/AUDI	Exciton dressing by extreme nonlinear magnons in a layered semiconductor — ●GEOFFREY M. DIEDERICH
SYQF 1.2	Fri	10:00–10:30	HSZ/AUDI	A tale of demons and decay in two-dimensional (alter)magnets — ●ALEXANDER MOOK
SYQF 1.3	Fri	10:30–11:00	HSZ/AUDI	Magnetism, light and matter - Role of excitons in two-dimensional magnets — ●FLORIAN DIRNBERGER
SYQF 1.4	Fri	11:15–11:45	HSZ/AUDI	Advantages and challenges of resonance Raman scattering with infrared excitation energy — ●LEONETTA BALDASSARRE
SYQF 1.5	Fri	11:45–12:15	HSZ/AUDI	Shining light on 2D antiferromagnets — ●DMYTRO AFANASIEV

Sessions

TT 1.1–1.5	Mon	9:30–12:15	HSZ/0003	Focus Session: New Routes to Localization and Quantum Non-Ergodicity I (joint session TT/DY)
TT 2.1–2.11	Mon	9:30–12:30	HSZ/0101	Quantum-Critical Phenomena (joint session TT/DY)
TT 3.1–3.5	Mon	9:30–10:45	HSZ/0103	Correlated Electrons: Electronic Structure Calculations
TT 4.1–4.12	Mon	9:30–12:45	HSZ/0105	Graphene, 2D and Twisted Materials
TT 5.1–5.11	Mon	9:30–12:30	CHE/0089	Superconductivity: Sample Preparation and Characterization
TT 6.1–6.6	Mon	9:30–11:00	CHE/0091	Topological Superconductors
TT 7.1–7.9	Mon	9:30–12:00	POT/0351	Surface Magnetism and Topological Insulators (joint session MA/TT)
TT 8.1–8.1	Mon	9:30–10:15	TRE/PHYS	Topical Talk Wulfhekel (joint session O/TT)
TT 9.1–9.7	Mon	10:30–12:30	TRE/MATH	2D Materials: Electronic structure, excitations, etc. I (joint session O/HL/TT)
TT 10.1–10.7	Mon	11:00–12:45	HSZ/0103	Correlated Electrons: Other Theoretical Topics
TT 11.1–11.5	Mon	11:15–12:30	CHE/0091	PtBi₂
TT 12.1–12.7	Mon	15:00–18:15	HSZ/0003	Focus Session: Tunable Correlations in van der Waals Quantum Materials I (joint session TT/DS/HL)
TT 13.1–13.13	Mon	15:00–18:30	HSZ/0101	Correlated Electrons: Method Development I
TT 14.1–14.12	Mon	15:00–18:15	HSZ/0103	Superconductivity: Properties and Electronic Structure
TT 15.1–15.13	Mon	15:00–18:30	HSZ/0105	Topology: Majorana Physics
TT 16.1–16.11	Mon	15:00–17:45	HSZ/0204	2D Materials beyond graphene: Growth, structure and substrate interaction (joint session O/HL/TT)
TT 17.1–17.11	Mon	15:00–18:30	BEY/0245	Quantum Manybody Systems (joint session QI/TT)
TT 18.1–18.6	Mon	15:00–18:00	CHE/0089	Focus Session: Relaxation Timescales in Open Quantum Systems (joint session TT/DY)
TT 19.1–19.9	Mon	15:00–17:30	CHE/0091	Focus Session: New Routes to Localization and Quantum Non-Ergodicity II (joint session TT/DY)
TT 20.1–20.6	Mon	15:00–16:30	POT/0081	2D Materials II – Electronic and Transport Properties (joint session HL/TT)
TT 21.1–21.11	Mon	15:00–18:00	POT/0151	Electron Theory of Magnetism and Correlations (joint session MA/TT)
TT 22.1–22.37	Mon	18:00–20:00	P1	Superconductivity – Poster I
TT 23.1–23.35	Mon	18:00–20:00	P1	Correlated Electrons – Poster I
TT 24.1–24.7	Tue	9:30–12:45	HSZ/0003	Focus Session: Quantum Sensing with Solid State Spin defects I (joint session TT/MA)
TT 25.1–25.11	Tue	9:30–12:30	HSZ/0101	f-Electron Systems
TT 26.1–26.10	Tue	9:30–12:15	HSZ/0103	Correlated Magnetism – Frustrated Systems
TT 27.1–27.4	Tue	9:30–10:45	HSZ/0105	Focus Session: Tunable Correlations in van der Waals Quantum Materials II (joint session TT/DS/HL)
TT 28.1–28.12	Tue	9:30–12:45	CHE/0089	Superconducting Electronics: SQUIDS and other Josephson Circuits and Components
TT 29.1–29.12	Tue	9:30–12:45	CHE/0091	Unconventional Superconductors
TT 30.1–30.7	Tue	9:30–11:30	POT/0151	Caloric Effects in Ferromagnetic Materials (joint session MA/TT)

TT 31.1–31.11	Tue	9:30–12:30	POT/0361	Frustrated Magnets I (joint session MA/TT)
TT 32.1–32.10	Tue	10:00–12:45	POT/0051	Nanomechanical systems (joint session HL/TT)
TT 33.1–33.6	Tue	11:00–12:30	HSZ/0105	Correlated Magnetism – Dynamics and Spectroscopy
TT 34	Tue	14:00–15:30	HSZ/0101	Members’ Assembly
TT 35.1–35.6	Tue	14:00–15:30	POT/0151	Cooperative Phenomena: Spin Structures and Magnetic Phase Transitions (joint session MA/TT)
TT 36.1–36.6	Tue	14:00–15:30	POT/0361	Weyl Semimetals (joint session MA/TT)
TT 37.1–37.21	Tue	14:00–16:00	P2	Ultrafast electron dynamics at surface and interfaces – Poster (joint session O/TT)
TT 38.1–38.4	Tue	14:00–16:00	P2	Topology and symmetry protected materials & Topological insulators – Poster (joint session O/TT)
TT 39.1–39.7	Wed	9:30–12:45	HSZ/0003	Focus Session: Nickelate Superconductivity: Insights into Unconventional Pairing and Correlation Effects I (joint session TT/DS/MA)
TT 40.1–40.4	Wed	9:30–10:30	HSZ/0101	Focus Session: Quantum Sensing with Solid State Spin defects II (joint session TT/HL/MA)
TT 41.1–41.11	Wed	9:30–12:30	HSZ/0103	Topological Semimetals
TT 42.1–42.12	Wed	9:30–12:45	HSZ/0105	Other Transport Topics
TT 43.1–43.12	Wed	9:30–12:45	CHE/0089	Superconducting Electronics: Qubits
TT 44.1–44.12	Wed	9:30–12:45	CHE/0091	Nonequilibrium Quantum Systems I (joint session TT/DY)
TT 45.1–45.12	Wed	9:30–12:45	HÜL/S186	Many-body Systems: Equilibration, Chaos, and Localization (joint session DY/TT)
TT 46.1–46.11	Wed	9:30–12:45	POT/0112	Spin Transport and Orbitronics, Spin-Hall Effects I (joint session MA/TT)
TT 47.1–47.12	Wed	9:30–12:45	POT/0361	Frustrated Magnets II (joint session MA/TT)
TT 48.1–48.8	Wed	10:30–12:30	TRE/MATH	2D Materials: Electronic structure, excitations, etc. II (joint session O/HL/TT)
TT 49.1–49.8	Wed	10:45–12:45	HSZ/0101	Correlated Electrons: Charge Order
TT 50.1–50.8	Wed	15:00–18:30	HSZ/0003	German-French Focus Session: Superconducting Junctions and Quantum Circuits
TT 51.1–51.12	Wed	15:00–18:15	HSZ/0101	Correlated Electrons: Method Development II
TT 52.1–52.6	Wed	15:00–16:30	HSZ/0103	Heavy Fermions
TT 53.1–53.9	Wed	15:00–17:30	HSZ/0105	Nonequilibrium Quantum Systems II (joint session TT/DY)
TT 54.1–54.11	Wed	15:00–17:45	HSZ/0204	Graphene: Electronic structure, excitations, etc. (joint session O/TT)
TT 55.1–55.11	Wed	15:00–17:45	HSZ/0401	Topology and symmetry protected materials & Topological insulators (joint session O/HL/TT)
TT 56.1–56.13	Wed	15:00–18:30	CHE/0089	Superconductivity: Theory I
TT 57.1–57.12	Wed	15:00–18:15	CHE/0091	Correlated Magnetism – Kagome Systems
TT 58.1–58.5	Wed	15:00–16:15	POT/0006	Quantum Transport and Quantum Hall effects (joint session HL/TT)
TT 59.1–59.7	Wed	15:00–17:15	POT/0081	2D Materials V – Magnetic, spintronic, and topological properties (joint session HL/TT)
TT 60.1–60.10	Wed	15:00–18:00	POT/0112	Spintronics (other effects) (joint session MA/TT)
TT 61.1–61.14	Wed	15:00–17:00	P4	Topology – Poster
TT 62.1–62.12	Wed	15:00–17:00	P4	Correlated Electrons – Poster II
TT 63.1–63.15	Wed	15:00–18:00	P5	Quantum Dynamics and Many-body Systems – Poster (joint session DY/TT)
TT 64.1–64.6	Wed	16:45–18:15	HSZ/0103	BKT Physics
TT 65.1–65.7	Wed	18:00–20:00	P2	2D materials: Stacking and heterostructures – Poster (joint session O/TT)
TT 66.1–66.23	Wed	18:00–20:00	P2	2D Materials: Electronic structure, excitations, etc. – Poster (joint session O/TT)
TT 67.1–67.6	Wed	18:00–20:00	P2	2D Materials beyond graphene: Growth, structure and substrate interaction – Poster (joint session O/TT)
TT 68.1–68.9	Wed	18:00–20:00	P2	Graphene: Electronic structure, excitations, etc. – Poster (joint session O/TT)

TT 69.1–69.11	Thu	9:30–12:30	HSZ/0003	Focus Session: Nickelate Superconductivity: Insights into Unconventional Pairing and Correlation Effects II (joint session TT/DS/MA)
TT 70.1–70.5	Thu	9:30–10:45	HSZ/0101	Correlated Electrons: Method Development III
TT 71.1–71.7	Thu	9:30–11:15	HSZ/0103	Ultrafast Phenomena
TT 72.1–72.9	Thu	9:30–12:00	HSZ/0105	Correlated Magnetism – Spin Liquids I
TT 73.1–73.12	Thu	9:30–12:45	CHE/0089	Superconductivity: Tunneling and Josephson Junctions
TT 74.1–74.12	Thu	9:30–12:45	CHE/0091	Topological Insulators
TT 75.1–75.12	Thu	9:30–12:45	HÜL/S186	Many-body Quantum Dynamics I (joint session DY/TT)
TT 76.1–76.8	Thu	9:30–13:00	POT/0151	Focus Session: Curvilinear magnetism: Magnetism with nanoscale curved geometries (joint session MA/TT)
TT 77.1–77.1	Thu	9:30–10:15	TRE/PHYS	Topical Talk Bibes (joint session O/TT)
TT 78.1–78.7	Thu	11:00–12:45	HSZ/0101	Quantum Dots and Point Contacts (joint session TT/HL)
TT 79.1–79.5	Thu	11:30–12:45	HSZ/0103	Correlated Magnetism – Transport
TT 80.1–80.9	Thu	15:00–18:45	HSZ/0003	Focus Session: High-Temperature Superconductivity in Hydride Materials at High Pressures (joint session TT/DS)
TT 81.1–81.8	Thu	15:00–17:15	HSZ/0101	Correlated Electrons: Other Materials
TT 82.1–82.6	Thu	15:00–16:30	HSZ/0103	Cryogenic Detectors and Sensors
TT 83.1–83.13	Thu	15:00–18:30	HSZ/0105	Topology: Quantum Hall Systems
TT 84.1–84.11	Thu	15:00–17:45	HSZ/0204	2D Materials: Electronic structure, excitations, etc. III (joint session O/HL/TT)
TT 85.1–85.8	Thu	15:00–17:15	CHE/0089	Superconductivity: Yu-Shiba-Rusinov and Andreev Physics
TT 86.1–86.7	Thu	15:00–16:45	CHE/0091	Correlated Magnetism – Spin Liquids II
TT 87.1–87.6	Thu	15:00–16:30	HÜL/S186	Many-body Quantum Dynamics II (joint session DY/TT)
TT 88.1–88.8	Thu	15:00–17:00	POT/0361	Spin Transport and Orbitronics, Spin-Hall Effects II (joint session MA/TT)
TT 89.1–89.4	Thu	16:45–17:45	HSZ/0103	Cryotechnique: Refrigeration
TT 90.1–90.6	Thu	17:00–18:30	CHE/0091	Quantum Impurities and Kondo Physics
TT 91.1–91.4	Thu	17:30–18:30	HSZ/0101	Superconductivity: Theory II
TT 92.1–92.19	Thu	18:00–20:00	P4	Transport – Poster
TT 93.1–93.19	Thu	18:00–20:00	P4	Superconductivity – Poster II
TT 94.1–94.9	Fri	9:30–12:00	HSZ/0101	Correlated Magnetism – Low-Dimensional Systems
TT 95.1–95.8	Fri	9:30–11:45	HSZ/0103	Fe-based Superconductors
TT 96.1–96.12	Fri	9:30–12:30	HSZ/0401	2D Materials: Stacking and heterostructures (joint session O/HL/TT)
TT 97.1–97.9	Fri	9:30–12:00	CHE/0089	Superconducting Diodes and Ratchets
TT 98.1–98.8	Fri	9:30–11:45	CHE/0091	Altermagnets
TT 99.1–99.11	Fri	9:30–12:45	HÜL/S186	Quantum Chaos and Coherent Dynamics (joint session DY/TT)

Members' Assembly of the Low Temperature Physics Division

Tuesday 14:00–15:30 HSZ/0101

- Report
- Elections
- Outlook 2026
- Miscellaneous

TT 1: Focus Session: New Routes to Localization and Quantum Non-Ergodicity I (joint session TT/DY)

This session explores how quantum many-body systems can fail to thermalize through mechanisms that extend beyond conventional many-body localization. Recent work has discovered new mechanisms that lead to non-ergodic behavior, including Hilbert-space fragmentation, disorder-free localization, and confinement effects that arise from destructive interference in Fock space. At the same time, experiments with ultracold atoms, trapped ions, Rydberg platforms, and superconducting qubits directly reveal many-body scars, slow relaxation, and unusual transport. This session highlights these developments and identifies the central open questions that are now driving the field forward.

Coordinators: Roderich Moessner (MPI PKS Dresden), Frank Pollmann (TU München)

Time: Monday 9:30–12:15

Location: HSZ/0003

Topical Talk TT 1.1 Mon 9:30 HSZ/0003
Eigenstate thermalization in thermal first-order phase transitions — ●MAKSYM SERBYN — IST Austria, Am Campus 1, 3400 Klosterneuburg

In my talk I will discuss the fate of eigenstates in quantum systems in vicinity of thermal first order phase transition. The eigenstate thermalization hypothesis (ETH) posits how isolated quantum many-body systems thermalize, assuming that individual eigenstates at the same energy density have identical expectation values of local observables in the limit of large systems. In my talk I will show that ETH requires generalization in the presence of thermal first-order phase transitions. I will argue that for energies in the vicinity of the thermal phase transition, eigenstate expectation values do not need to converge to the same thermal value. The system has a regime with coexistence of two classes of eigenstates corresponding to the two branches with distinct expectation values at the same energy density, and another regime with Schrodinger-cat-like eigenstates that are inter-branch superpositions; these two regimes are separated by an eigenstate phase transition. I will also discuss potential extensions of these results to more physical models, and outline how the special structure of eigenstates near first order phase transition can be probed via quench dynamics.

Topical Talk TT 1.2 Mon 10:00 HSZ/0003
Stabilizing Floquet orders to infinite time — ●ANUSHYA CHANDRAN¹, SHREYAS RAMAN², ROBIN SCHÄFER³, and ALICIA KOLLÄR⁴ — ¹Boston University, Boston, USA — ²Boston University, Boston, USA — ³Helmholtz-Zentrum Berlin, Berlin, Germany — ⁴University of Maryland, College Park, USA

Floquet engineering, in which the properties of a quantum system are modified through the application of strong periodic drives, is an indispensable tool in atomic and condensed matter systems. It enables quantum simulation, the dynamic stabilization of unstable states, and the realization of exotic topological order and time crystals. However, it is inevitably limited by intrinsic heating processes, so that the engineered states are, at best, pre-thermal. I will describe a general-purpose dissipative scheme that autonomously cools a strongly driven system to close to a desired Floquet engineered state. I will demonstrate this stabilization in a driven many-body spin chain, that either spontaneously breaks a symmetry or exhibits discrete time-crystalline order in the steady state.

Topical Talk TT 1.3 Mon 10:30 HSZ/0003
Dynamical landscape of out of equilibrium emergent lattice gauge theories in two dimensions — ●NILOTPAL CHAKRABORTY — University of Cambridge

Many-body models with local constraints, such as dimer, ice or generally quantum link type models often are described as emergent gauge theories. I will describe a range of recent results, comprising classical and quantum dynamics of different kind, highlighting the rich dynamical phenomenology present in these models. In line with the session's topic, I will focus more on the two-dimensional U(1) quantum link model, and highlight its potential as a new route toward localisation and non-ergodicity in the absence of quenched disorder. In doing so, I will also present spectral signatures of such localization. Finally, I will end by discussing possibilities of realising the different constrained

models and their dynamics in quantum simulators, for which there appears to be palpable current interest.

15 min. break

Topical Talk TT 1.4 Mon 11:15 HSZ/0003
Interference, topology, and new Hilbert-space routes to quantum non-ergodicity — ●YI-PING HUANG^{1,2,3} and TAO-LIN TAN¹ — ¹Department of Physics, National Tsing Hua University, Hsinchu 30013, Taiwan — ²Physics Division, National Center for Theoretical Sciences, Taipei 10617, Taiwan — ³Institute of Physics, Academia Sinica, Taipei 115, Taiwan

A central challenge in nonequilibrium quantum physics is to understand why certain many-body systems fail to thermalize even in the absence of disorder or integrability. In this talk, I will outline a different perspective in which non-ergodicity is governed by hidden geometric structures in Hilbert space rather than by conventional real-space mechanisms. This viewpoint leads to the concept of interference-caged quantum many-body scars (ICQMBS), where exact many-body destructive interference confines eigenstates to small regions of the Fock-space graph. Remarkably, interference zeros and graph automorphisms emerge as universal organizing principles, revealing a class of topological ICQMBS whose robustness originates from local Fock-space topology rather than symmetries or constraints. This framework not only explains diverse non-ergodic phenomena from one-dimensional systems to two-dimensional gauge models but also provides new tools for systematically identifying them. I will end with a brief look at stabilizing QMBS through the lens of Kramers-Wannier duality, illustrating the challenges and possibilities that arise when studying QMBS under duality.

Topical Talk TT 1.5 Mon 11:45 HSZ/0003
Fock-space cages and their spectral signatures — ●CHERYNE JONAY — University of Ljubljana

Generic quantum many-body systems thermalize. Yet several mechanisms can prevent this, notable examples include integrability, many-body localization, Hilbert-space fragmentation, and scars. We will discuss a new mechanism of ergodicity breaking that arises from destructive interference in Fock space. This leads to exact eigenstates localized on polynomially many configurations within an exponentially large, fully connected Hilbert space sector. We call these states Fock-space cages. They emerge naturally in kinetically constrained models with chiral symmetry. We will present graph-theoretic methods to explicitly construct cages with support ranging from O(1) to O(L) sites, and examine how their dynamical signatures, such as return probabilities and magnetization, resist thermalization. Finally, we will explore the spectral statistics through the lens of chiral random matrix theory. The exponentially degenerate zero-energy manifold produces distinctive signatures, yet the agreement with random matrix predictions varies across energy scales - a direct consequence of localized and thermal eigenstates coexisting within the same Hilbert space sector. We will also probe the stability of these phenomena: the gap between the zero-energy manifold and the spectral bulk may give rise to protected slow dynamics.

TT 2: Quantum-Critical Phenomena (joint session TT/DY)

Time: Monday 9:30–12:30

Location: HSZ/0101

TT 2.1 Mon 9:30 HSZ/0101

Possible Quantum Criticality Tuned by Pressure in CeVGe₃ — RONG-ZHU LIN¹, PO-YUAN CHENG¹, YUSEI SHIMIZU², TIMOTHÉE VASINA³, DANIEL BRAITHWAITE³, HANSHANG JIN⁴, PETER KLAVINS⁴, VALENTIN TAUFER⁴, and •CHIEN-LUNG HUANG¹ — ¹Department of Physics, National Cheng Kung University and Center for Quantum Frontiers of Research & Technology, Tainan 701, Taiwan — ²International Research Center for Nuclear Materials Science, Institute for Materials Research (IMR-Oarai), Tohoku University, Ibaraki 311-1313, Japan — ³Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG, PHELIQS, 38000, Grenoble, France — ⁴Department of Physics and Astronomy, University of California, Davis, California 95616, USA

In this work, we focus on the helical antiferromagnetic (AFM) CeVGe₃ to explore whether an AFM quantum critical point (QCP) can be approached. By performing resistivity measurements under pressure, we construct the pressure-temperature-field phase diagram and track the evolution of multiple field-induced phases. The AFM ordering temperature is suppressed at the critical pressure $p_c = 0.7$ GPa. The coefficient A in the temperature-dependent resistivity $\rho = \rho_0 + AT^2$ exhibits a maximum at p_c and gradually decreases at higher pressures, indicating enhanced electron-electron correlations near the critical point. These results reveal how the competition between Ruderman-Kittel-Kasuya-Yosida (RKKY) and Kondo interactions evolves under pressure, leading to a plausible pressure-induced QCP in CeVGe₃.

TT 2.2 Mon 9:45 HSZ/0101

Spin and charge criticality in the pseudogap two-impurity Anderson model — •CHARLOTTE BENEKE and MATTHIAS VOJTA — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

The Kondo effect originates from spin screening of localized impurities by conduction electrons. This Kondo screening can be suppressed by a fermionic bath following a pseudogap (i.e. power-law) density of states, by inter-impurity interactions, or by coupling to multiple conduction channels. We investigate the two-impurity Anderson model in various limits, and establish mappings to known Kondo and Anderson models. This leads to rich phase diagrams with Kondo-breakdown transitions of distinct universality classes giving rise to non-Fermi-liquid behavior. We analyze the phase diagram, and critical exponents of the pseudogap two-impurity Anderson model in the particle-hole symmetric, SU(2)-invariant case using perturbative renormalization-group techniques. We recover the transitions of the pseudogap single-impurity Anderson model, and find additional Kondo-breakdown quantum transitions to inter-impurity singlet-, triplet- and charge-ordered phases. At the quantum critical points, superconducting-pairing susceptibilities can be enhanced depending on the type of spin- and charge criticality. We discuss connections to heavy-fermion systems and two-quantum-dot realizations where quantum dots act as tunable magnetic impurities.

TT 2.3 Mon 10:00 HSZ/0101

Stability of Deconfined Quantum Critical Points Coupled to Quantum Phonons — •ANTON ROMEN^{1,2}, JOSEF WILLISHER^{1,2,3}, DAVID HOFMEIER⁴, JOHANNES KNOLLE^{1,2,5}, and MICHAEL KNAP^{1,2} — ¹Technical University of Munich, Garching, Germany — ²Munich Center for Quantum Science and Technology, München, Germany — ³Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — ⁴University of Southern Denmark, Odense M, Denmark — ⁵Imperial College London, London, United Kingdom

Deconfined quantum criticality (DQC) describes continuous transitions beyond the Landau-Ginzburg paradigm. A typical example is the VBS-Néel transition in frustrated antiferromagnets. Since the VBS order parameter breaks lattice symmetries, it can couple to lattice distortions (phonons). Field-theory (PRB 110, 125130 (2024)) predicts that static lattice vibrations induce strong first-order character. A full quantum treatment, however, indicates that DQC survives above a critical phonon frequency. In this work, we provide a detailed study on the stability of 1D DQC under spin-phonon coupling resorting to a frustrated anisotropic J1-J2 model as a paradigmatic example. Using large-scale tensor network simulations, we determine the flow of the continuously varying critical exponents with phonon frequency and the critical phonon frequency, at which the transition becomes strongly first-order. By relating the critical theory to an Ashkin-Teller type

model, we argue that the critical endpoint is in the four-state Potts universality class. We further compute dynamical phonon spectral functions that provide a powerful experimental signature of DQC.

TT 2.4 Mon 10:15 HSZ/0101

Inducing extraordinary-log criticality in the Heisenberg spin chain — •GRIGORIOS MAKRIKIS, FRANCESCO PARISEN TOLDIN, and STEFAN WESSEL — Institute for Theoretical Solid State Physics, RWTH Aachen University, Germany

We examine the ground state correlations emerging in a spin-1/2 Heisenberg chain upon coupling it to a quantum critical two-dimensional bilayer Heisenberg model. Based on the quantum-to-classical mapping and recent findings of unconventional surface criticality of three-dimensional classical Heisenberg models, extraordinary-log criticality is expected to become accessible within this setup along the coupled chain, which serves as a line defect. In particular, such a defect corresponds, through the quantum-to-classical mapping, to a planar defect in the classical case which exhibits extraordinary-log criticality. We use large-scale quantum Monte Carlo simulations to systematically explore this scenario, based on measurements of correlations and the spin stiffness, using the stochastic series expansion methods.

TT 2.5 Mon 10:30 HSZ/0101

Kibble-Zurek Dynamics in the Anisotropic Ising Model of the Si(001) Surface — •GERNOT SCHALLER¹, FRIEDEMANN QUEISSER¹, PARYA KATOORANI¹, CHRISTIAN BRAND², CHRISTIAN KOHLFÜRST¹, MARK FREEMAN³, ALFRED HUCHT², PETER KRATZER², BJÖRN SOTHMANN², MICHAEL HORN-VON HOEGEN², and RALF SCHÜTZHOLD^{1,4} — ¹Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — ²Fakultät für Physik, Universität Duisburg-Essen and CENIDE, Lotharstraße 1, 47057 Duisburg, Germany — ³Department of Physics, University of Alberta, 4-181 Centennial Center for Interdisciplinary Science Edmonton, Alberta T6G 2E1, Canada — ⁴Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

As a simplified description of the nonequilibrium dynamics of buckled dimers on the Si(001) surface, we consider the anisotropic two-dimensional (2D) Ising model [1,2] and study the freezing of spatial correlations during a cooling quench across the critical point. Depending on the cooling rate, we observe a crossover from one-dimensional (1D) to 2D behavior [3]. For rapid cooling, we find effectively 1D behavior in the strongly coupled direction, for which we provide an exact analytic solution of the nonequilibrium dynamics. For slower cooling rates, we start to see 2D behavior where our numerical simulations show an approach to the usual Kibble-Zurek scaling in 2D.

[1] C. Brandt *et al.*, Phys. Rev. Lett. **130**, 126203 (2023).

[2] C. Brandt *et al.*, Phys. Rev. B **109**, 134104 (2024).

[3] G. Schaller *et al.*, Phys. Rev. Lett. **134**, 246202 (2025).

TT 2.6 Mon 10:45 HSZ/0101

Frustration effects and self-consistent matter description in the Dicke-Ising model on the sawtooth chain — •JONAS LEIBIG, MAX HÖRMANN, ANJA LANGHELD, ANDREAS SCHELLENBERGER, and KAI PHILLIP SCHMIDT — Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

We investigate how the exact thermodynamic-limit mapping of the Dicke-Ising model to a self-consistent effective matter Hamiltonian applies to the geometrically frustrated sawtooth chain. The mapping, established in Ref. [2], was recently solved with NLCE+DMRG for the unfrustrated chain in our work [1]. Using the same method, we obtain the zero-temperature phase diagram of the sawtooth geometry and identify frustration-induced features absent in the unfrustrated case. In the frustrated Ising limit, an infinitesimal effective transverse field lifts the classical degeneracy and produces a disorder-by-disorder transition, analogous to the transverse-field Ising model [3].

[1] J. Leibig, M. Hörmann, A. Langheld, A. Schellenberger, and K. P. Schmidt, *to be published* (2025).

[2] J. Román-Roche, Á. Gómez-León, F. Luis, and D. Zueco, *Physical Review B* **111**, 035156 (2025).

[3] D. J. Priest, M. P. Gelfand, and S. L. Sondhi, *Phys. Rev. B* **64**, 134424 (2001).

15 min. break

TT 2.7 Mon 11:15 HSZ/0101

Potts nematic quantum phase transition in Dirac fermion systems — ●MAX FORNOVILLE^{1,2}, KILIAN FRABOULET¹, MICHAEL M. SCHERER³, and LAURA CLASSEN^{1,2} — ¹Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany — ²School of Natural Sciences, Technische Universität München, 85748 Garching, Germany — ³Theoretische Physik III, Ruhr-Universität Bochum, 44801 Bochum, Germany

With the advent of 2D moiré materials, Dirac fermion models have yet again emerged as promising candidates to describe putative quantum critical points in these systems. The presence of gapless fermions provides an avenue towards criticality beyond the conventional universality classes because it profoundly alters the quantum critical behavior, also giving rise to non-Fermi liquid behavior. We investigate the onset of nematic order in Dirac systems with hexagonal symmetry. Owing to the sixfold rotational symmetry, the nematic director selects among three equivalent orientations and the associated order parameter is described by a 3-state Potts model coupled to the Dirac fermions via a Yukawa interaction. In the ordered phase, the fermions remain gapless but the Dirac points split, dynamically breaking rotational symmetry. At the mean-field level, the transition is of first order, which we demonstrate using a minimal lattice model. We further employ a functional renormalization group approach to investigate the influence of the Dirac fermions on the Potts model and the nature of the transition due to a possible fermion-induced continuous quantum critical point.

TT 2.8 Mon 11:30 HSZ/0101

Chiral Quantum Phase Transition in Moiré Dirac Materials at finite density — ●ANA GARCIA-PAGE¹ and LAURA CLASSEN^{1,2} — ¹Max-Planck-Institute for Solid State Research, Stuttgart, Germany — ²Technical University of Munich, Munich, Germany

Chiral quantum phase transitions in Dirac materials at finite density: Strong enough interactions induce a semimetal-to-insulator transition in Dirac materials, which can be viewed as the solid-state analogue of the chiral phase transition in quantum chromodynamics. Moiré Dirac materials such as twisted bilayer graphene offer a new opportunity to study this transition because they facilitate tuning the effective interaction via a twist angle. Motivated by this, we explore the quantum phase transition of a (2+1) dimensional Dirac material at $T = 0\text{K}$ which spontaneously develops a gap that breaks an Ising symmetry. It is still an open question what is the structure of the phase diagram at finite chemical potential. To explore it, we study a Gross-Neveu-Yukawa model for the phase transition using both a mean-field theory and a functional renormalization group approach. Interestingly, we find an intermediate state between semi-metal and insulator where a homogeneous solution appears to be unstable.

TT 2.9 Mon 11:45 HSZ/0101

Pseudo-first-order transition from competing Dirac masses in one dimension — ●MANUEL WEBER — Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, Germany

Emergent symmetries and slow crossover phenomena are central themes in quantum criticality and manifest themselves in the pseudocritical scaling experienced in the context of deconfined criticality. Here we discover its conceptual counterpart, i.e., a symmetry-enhanced *pseudo-first-order transition*. It emerges from a one-dimensional re-

alization of deconfined criticality between charge- and bond-ordered states driven by competing Holstein and Su-Schrieffer-Heeger electron-phonon couplings, for which quantum fluctuations and thereby the nature of the transition can be tuned systematically via the phonon frequency ω_0 . In the classical limit $\omega_0 \rightarrow 0$, a low-energy Dirac theory predicts a direct first-order transition with emergent $U(1)$ symmetry. Using exact quantum Monte Carlo simulations, we provide strong evidence for symmetry enhancement and even finite-size scaling on intermediate length scales but in the thermodynamic limit it turns into a narrow intermediate phase where both order parameters are finite, as chiral $U(1)$ symmetry is weakly broken on the lattice. Including quantum lattice fluctuations diminishes the width of the intermediate phase, gradually restores the $U(1)$ symmetry, and eventually tunes the system to a deconfined quantum critical point.

TT 2.10 Mon 12:00 HSZ/0101

Spectral Optimization of the 2-Sphere and Applications to Classical and Quantum Interacting Spin Systems — ●JONAS VÖLLER¹, GRIGORIOS MAKRI¹, FABIAN HASSLER², and STEFAN WESSEL¹ — ¹Institute for Theoretical Physics, RWTH Aachen University, Germany — ²Institute for Quantum Information, RWTH Aachen University, Germany

We investigate discretizations of the 2-sphere using non-uniform simplicial lattices. Starting from an icosahedral seed, we optimize the lattice by solving the free-particle tight-binding model and applying gradient descent to reduce spectral degeneracy breaking, with the goal of restoring the $2\ell + 1$ -fold degeneracy of an $SO(3)$ -symmetric system. We then perform Monte Carlo simulations of the critical Ising and Potts models and quantify the rotational symmetry breaking by projecting the two-point correlation function onto spherical harmonics. For sufficiently fine discretizations, we successfully recover the expected $SO(3)$ -symmetric behavior. Finally, we carry out quantum Monte Carlo simulations of the transverse-field Ising model and locate its critical point by studying Binder-cumulant crossings.

TT 2.11 Mon 12:15 HSZ/0101

Hybrid Monte Carlo on the fuzzy sphere for conformal critical phenomena — ●LIDIA STOCKER¹, ZHENG ZHOU², YIN-CHEN HE³, EMILIE HUFFMANN⁴, and JOHANNES STEPHAN HOFMANN¹ — ¹Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ²Perimeter Institute for Theoretical Physics, Waterloo, Ontario N2L 2Y5, Canada — ³C. N. Yang Institute for Theoretical Physics, Stony Brook University, Stony Brook, NY, USA — ⁴Department of Physics, Wake Forest University, Winston-Salem, NC, USA

The fuzzy sphere regularization was recently introduced to study conformal symmetry in the 3D Ising transition [1]. Preliminary analysis with this approach showed excellent agreement with the state-operator correspondence, even though the size of the system considered was particularly restricted. Building on a sign-problem-free formulation of quantum many-body models on the fuzzy sphere [2], we extend the study to significantly larger system sizes using a hybrid Monte Carlo (HMC) scheme. In contrast to microscopic lattice models, we study the deconfined quantum critical point from a low-energy perspective and address whether the transition is of first- or second-order nature, assuming $SO(5)$ symmetry. Our results demonstrate that HMC on the fuzzy sphere is a powerful and scalable framework for exploring conformal critical phenomena in models with many degrees of freedom.

[1] Phys. Rev. X 13, 021009 (2023)

[2] SciPost Phys. Core 7, 028 (2024)

TT 3: Correlated Electrons: Electronic Structure Calculations

Time: Monday 9:30–10:45

Location: HSZ/0103

TT 3.1 Mon 9:30 HSZ/0103

Electronic structure, effective model and electron correlation in Ruddlesden-Popper Cobalt Oxychloride — •XIAOLONG FENG¹, YANG ZHANG^{2,3}, and CLAUDIA FELSER¹ — ¹Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — ²Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996, USA — ³Min H. Kao Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville, Tennessee 37996, USA

Recent advances in Ruddlesden-Popper(RP)-layered nickelates have revealed a remarkable superconducting transition above the boiling point of liquid nitrogen under high pressure. Here, we report a theoretical investigation of RP cobalt oxychloride, which shows a correlation-driven metal-insulator transition. Strong hybridization between Co-*d* orbitals and O-*p* orbitals is identified close to the Fermi level. Upon incorporating enhanced electronic correlations, the Co-*d* orbital emerges as the dominant component at the Fermi level with partial filling. To further explore the ground state, we construct a minimal effective model via Wannier downfolding, capturing the essential physics of the system. Notably, our results predict an insulator-metal transition under high pressure, positioning RP cobalt oxychloride as a compelling candidate for studying correlated transition metal compounds with potential magnetism and superconductivity.

TT 3.2 Mon 9:45 HSZ/0103

Imaging the 3d orbitals in V₂O₃ across the AFI-PM-PI transitions — •PAULIUS DOLMANTAS¹, CHUN-FU CHANG¹, MARTIN SUNDERMANN^{1,2}, HLYNUR GRETARSSON², JONATHAN DENLINGER³, MAURITS HAVERKORT⁴, and LIU HAO TJENG¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²DESY, Hamburg, Germany — ³ALS, Berkeley, USA — ⁴Institute for Theoretical Physics, Heidelberg University, Heidelberg, Germany

V₂O₃ exhibits a rich phase diagram in which the transitions between the antiferromagnetic insulating (AFI), paramagnetic metallic (PM) and paramagnetic insulating (PI) phases are all 1st order. The presence of *c*-axis V-V dimers in the crystal structure is the reason for proposing the standard model for V₂O₃ in which *a*_{1g}-*a*_{1g} molecular singlets are formed, leaving each V ion with an *S*=1/2 electron to generate the complex phase diagram. Numerous *ab-initio* electronic structure calculations and spectroscopy studies have been carried out to determine the mechanism of the phase transitions, with contradicting results. The main problem underlying this issue is that the actual valence charge density in V₂O₃ has not yet been determined with sufficient reliability, a quantity that forms the very basis for modeling the properties. Here we utilized a newly developed experimental method with which we can make a direct image of the active orbital. The method is non-resonant inelastic X-ray scattering using an *s*-core level. Our experimental results unveiled that the *a*_{1g}-*a*_{1g} molecular singlets have not materialized and that instead, subtle changes changes in the orbital occupations across the transitions must be considered.

TT 3.3 Mon 10:00 HSZ/0103

Ni_{1/3}NbS₂: A correlated impurity-lattice with Ni²⁺ in a metallic Van der Waals magnet — •SHENG-HUAI CHEN¹, CHUN-FU CHANG¹, YU-CHIH KU^{2,3}, PO-YU CHO², CHANG-YANG KUO^{2,3}, MARCUS SCHMIDT¹, ANTOINE MAIGNAN⁴, ATSUSHI HARIKI⁵, and LIU HAO TJENG¹ — ¹Max Planck Institute for Chemical Physics of Solids, Germany — ²Natl. Synchrotron Radiation Research Center, Taiwan — ³Dep. of Electrophysics, Natl. Yang Ming Chiao Tung University, Taiwan — ⁴CRISMAT, Normandie Univ., CNRS, France — ⁵Dep. of Phys. and Electronics, Osaka Metropolitan University, Japan

Ni-intercalated NbS₂ has attracted considerable attention as a chi-

ral metallic van der Waals magnet that couples helical antiferromagnetism to a conducting Nb-4d/S-3p host, exhibiting current-driven spin-texture control, and showing pocket-selective Fermi surface doping. Our objective is to investigate the specific role of the Ni ions in here. In particular, we would like to know as to what extent electron correlations play a role, and if so, what the actual valence and electronic configurations the Ni has. By combining Ni *L*_{2,3} XAS, Ni 2*p* XPS, valence band and resonant PES with material-specific DFT+DMFT calculations, we establish that the Ni has a strongly correlated local electronic structure with the Ni²⁺ (3d⁸) as the main configuration. The NiS₆ octahedra thus set the existence and scale of the local moment and single-ion anisotropy that are the ingredients for the helical state. The interplay between the correlated Ni states with the dispersing bands forming the Fermi surface is the subject of ongoing study.

TT 3.4 Mon 10:15 HSZ/0103

Origin of orbital and magnetic transitions in rare-earth perovskites — •XUEJING ZHANG¹, ERIK KOCH², and EVA PAVARINI¹ — ¹Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — ²Jülich Supercomputing Centre, Forschungszentrum Jülich, 52425 Jülich, Germany

Strongly-correlated transition-metal oxides are characterized by complex phase diagrams, which result from the interplay of orbital, charge, lattice and spin degrees of freedom. Recently, we introduced an efficient scheme to investigate these phenomena [1-3]. It combines the LDA+DMFT method with a analysis scheme based on the decomposition of the order parameter into its irreducible components. Thanks to this approach, we could explain the origin of the inversion of orbital and magnetic order observed with increasing rare-earth (R) radius in the *t*_{2g} series RVO₃ [3]. Here we present results for these as well as for other systems.

[1] X. J. Zhang, E. Koch, E. Pavarini, PRB **105** (2022) 115104[2] X. J. Zhang, E. Koch, E. Pavarini, PRB **106** (2022) 115110[3] X. J. Zhang, E. Koch, E. Pavarini, PRL **135** (2025) 026508

TT 3.5 Mon 10:30 HSZ/0103

Real-frequency DMFT for multi-orbital models with the neural network configuration interaction impurity solver — •ALEXANDER KOWALSKI¹, PHILIPP HANSMANN², GIORGIO SANGIOVANNI¹, and ADRIANA PÁLFFY¹ — ¹Institute for Theoretical Physics and Astrophysics, Universität Würzburg, 97074 Würzburg, Germany — ²Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

The numerical solution of an auxiliary Anderson Impurity Model is usually the most resource-intensive part of the dynamical mean-field treatment of strongly correlated lattice models. Among the variety of approaches with different trade-offs that have been developed, the problem with exact diagonalization is that the exponential scaling of the Hilbert space constrains it to describing the infinite bath in terms of only a small finite number of sites. Selected Configuration Interaction (CI) methods try to achieve more favorable scaling by performing an a priori restriction of the basis used for diagonalization to try to capture only the most important subspace of the desired size. Neural networks have been shown to be remarkably suitable for performing the CI basis selection [1] and we have previously previewed the integration of such a CI algorithm as impurity solver in DMFT. Further developments since then have allowed us to do DMFT calculations with self-consistency directly on the real frequency axis for multi-orbital models with numbers of bath sites well beyond the reach of exact diagonalization.

[1] P. Bilous, L. Thirion, H. Menke, M. W. Haverkort, A. Pálffy, P. Hansmann, Phys. Rev. B **111**, 035124 (2025)

TT 4: Graphene, 2D and Twisted Materials

Time: Monday 9:30–12:45

Location: HSZ/0105

TT 4.1 Mon 9:30 HSZ/0105

Toward electron lensing in graphene — YI-CHEN TSAI^{1,2}, YU-EN WU³, CHUNG-TING KE^{2,4}, and •MING-HAO LIU³ — ¹Institute of Physics, Academia Sinica, Taipei, Taiwan — ²Department of Engineering and System Science, National Tsing Hua University, Hsinchu, Taiwan — ³Department of Physics and Center for Quantum Frontiers of Research and Technology (QFort), National Cheng Kung University, Tainan, Taiwan — ⁴Research Center for Critical Issues, Academia Sinica, Tainan, Taiwan

Electron lensing in graphene based on the combined effects of Klein collimation and negative refraction was theoretically proposed in [1]. The proposal promises striking phenomena that could advance the emerging field of electron optics in graphene. Yet, the original design requiring a parabolic pn junction and a point-like injector at the focal point has remained experimentally demanding and unverified. Here, we present recent progress toward realizing electron lensing in state-of-the-art ultraclean graphene devices. These devices feature multiple contacts—point injectors, narrow collectors, and wide drains—engineered to probe the lensing regime. Low-temperature transport measurements are systematically compared with fully ballistic quantum transport simulations at zero temperature. This combined experimental-theoretical approach enables us to assess how closely current devices approach the envisioned lensing regime described in [1] and to identify critical steps still needed for its experimental confirmation.

[1] M.-H. Liu, C. Gorini, and K. Richter, PRL **118**, 066801 (2017).

TT 4.2 Mon 9:45 HSZ/0105

Non-collinear magnetism of flat bands in magic-angle twisted bilayer graphene — •MAXIME LUCAS¹, ARNAUD RALKO², ANDREAS HONECKER¹, and GUY TRAMBLÉ DE LAISSARDIÈRE¹ — ¹Laboratoire de Physique Théorique et Modélisation, CY Cergy Paris Université / CNRS, France — ²Institut Néel, Université de Grenoble Alpes / CNRS, France

Recent advances of twisted bilayer graphene (and related moiré materials) have been stimulated by the discovery of strong electronic correlations [1] between flat-band states due to a moiré pattern [2]. It is shown experimentally and theoretically that the filling of the flat bands affects their magnetic properties significantly. Similar to what we have done in monolayer graphene [3], we investigate how electronic filling and on-site interactions drive magnetic ordering by studying a Hubbard model on the moiré lattice within an unrestricted Hartree-Fock framework. We mapped out a rich magnetic ground-state phase diagram and uncover a variety of exotic non-collinear spin textures.

[1] Y. Cao et al., Nature **556**, 43 (2018); Nature **556**, 80 (2018).

[2] G. Trambly de Laissardièrre et al., Physica E **175**, 116362 (2026)

[3] M. Lucas et al., arXiv:2511.22714 [cond-mat.str-el] (2025)

TT 4.3 Mon 10:00 HSZ/0105

Quantum diffusion in twisted bilayer graphene — •TAHER RHOUMA and GUY TRAMBLÉ DE LAISSARDIÈRE — LPTM, CY Cergy Paris Univ / CNRS, Cergy-Pontoise, France.

The discovery of correlated insulating and superconducting phases arising from the flat bands of magic-angle twisted bilayer graphene (TBG) [1] has stimulated intense interest in their electronic properties. We present a theoretical study of the electronic structure and quantum transport in these flat-band states, incorporating the structural effects of local defects such as non-resonant scatterers. Our real-space method [2,3,4,5] fully accounts for the modification of the electronic structure by defects and for multiple-scattering effects in the conductivity. It shows, in particular, that because of the extremely low Fermi velocity in the flat bands, standard semiclassical Bloch–Boltzmann approaches break down. We present the impact of non-resonant short-range disorder, modeled as diagonal Anderson disorder [4,5] with on-site energies $\varepsilon_i = \varepsilon_0 \pm \Delta W$, on the bandwidth, conductivity, focusing on the impact of filling on the quantum diffusion of twisted bilayer graphene close to the magic angle.

[1] Y. Cao, et al., Nature **556**, 43 (2018); Nature **556**, 80 (2018).

[2] F. Triozon, et al., Phys. Rev. B **65**, 220202, (2002).

[3] O. Faizy Namarvar, et al., Phys. Rev. B **101**, 245407 (2020).

[4] P. Guerrero, et al., Phys. Rev. Lett. **134**, 126301, (2025).

[5] G. Trambly de Laissardièrre, et al., Physica E **175** 116362 (2026).

TT 4.4 Mon 10:15 HSZ/0105

Quasiparticle Interference as a Probe of Electron's Form Factor in Twisted Bilayer Graphene — D.-H.-MINH NGUYEN¹, FRANCISCO GUINEA^{1,2}, and •DARIO BERCIoux^{1,3} — ¹Donostia International Physics Center, 20018 Donostia-San Sebastián, Spain — ²IMDEA Nanoscience, C/ Faraday 9, 28049 Madrid, Spain — ³IKERBASQUE, Basque Foundation for Science, Euskadi Plaza, 5, 48009 Bilbao, Spain

We show that characteristics of the electron's form factor in two-dimensional materials are observable in the quasiparticle interference (QPI) spectrum. We study QPI in twisted bilayer graphene using real-space tight-binding calculations combined with the kernel polynomial method, which agrees excellently with the form-factor norm obtained from the continuum Hamiltonian. The QPI signals, displaying a chiral structure, reveal all distinct interference processes between states near the Dirac points. We propose pseudospin textures of twisted bilayer graphene to explain all the interference mechanisms. Our results provide microscopic insights into the electronic eigenstates of twisted bilayer graphene and suggest that QPI could be a promising method for probing the form factor, which governs the material's quantum geometry and many-body states.

[1] D.-H.-M. Nguyen, F. Guinea, D. Bercioux, arXiv:2509.11223.

TT 4.5 Mon 10:30 HSZ/0105

Charge neutrality phase diagram of twisted bilayer graphene from sign-free Monte Carlo simulations — •JOHANNES S. HOFMANN¹, JONG YEON LEE², PATRICK LEDWITH³, ESLAM KHALAF⁴, ASHVIN VISHWANATH⁴, and EREZ BERG⁵ — ¹Max Planck Institute for the physics of complex systems, Dresden, Germany — ²University of Illinois at Urbana-Champaign, Urbana, USA — ³Massachusetts Institute of Technology, Cambridge, USA — ⁴Harvard University, Cambridge, USA — ⁵Weizmann Institute of Science, Rehovot, Israel

We study the phase diagram of twisted bilayer graphene at charge neutrality as a function of twist angle θ , uniaxial heterostrain ε , and temperature T using sign-problem-free quantum Monte Carlo simulations. At $T = 0$ and zero strain, we find a continuous transition from a Dirac semimetal to a gapped Kramers inter-valley coherent (KIVC) phase as θ decreases toward the magic angle. With finite strain, the KIVC phase undergoes a further continuous transition at smaller θ into an anisotropic semimetal with gapless excitations near the center of the moiré Brillouin zone. In the KIVC regime, the entropy rises sharply with temperature and plateaus at $15\text{ K} \lesssim T \lesssim 40\text{ K}$ near the value expected from a Mott-like regime of localized electrons with nearly uncorrelated spin, valley, and orbital degrees of freedom. The spectral function evolves continuously with θ : at low T , a gap opens at the K points and the minimal gap shifts to Γ as θ decreases; at intermediate T , the spectral function smoothly interpolates between a Dirac semimetal spectrum with coherent K -point quasiparticles and a spectrum with gapless Γ -centered quasiparticles near the magic angle.

TT 4.6 Mon 10:45 HSZ/0105

Probing doping profiles in large-angle twisted bilayer graphene by Fabry-Perot interference — •ALINA MRENCA-KOLASINSKA¹, CURTIS McDOWELL², THITI TAYCHATANAPAT², and MING-HAO LIU³ — ¹AGH University of Krakow, Faculty of Physics and Applied Computer Science, Poland — ²Chulalongkorn University, Department of Physics, Faculty of Science, Patumwan, Bangkok, Thailand — ³National Cheng Kung University, Department of Physics, Tainan, Taiwan

In graphene, p-n junctions can be induced by electrostatic gating. Fabry-Perot (FP) interferometers formed in gate-defined bipolar cavities have been used to probe Klein tunneling [1], miniband structure in moiré superlattices [2], and transport in decoupled bilayer graphene [3]. In this work, we investigate a decoupled large-angle twisted bilayer graphene device that shows rich fringe patterns that resemble FP oscillations. We postulate that they originate from extra electronic cavities created by unintentional local doping in the device. Our quantum transport simulations incorporating this assumption reproduce the observed patterns. Our findings demonstrate that disorder can lead to unexpected and rich structures that can be probed by transport.

[1] A.F. Young, P. Kim, Nat. Phys. **5** (2009) 222.

[2] C. Handschin et al., Nano Lett. **17** (2017) 328.

[3] P. Rickhaus et al. , Sci. Adv. 6 (2020) eaay8409.

15 min. break

TT 4.7 Mon 11:15 HSZ/0105

Theory for optical control of correlated states in moiré transition metal dichalcogenide heterostructures — •HAOYANG TIAN and URBAN F.P. SEIFERT — Institut für Theoretische Physik, Universität zu Köln, Zùlpicher Str. 77a, 50937 Köln, Germany

In recent years, moiré transition metal dichalcogenide (TMD) heterostructures have emerged as highly versatile platforms for investigating phases and phenomena of strongly correlated electrons on emergent lattice scales. However, experimental characterization of the precise nature of some interaction-driven orders, in particular antiferromagnetism, and their excitations has remained a challenge. Given strong light-matter couplings and valley selection rules in TMD materials, ultrafast optical methods may constitute a promising avenue for probing and controlling these states and their collective modes.

In this work, we develop a theoretical framework to describe the coherent light-driven dynamics of type-II moiré TMD heterobilayers under circularly polarized laser irradiation. We construct a moiré-Floquet Hamiltonian for the electronic states under periodic driving. In the off-resonant regime, we find that the moiré valence band flattens due to hybridization with the photon-dressed conduction band and derive an effective low-energy model for the Floquet valence band. By incorporating electron-electron interactions via a Hartree-Fock framework, we analyze the impact of optical driving on the phase structure and collective excitations (e.g., magnons).

TT 4.8 Mon 11:30 HSZ/0105

Unveiling structural transitions in the van der Waals multiferroic CuCrP_2S_6 under pressure and temperature — •SWARNAMAYEE MISHRA^{1,3}, GASTON GARBARINO², ALEXANDER MISTONOV^{1,3}, STEVEN GEBEL¹, and JOCHEN GECK^{1,3} — ¹Institute for Solid State and Materials Physics, TU Dresden, Dresden, Germany — ²European Synchrotron Radiation Facility (ESRF), Grenoble, France — ³Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, Germany

Two-dimensional (2D) crystals with strong in-plane covalent bonds and weak van der Waals interlayer interactions have garnered significant attention following the discovery of graphene and its remarkable properties. CuCrP_2S_6 (CCPS) is a promising 2D material exhibiting antiferromagnetic behavior due to the collective ordering of Cr^{3+} spins and antiferroelectric properties driven by Cu^{+} ion ordering. These ferroic properties arise from spin-orbit coupling associated with crystal symmetry breaking. Despite its potential, a detailed pressure-dependent crystallographic study of CCPS remains unexplored. In this work, high-resolution single crystal x-ray diffraction is employed to explore its response to variations in pressure and temperature. Our measurements reveal a clear pressure-driven change of lattice symmetry at low temperatures from monoclinic Pc to monoclinic C2/c , together with signatures of charge ordering that point to strong coupling between structure and electronic degrees of freedom. In addition, a pressure-induced reorientation of a structural modulation is found, shifting it from the ac plane at low pressure to the ab plane at higher pressure.

TT 4.9 Mon 11:45 HSZ/0105

Switching Magnetic Anisotropy by Chemical Substitution in Single Crystals of the 2D van der Waals System $(\text{Fe}_{1-x}\text{Ni}_x)_2\text{P}_2\text{S}_6$ — •YULIA SHEMERLIUK¹, ANJA U. B. WOLTER¹, BERND BÜCHNER^{1,2}, and SAICHARAN ASWARTHAM³ — ¹The Leibniz Institute for Solid State and Materials Research, Dresden, Germany — ²Institute for Solid State and Materials Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, Germany — ³International Center for Interfacing Magnetism and Superconductivity with Topological Matter - MagTop, Institute of Physics, Polish Academy of Sciences: Warsaw, Poland

During recent years, layered quasi-two-dimensional van der Waals materials have attracted considerable attention in fundamental science due to their intrinsic low-dimensional crystal structure, which affects their physical properties. Among these materials, layered thiophosphates $\text{M}_2\text{P}_2\text{S}_6$ ($\text{M} = \text{Ni}, \text{Co}, \text{Fe}, \text{Mn}, \text{V}$) stand out as a versatile platform for exploring the interplay between structure and magnetic exchange interactions. In this talk, we will show how chemical substitution and structural tuning influence magnetic ground states in the quasi-2D system $(\text{Fe}_{1-x}\text{Ni}_x)_2\text{P}_2\text{S}_6$. This series combines two

structurally compatible parent compounds with fundamentally different magnetic behaviors, interlayer couplings, and ordering temperatures. Our magnetization measurements on single crystals across the substitution series reveal antiferromagnetic ground states throughout. Importantly, we observe a continuous reorientation of magnetic anisotropy from out-of-plane to in-plane with increasing Ni content.

TT 4.10 Mon 12:00 HSZ/0105

Tuning surface resonance states on black phosphorus — •DONGMING ZHAO¹, BYEONGIN LEE², JUNHO BANG², CLAUDIA FELSER¹, JIAN-FENG GE¹, and DOOHEE CHO² — ¹Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — ²Department of Physics, Yonsei University, Seoul 03722, Republic of Korea

Surface resonance states can significantly alter how semiconductors respond to external electric fields. When present, such states can accommodate charge accumulation at the surface, reducing the response from bulk carriers and thereby suppressing band bending. In this work, we show that surface-resonance states near the band edge of black phosphorus couple strongly to the tip-induced electrostatic potential in scanning tunneling spectroscopy. This coupling produces a characteristic dip in the tunneling conductance spectrum. Our simulations indicate that this dip arises from a field-driven change in the tunneling probability into surface resonance states. By effectively tuning the electric field in the junction, we drive the surface-resonance band across the Fermi level, enhancing its contribution to the tunneling current. Our results illustrate how localized surface resonances under an external field dominate electrostatic screening, highlighting their importance in designing and operating semiconductor devices.

TT 4.11 Mon 12:15 HSZ/0105

Quantifying Twist Angles in Cuprate Heterostructures with Anisotropic Raman Signatures — •FLAVIA LO SARDO^{1,2}, MARINA ESPOSITO^{3,4}, TOMMASO CONFALONE^{1,5}, KORNELIUS NIELSCH^{1,2,5}, NICOLA POCCIA^{1,3}, and HAIDER GOLAM¹ — ¹Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), 01069 Dresden, Germany — ²Institute of Materials Science Technische Universität Dresden Dresden 01062, Germany — ³Department of Physics University of Naples Federico II Naples 80126, Italy — ⁴National Institute for Nuclear Physics (INFN) - Sezione di Napoli-Naples 80126, Italy — ⁵Institute of Applied Physics Technische Universität Dresden, 01062 Dresden, Germany

Artificially engineered twisted van der Waals (vdW) heterostructures have unlocked new pathways for exploring emergent quantum phenomena and strongly correlated electronic states. Many of these phenomena are highly sensitive to the twist angle, which can be deliberately tuned to tailor the interlayer interactions which makes the twist angle a critical tunable parameter. In particular, twisted cuprate heterostructures based on $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+x}$ (BSCCO) have demonstrated angle-dependent superconducting properties, positioning the twist angle as a key tunable parameter. In this work, a fully non-invasive, polarization-resolved Raman spectroscopy approach is introduced for determining twist angles in artificially stacked BSCCO heterostructures. By analyzing twist-dependent anisotropic vibrational Raman modes, clear optical fingerprints of the rotational misalignment between cuprate layers are identified.

TT 4.12 Mon 12:30 HSZ/0105

Polaritonic near-field effects on the metal-to-insulator transition of the Hubbard model — •PAUL FADLER¹, MARIOS MICHAEL², KATHARINA LENK³, MICHAEL SENTEF¹, and MARTIN ECKSTEIN³ — ¹Institute for Theoretical Physics, University of Bremen — ²Max-Planck-Institut für Physik komplexer Systeme, Dresden — ³Department of Physics, University of Hamburg

The influence of the dielectric environment on material properties has been studied theoretically mostly within two different contexts: Within Coulomb engineering one uses electrostatic screening of the longitudinal electromagnetic field to renormalize interactions [1]. In contrast, within cavity material engineering one tries to shape the transverse electromagnetic field to produce desired material properties [2]. For certain settings, such as in the near-field of materials hosting phonon- or plasmon-polaritons, this separation is no longer possible as the longitudinal and transverse components of the electromagnetic field mix. We investigate the resulting effect on the metal-to-insulator phase transition of a 2-D Hubbard model suspended above a polariton-hosting material using DMFT + GW treating the longitudinal and transverse fields consistently. Lastly, we consider the gauge dependence intro-

duced by our scheme for the Coulomb [3] and Weyl gauge [4].

[1] E. van Loon et al., npj 2D Mater. Appl. **7**, 47 (2023)

[2] F. Schlawin et al., Appl. Phys. Rev. **9**, 011312 (2022)

[3] K. Lenk et al., Phys. Rev. B **106**, 245124 (2022)

[4] C. Eckhardt et al., Phys. Rev. Lett. **135**, 156902 (2025)

TT 5: Superconductivity: Sample Preparation and Characterization

Time: Monday 9:30–12:30

Location: CHE/0089

TT 5.1 Mon 9:30 CHE/0089

Dielectric properties of NbN-films at the insulating side of the superconductor-insulator-transition — ●MAX REINHART¹, LEA PFAFFINGER¹, SVEN LINZEN², EVGENII IL'ICHEV², ALEXANDER WEIZEL¹, and CHRISTOPH STRUNK¹ — ¹Experimental and Applied Physics, Uni Regensburg, Germany — ²Leibniz Institute of Photonic Technology, Jena, Germany

In 2D strongly disordered thin films the superconductor-insulator-transition (SIT) occurs [1]. The resistive behavior of the insulating side of this transition is well studied, as it has been observed in various materials [2,3]. For the imaginary part of the impedance the situation is less clear. To obtain information on the dielectric properties of 3nm thin NbN in the insulating regime at $R_{sq}(2\text{ K}) = 60\text{ k}\Omega$ we deposited interdigitated gold fingers as capacitor within an LC-circuit on SiOx and NbN. On SiOx, we obtained $C \approx 6\text{ pF}$. On insulating NbN, the measured capacitance was 6.6 pF. In the latter case the capacitance has a contribution, that depends non-monotonically on temperature, magnetic field and DC bias voltage.

[1] D.B. Haviland et al., Phys. Rev. Lett. **62** (1989) 2180

[2] V.F. Gantmakher and V.T. Dolgoplov, Phys. Usp. **180** (2010) 3

[3] N. G. Ebensperger, Dielectric properties on the insulating, side of the superconductor-insulator-transition [PhD thesis], Universität Stuttgart, 2021

TT 5.2 Mon 9:45 CHE/0089

Gap smearing and sub-gap states in disordered nitride superconductors — ●FREDERIK BOLLE¹, YAYI LIN¹, HEIDEMARIE KRÜGER², MARTIN DRESSEL¹, and MARC SCHEFFLER¹ — ¹Physikalisches Institut, Universität Stuttgart — ²Leibniz IPHT, Jena

In recent years nitride-based superconductors have gathered a lot of attention due to their high critical temperatures, large kinetic inductances, and ease of manufacturing. According to the BCS theory, at temperatures far below the critical transition temperature, the superconducting s-wave state is characterized by a hard gap Δ and a coherence peak above the gap. In the case of substantial disorder, subgap states emerge and the coherence peak is suppressed.

We present the quasiparticle dynamics of ultra-thin NbN and MoN films with various levels of disorder, probed at energies comparable to the energy gap using THz spectroscopy (0.2 meV – 10 meV). To quantify the additional pair-breaking we employ the phenomenological Dynes model for the optical conductivity. We find in the case of NbN, a temperature-independent pair-breaking rate, which suggests magnetic impurities, while MoN shows a strongly temperature-dependent pair-breaking rate, which we attribute to inhomogeneities of the local gap function. The understanding of this excess quasiparticle density plays an important role for decoherence and loss mechanisms in quantum circuits at millikelvin temperatures.

TT 5.3 Mon 10:00 CHE/0089

Superconducting resonators from ultrathin NbN films — ●MEENAKSHI SHARMA¹, HRISHIKESH BORAH¹, SURINDER SINGH², SANDEEP SINGH², HAOLIN JIN¹, YEJIN LEE¹, and URI VOOL¹ — ¹MPI CPFS, Dresden, Germany — ²CSIR NPL, Delhi, India

We investigate superconducting microwave resonators fabricated from ultrathin niobium nitride (NbN) films with thicknesses down to 3 nm. Such films show extremely high kinetic inductance values of 298 pH per square, approaching the regime where disorder strongly influences superconductivity. However, they remain robust and exhibit a critical temperature of 7.8 K, making them suitable for high-impedance circuit applications. The resonators achieve internal quality factors of approximately 10^4 – 10^5 , demonstrating that reliable device performance can be sustained even at such critical thicknesses. By monitoring the resonance frequency as a function of temperature, we probe the electrodynamic response of the ultrathin superconducting state. The superfluid density departs from the exponential temperature dependence expected for conventional BCS superconductors and instead follows a

power-law behavior at low temperatures, indicating spatial inhomogeneity in the superconducting condensate. At millikelvin temperatures, dissipation is dominated by two-level systems, but the large kinetic inductance suppresses their influence on the resonance frequency, thereby enabling stable and reproducible devices. These results establish ultrathin NbN as both a practical platform for high-impedance quantum circuits and an accessible system for studying unconventional superconducting physics.

TT 5.4 Mon 10:15 CHE/0089

Tuning Superconductivity and Vortex Dynamics in NbRe Films via Grain-Size Control — ●ZAHRA MAKHDOUNI KAKHAKI¹, FRANCESCO AVITABILE², ABHISHEK KUMAR², FRANCESCO COLANGELO², CARLA CIRILLO³, CARMINE ATTANASIO², and OLEKSANDR DOBROVOLSKIY¹ — ¹Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany — ²Università degli Studi di Salerno, Italy — ³CNR-SPIN, Università di Salerno, Italy

NbRe, a non-centrosymmetric superconductor with strong antisymmetric spin-orbit coupling and relatively high T_c , is of interest for superconducting spintronics and single-photon detectors. Yet, it poses a challenge: understanding how its order parameter evolves in thin films as crystallite size changes. Here, we induce a significant structural transformation in 20 nm-thick NbRe films through thermal annealing, increasing the average crystallite size from about 2 nm to approximately 8 nm across as-grown and annealed conditions [1]. We probe superconducting pairing via upper critical field measurements and quantify vortex dynamics through current-voltage curves under varying temperatures and magnetic fields. The annealed films exhibit discrete resistive states and traces of normal-conducting domains attributed to dissipative vortex motion and local overheating [2]. In addition to spin-triplet correlations in NbRe-based hybrids [3], the annealed films show indications of two superconducting gaps.

[1] Makhdouni Kakhaki et al., SUST **37** (2024) 125002

[2] Bezuglyj et al., PRB **99** (2019) 174518

[3] Colangelo et al., PRL (2025), arXiv:2510.08110

TT 5.5 Mon 10:30 CHE/0089

Superconductivity of $[(\text{SnSe})_{1+\delta}]_m[\text{NbSe}_2]$ superlattices with varying NbSe_2 interlayer spacing — ●OLIVIO CHIATTI¹, LINUS P. STAHLBERG¹, WIELAND G. STOFFEL¹, TOM HERTER-LEHMANN¹, WILLI VALLANT¹, ALINA DIETRICH¹, DANIELLE HAMANN², DAVID C. JOHNSON², and SASKIA F. FISCHER^{1,3} — ¹Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — ²Department of Chemistry and Materials Science Institute, University of Oregon, Eugene OR 97403, USA — ³Center for the Science of Materials Berlin, Humboldt-Universität zu Berlin, 12489 Berlin, Germany

In layered superconductors the coupling between superconducting layers is crucial due to its strong impact on their properties [1]. We investigate the properties of $[(\text{SnSe})_{1+\delta}]_m[\text{NbSe}_2]$ superlattices, which allow for nearly arbitrary stacking sequences due to the growth technique [2]. With this degree of freedom we study how coupling mechanisms enable the occurrence of superconductivity.

Temperature-dependent resistance measurements show superconductivity for NbSe_2 interlayer distances of 2.4 nm or smaller. This is explained by the interplay of grain boundaries, crossplane tunneling and proximity effect in the SnSe spacer layer. Additionally, current-voltage characteristics provide insights into the coupling mechanisms of 2D superconductors.

[1] Chiatti et al., J. Phys.: Condens. Matter **35**, 215701 (2023)

[2] Grosse et al., Sci. Rep. **6**, 33457 (2016)

TT 5.6 Mon 10:45 CHE/0089

Characterization and superconducting properties of SrBi_2Se_4 — ●MAX BRÜCKNER¹, JULE KIRSCHKE¹, ASHIWINI BALODHI¹, CEDRIC SCHMITT², LUKAS GEHRIG², KILIAN STRAUSS², CHRISTOPH FLATHMANN³, DINA I. FAZLIZHANOVA⁴, CHRISTIAN LIEBSCHER³, ILYA

EREMIN⁵, SIMON MOSER^{1,2}, ANDREAS KREYSSIG¹, and ANNA E. BÖHMER¹ — ¹Experimental Physics IV, Ruhr-University Bochum, Bochum — ²Physikalisches Institut und Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Würzburg — ³Faculty of Physics and Astronomy, Ruhr-University Bochum, Bochum — ⁴private — ⁵Theoretical Physics III, Ruhr-University Bochum, Bochum

SrBi₂Se₄ is a newly discovered quasi-one-dimensional superconductor that offers a promising platform for exploring exotic superconductivity in low-dimensional systems. We present the growth of free-standing single crystals using a Bi-Se-rich self-flux method and characterize their structure and composition via x-ray diffraction, transmission electron microscopy, and energy-dispersive x-ray spectroscopy. Heat-capacity and magnetization measurements confirm bulk superconductivity below $T_c = 2.9$ K, while magnetotransport reveals an anisotropic upper-critical field. Additionally, we present angle-resolved photoemission spectroscopy and density-functional theory calculations, that provide insight into the electronic structure and lay the groundwork for understanding possible unconventional superconductivity in SrBi₂Se₄.

We acknowledge funding from the European Research Council through Project 101040811, Distort-to-Grasp.

15 min. break

TT 5.7 Mon 11:15 CHE/0089

Structural transition and emergent bulk superconductivity in Te-doped PtBi₂ — ●SOU MEN ASH^{1,2}, KILIAN SROWIK^{1,2}, PABLO PEDRAZZINI^{1,3}, OKSANA E. KVITNITSKAYA¹, ANDRII KUIBAROV¹, SUSMITA CHANGDAR¹, RUI LOU¹, ALEXANDER FEDOROV¹, SWARNAMAYEE MISHRA⁴, ALEXANDER MISTONOV⁴, SAICHARAN ASWARTHAM¹, JOCHEN GECK⁴, SERGEY BORISENKO¹, LAURA T. CORREDOR¹, and BERND BÜCHNER^{1,4} — ¹Institute for Solid State Research, Leibniz IFW Dresden, 01069 Dresden, Germany — ²Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — ³Lab. Bajás Temperaturas, Centro Atómico Bariloche, CNEA-CONICET, 8400 San Carlos de Bariloche, Argentina — ⁴Institute of Solid State and Materials Physics, TU Dresden, 01062 Dresden, Germany

Noncentrosymmetric trigonal PtBi₂ has emerged as a topological system exhibiting signatures of unconventional surface superconductivity, while sub-Kelvin superconductivity, as revealed by resistivity measurements, makes it a promising platform for studying chemical-tuning effects. We have carried out Te doping at the Bi sites of PtBi₂ and grown plate-like crystals with nominal compositions of PtBi_{2-x}Te_x ($x = 0.02 - 0.05$) using a stoichiometric-melt-growth method. Detailed structural, electrical transport, magnetic, thermodynamic, and spectroscopic studies reveal that doping of Te at Bi-sites results in a transition from noncentrosymmetric (space group: $P31m$) to centrosymmetric (space group: $P3m1$) crystal structure and gives rise to a bulk superconductivity with comparatively higher $T_c \approx 2.4$ K.

TT 5.8 Mon 11:30 CHE/0089

High-pressure high-temperature synthesis of uranium-silver compounds — ●JORDAN TIERNEY¹, JULIA-MARIA HÜBNER², ULRICH SCHWARZ¹, ANDREAS LEITHE-JASPER¹, ULRICH BURKHARDT¹, MARKUS KÖNIG¹, ANAMARIA GHIHOR¹, YURI PROTS¹, and ETERI SVANIDZE¹ — ¹MPI CPFS, Dresden — ²TU Dresden

Uranium-based quantum materials have recently entered a renaissance. Evidence of correlated topological states, spin-liquid behavior, hidden order phases, and spin-triplet superconductivity prove that these materials are exceptionally interesting. Because of their complex chemistry and fragile stability, many potentially fascinating uranium-based systems are currently entirely beyond the reach of conventional synthesis methods. In this talk, we will show how simultaneous high-pressure high-temperature synthesis, combined with micro-scale specimen isolation, can reach previously unattainable phases. We will discuss the uranium-silver system, in which no binary compounds have been previously reported; the two elements have appeared to be immiscible during conventional synthesis. By employing simultaneous high-pressure high-temperature synthesis instead, we have discovered several new materials. In particular, we were able to identify new magnetic and superconducting phases, with the detailed analysis of chemical and physical properties still currently underway. This proof-of-principle work shows that by implementing this methodology we can access high-purity materials and study their novel crystallographic arrangements and exotic quantum states. Supported by DFG grant number 553528746.

TT 5.9 Mon 11:45 CHE/0089

From superconductivity to unusual magnetic behaviour in noncentrosymmetric mercurides — ●R. NIXON^{1,2}, N. ZAREMBA¹, S. ADEGBOYE³, A. LEITHE-JASPER¹, M. KRNL¹, YU. PROTS¹, L. AKSELRUD^{1,4}, M. SCHMIDT¹, U. BURKHARDT¹, J. SICHELSCHEIDT¹, L. AMIDANI^{5,6}, F. LA MATTINA⁷, M. SHATRUK³, A. SHENGELAYA⁸, M. BRANDO¹, YU. GRIN¹, and E. SVANIDZE¹ — ¹MPI CPFS, Dresden — ²Uni. of St Andrews, UK — ³Florida St. Uni., US — ⁴Ivan Franko Lviv National Uni., Ukraine — ⁵ESRF, Grenoble, France — ⁶HZDR, Dresden — ⁷Lab. for Transport at Nanoscale Interfaces, Duebendorf, Switzerland — ⁸Ivane Javakhishvili Tbilisi State Uni., Georgia

Mercury and superconductivity are forever linked due to the discovery of zero resistivity (Onnes 1911), yet superconductivity in elemental Hg remains non-trivial (Tresca 2022). Here we examine superconductivity in noncentrosymmetric mercurides, A_{11-x}Hg_{54+x}, (A = Na, Ca, Sr). Due to their complexity, these structures were refined over many years (Tambornino 2015), the Ca and Sr adopt A_{11-x}Hg_{54+x} (Tkachuk 2008), and Na forms a 3-fold superstructure, Na₁₁Hg₅₂ (Hoch 2012). Mercurides are often structurally characterised, but physical properties are rarely reported. We previously identified Sr_{11-x}Hg_{54+x} to superconduct (Nixon 2024), motivated by growing interest of unconventional pairing in noncentrosymmetric superconductors (Bauer 2004), we extend to the Na and Ca analogues, also identified to superconduct (Nixon in prep.). Moving to rare-earths, we obtain the related Eu_{11-x}Hg_{54+x} phase, however, multiple Eu sites give several magnetic phases (Nixon 2025). Research funded by DFG - No. 528628333.

TT 5.10 Mon 12:00 CHE/0089

Atomic scale imaging of the effect of chemical pressure in Sr_{2-x}Ba_xRuO₄ — ●SIRI A. BERGE¹, REBECCA BISSET¹, DANIEL HALLIDAY¹, CAROLINA DE ALMEIDA MARQUES¹, LUKE C. RHODES¹, ALEXANDER C. KOMAREK², PHIL D. C. KING¹, and PETER WAHL^{1,3} — ¹SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, United Kingdom — ²Max Planck Institute for Chemical Physics of Solids Nöthnitzer Strasse 40, Dresden 01187, Germany — ³Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany

Tuning the electronic structure of layered perovskites is a powerful pathway to control their properties for future applications. Structural distortion in Sr₂RuO₄ affects the electronic structure, moving the van Hove singularity across the Fermi level, with significant consequences for physical properties such as superconductivity [1-2]. Here, we study the effect of chemical pressure by substitution with isovalent Ba atoms in Sr_{2-x}Ba_xRuO₄ for $x = 0, 0.2$, and 0.4 by Scanning Tunneling Microscopy (STM). We report changes in the electronic structure with rotation of the surface RuO octahedra as well as surface inhomogeneity with regions of varying degrees of rotation. Our results highlight the connection between electronic and lattice degrees of freedom and demonstrate control of the electronic structure.

[1] C.A. Marques et al. Advanced Materials 33 (2021) 2100593

[2] J.B. Profe et al. Phys. Rev. Research 6 (2024) 043057

TT 5.11 Mon 12:15 CHE/0089

Multiple superconducting transitions in Yb_{3+x}Co₄Sn_{13-x} — ●ROMAN GUMENIUK¹, MERET ORLOB¹, VOLODYMYR LEVYTSKYI¹, ALEXANDER A. TSIRLIN², BOHDAN KUNDYS³, and ANDREAS LEITHE-JASPER⁴ — ¹Institut für Experimentelle Physik, TU Bergakademie Freiberg, 09596 Freiberg, Germany — ²Felix-Bloch-Institut für Festkörperphysik, Universität Leipzig, 04103 Leipzig, Germany — ³Université de Strasbourg, CNRS, Institut de Physique et Chimie des Matériaux, Strasbourg F-67000, France — ⁴Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany

Yb_{3+x}Co₄Sn_{13-x} is shown to possess homogeneity range within $0 \leq x \leq 0.5$. For all x a primitive cubic [space group $Pm\bar{3}n$, $a \approx 9.54$ Å] structure of strongly disordered Sc₃Ir₄Si_{13+x} type is found. Despite showing no signatures of presence of additional phases, different pieces of the same stoichiometric Yb₃Co₄Sn₁₃ sample revealed multiple superconducting transitions of varying intensity at $T_c = 3.1(2)$ K and $T_c = 2.4(2)$ K in temperature dependence of specific heat. On the other hand, Yb_{3.2}Co₄Sn_{12.8} is found to be a strongly coupled superconductor with single transition at $T_c = 2.4(2)$ K and enhanced critical magnetic field $B_{c2} = 4.79(9)$ T. To shed light on superconducting behaviors in both stannides diverse models were applied to describe $B_{c2}(T_c)$ and $c_{el}(T)$ dependencies. Both Yb_{3+x}Co₄Sn_{13-x} ($x = 0, 0.2$) compounds reveal bosonic peaks in specific heat and thus, possible ‘rattling’ behavior. They are also metallic systems, some aspects of which are described by a free electron gas model [1].

[1] M. Orlob et al., Phys. Rev. B 112 (2025) 174513

TT 6: Topological Superconductors

Time: Monday 9:30–11:00

Location: CHE/0091

TT 6.1 Mon 9:30 CHE/0091

Experimental Signatures of Gate-Tuneable One-Dimensional Edge Channels in Bi_2Se_3 Josephson Junctions — ●FEIKE VAN VEEN¹, FEMKE WITMANS¹, JARA VLIEM², DANIEL VANMAEKELBERGH², CHUAN LI¹, and ALEXANDER BRINKAMN¹ — ¹MESA+ Institute for Nanotechnology, University of Twente, Halletweg 15, 7522 NH Enschede, The Netherlands — ²Debye Institute for Nanomaterials Science, Utrecht University, Princetonplein 1, 3584 CC Utrecht, The Netherlands

The quantum spin Hall (QSH) effect exhibits helical edge channels that can be utilized in the development of quantum computing [1]. Such QSH states are expected to be present in the hybridization gap that opens at the Dirac point in ultrathin 3D topological insulators (TIs) when opposite topological surface states hybridize [2]. In a previous study, an enhanced density of states has been probed at the edges of ultrathin colloidal Bi_2Se_3 nanoplatelets (NPLs) with scanning tunnelling spectroscopy [3]. Here, we study superconducting transport properties of these Bi_2Se_3 NPLs and reveal strong signatures of a 1D edge state contribution. Moreover, we found experimental evidence of a thickness dependence as is described by theoretical frameworks [2]. We can deplete the NPLs, hereby destroying the supercurrent, allowing for an "on" or "off" mode of the JJs. These observations contribute to the understanding and development of (non)-topological JJs made of ultrathin 3D TIs and shed new light on previous studies on superconductivity induced in QSH states.

[1] 10.1103/RevModPhys.82.3045

[2] 10.1103/PhysRevB.97.075419

[3] 10.1021/acs.nanolett.3c04460

TT 6.2 Mon 9:45 CHE/0091

Higher-order topological states in antiferromagnet/superconductor interface — ●IGNACIO SARDINERO^{1,4}, YURIKO BABA², RUBÉN SEOANE-SOUTO³, and PABLO BURSET^{1,4} — ¹Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid, 28049 Madrid, Spain — ²Instituto de Estructura de la Materia (IEM-CSIC), Serrano, 121, 28006 Madrid, Spain — ³Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC), Sor Juana Inés de la Cruz, 3, 28049 Madrid, Spain — ⁴Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain

Topological superconductors (TSs) are promising candidates for reliable quantum information processing. While field-free platforms often rely on ferromagnets, their stray magnetization hinders scalability. Antiferromagnets (AFMs) offer a novel approach by providing local time-reversal symmetry breaking without macroscopic magnetization. Motivated by recent experiments [1], we investigate TS in van der Waals AFM/superconductor hybrid structures. We show that trivial Andreev bound states can localize at uncompensated magnetic edges, which could explain the recent experiment [1]. Then, we propose a pathway to nontrivial topological phases driven by the interplay of AFM with Rashba or Ising spin-orbit couplings. We demonstrate that specific crystalline symmetries, particularly mirror symmetry combined spin-flip operations, stabilize second-order topological superconducting phases, characterized by a finite quadrupole moment.

[1] C. González-Sánchez et al., arXiv:2505.18578

TT 6.3 Mon 10:00 CHE/0091

Topological superconductivity induced by atomic-scale skyrmion lattices — ●FELIX NICKEL and STEFAN HEINZE — Institute of Theoretical Physics and Astrophysics, University of Kiel

Topological superconductivity, which can host Majorana zero modes with potential applications in topological quantum computing, relies on unconventional superconductors not known to exist in nature. However, magnet*superconductor hybrid systems (MSHs), built from ultra-thin magnetic layers on conventional superconductors, can induce such unconventional pairing [1]. While much research has focused on ferromagnetic systems with substantial spin*orbit coupling (SOC), non-collinear magnetic structures have been only sparsely investigated. Among them, atomic-scale skyrmion lattices are particularly interesting, as they lead to topological orbital moments and a topological Hall effect. They also offer a promising platform for MSHs, since their non-

coplanar spin arrangement, characterized by the scalar spin chirality, induces spin mixing naturally, even in the absence of SOC.

We present a systematic study based on a tight-binding model of various collinear, non-collinear, and non-coplanar spin textures and analyze their effect on the superconducting substrate. We relate the scalar spin chirality to the topological phase of the superconductor, characterized by its Chern number. For magnetic textures with finite scalar spin chirality, we find topological superconductivity, indicating a direct link between both properties [2].

[1] R. Lo Conte *et al.*, Riv. Nuovo Cim. **47**, 453 (2024)[2] F. Nickel *et al.*, npj Spintronics **3**, 13 (2025)

TT 6.4 Mon 10:15 CHE/0091

Topologically enabled superconductivity in 2D quantum materials — ●FRANCESCA PAOLETTI¹, DANIELE GUERCI², GIORGIO SANGIOVANNI¹, URBAN F. P. SEIFERT³, and ELIO J. KÖNIG⁴ — ¹JMU Würzburg — ²Massachusetts Institute of Technology — ³Universität zu Köln — ⁴University of Wisconsin-Madison

We investigate the role of Green's function zeros in strongly interacting topological Mott insulators, focusing on their meaning and physical interpretation. Recent advancements, particularly through slave rotor calculations of the Kane-Mele-Hubbard model, have established a connection between zeros and spinons and with U(1) gapped spin liquids. We find a macroscopic spin-charge separation resulting from the non-trivial interplay with the conventional boundary modes of the topological insulator. We further employ our method to an attractive Hubbard-Haldane honeycomb model. In this context, the extensive slave-rotor mean-field calculations are used as a microscopic foundation to determine the phase diagram of the model as well as important phenomenological properties, such as the coherence length and penetration depth (Pearl length) within a topologically enabled mechanism of superconductivity.

TT 6.5 Mon 10:30 CHE/0091

Euler band topology in superfluids and superconductors — ●SHINGO KOBAYASHI¹, MANABU SATO², and AKIRA FURUSAKI¹ — ¹RIKEN Center for Emergent Matter Science, Wako, Saitama, Japan — ²Department of Applied Physics, University of Tokyo, Bunkyo, Tokyo, Japan

Real band topology often appears in systems with space-time inversion symmetry and is characterized by invariants such as the Euler and second Stiefel-Whitney classes. Here, we examine the generic band topology of Bogoliubov de-Gennes (BdG) Hamiltonians with $C_{2z}T$ symmetry, where C_{2z} and T are twofold rotation about the z axis and time-reversal symmetries, respectively. We discuss the Euler band topology of superfluids and superconductors in the DIII and CI Altland-Zirnbauer symmetry classes. We demonstrate our theory with two examples: the superfluid ^3He B phase in magnetic field and the nodal lines of multi-orbital s -wave superconductors in class CI. These results provide a theoretical framework for exploring Euler band topology in superfluids and superconductors and offer a unified understanding of the robustness of topological phases under TRSB perturbations, including Majorana Ising physics and higher-order topology.

TT 6.6 Mon 10:45 CHE/0091

Topology of non-normalizable physical vector fields — ●PHILIPP GESSLER, ALESSANDRO PIGNEDOLI, ALEXANDER NEUHAUS, PASCAL DREHER, FRANK MEYER ZU HERINGDORF, MARIA AZHAR, and KARIN EVERSCHOR-SITTE — Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47048 Duisburg, Germany

Topological classification of physical vector fields typically relies on normalizing the field and using homotopy groups to classify them. When field amplitudes vanish, normalization becomes impossible, preventing a direct topological classification. We resolve this by mapping the d -dimensional vector field into a $(d+1)$ -dimensional space, enabling a general classification scheme for non-normalizable fields. Applying this method to the transverse electric mode of a classical electromagnetic waveguide, we reveal their topological nature. This approach extends topological analysis to a broad range of physical systems, including magnetism, water waves, and ferroelectrics.

TT 7: Surface Magnetism and Topological Insulators (joint session MA/TT)

Time: Monday 9:30–12:00

Location: POT/0351

TT 7.1 Mon 9:30 POT/0351

Impact of keV He-ion bombardment on the magnetic proximity effect in Pt/Fe bilayers — ●MIKA OSSENSCHMIDT¹, ARNE VEREIJKEN¹, YAHYA SHUBBAK¹, VARUN VANAKALAPU¹, MAIK GAERNER², ARNO EHRESMANN¹, and TIMO KUSCHEL² — ¹University of Kassel, Germany — ²Bielefeld University, Germany

The static magnetic proximity effect (MPE) describes the occurrence of spin polarization at the interface of nominally paramagnetic materials caused by its adjacency to a ferromagnetic material. KeV-He light ion bombardment (IB) of thin-film interfaces offers the opportunity to modify the interface properties of thin-film systems without destroying the thin films, e.g., as shown for exchange-bias systems [1].

Samples of Pt 4 nm/Fe 10 nm/MgO(001) were fabricated by sputter deposition and the subsequent IB was performed with 10 keV He⁺ ions with a varying ion dose from 10¹⁵ to 10¹⁷ ions/cm² in a few steps. To analyze the strength of the MPE in Pt, x-ray resonant magnetic reflectivity measurements were performed at the Pt L₃ absorption edge (11.567 keV) at DESY beamline P09 [2].

The fits of the x-ray reflectivity measurements provide a significant difference for the roughness σ of the Pt-Fe interface due to IB while substrate and surface roughnesses as well as layer thicknesses remained nearly unchanged. The resulting maximum Pt moment at the interface for the sample with IB is higher than without IB, due to the increasing intermixing of Pt and Fe atoms at the Pt-Fe interface.

[1] Ehresmann et al., J. Phys. D: Appl. Phys. 38, 801 (2005)

[2] Kuschel et al., Phys. Rev. Lett. 115, 097401 (2015)

TT 7.2 Mon 9:45 POT/0351

Exchange splitting at surfaces: a new paradigm for spin-polarization in antiferromagnets — ●WILLIAM SCHAARMAN and SOPHIE WEBER — Chalmers University of Technology, Göteborg, Sweden

There has been recent interest in combining the robustness and ultrafast dynamics of antiferromagnets with the transport properties of spin-polarized band structures. While antiferromagnetic bands are typically spin-degenerate, exceptions to this rule such as the altermagnets have demonstrated the possibility to obtain spin polarization in bulk antiferromagnets via selective symmetry lowering. Here, we use symmetry analysis and density functional theory to examine a ferromagnetic-like exchange splitting at certain surfaces. Such spin polarization of the surface-projected band structure can occur for surface orientations with a net two-dimensional magnetization which can emerge via symmetry-lowering at the antiferromagnet's surface. By analyzing the band structure of a slab geometry projected onto a single surface, we confirm surface spin polarization in two representative materials, magnetoelectric Cr₂O₃ and altermagnetic FeF₂. We rationalize the magnitudes of exchange splitting on distance surface orientations in these two materials as a complex interplay between the exchange and crystal field splittings of individual magnetic atoms making up the surface. Notably, our analysis shows the effect of surface exchange splitting can in some cases be of the order of eV which has important implications for spintronic devices.

TT 7.3 Mon 10:00 POT/0351

Image-potential states on a 2D Gr-ferromagnet hybrid: enhancing spin and stacking sensing — MACIEJ BAZARNIK^{1,2} and ●ANIKA SCHLENHOFF^{1,2} — ¹Institute of Physics, University of Münster, Germany — ²Department of Physics, University of Hamburg, Germany

With the increasing research interest in 2D materials, image-potential states (IPSSs) have regained attention as sensitive probes, e.g. for a charge transfer at buried graphene(Gr)-metal interfaces. For a Gr-ferromagnet hybrid, the question arises how IPSSs sense a respective spin transfer laterally varying within the moiré heterostructure.

Here, we present spin-resolved scanning tunneling microscopy and spectroscopy studies on Fe intercalated Gr/Ir(111), that show the IPSSs' sensitivity to the spatial variation of the Gr-Fe distance, and of the interfacial charge and spin transfer within the moiré unit cell [1]. A stacking contrast between fcc and hcp sites, indistinguishable in the direct tunneling mode, is provided by the IPSSs. We observe a moiré-site- and energy-dependent spin-polarization of the IPSSs that can be mapped across the entire moiré unit cell. Unlike the electronic states

around the Fermi energy, the lowest IPSSs are found to exhibit a high spin-polarization on the on-top sites attributed to their interfacial character at the respective Gr-Fe distance. Since the physisorbed Gr is only weakly spin-polarized on these sites, our work demonstrates that the lowest order IPSSs can be used to locally sense the spin density at magnetic interfaces buried by a nonmagnetic passivation layer.

[1] M. Bazarnik and A. Schlenhoff, ACS Nano 19, 25812 (2025).

TT 7.4 Mon 10:15 POT/0351

Theoretical Investigation of Intrinsically Patterned 2D Transition Metal Halides: Defects, Structure, and Magnetic Phenomena — ●NEETA BISHT¹, ANDREAS GÖRLING¹, FEIFEI XIANG², BINBIN DA², MOHAMMAD SAJJAN², SABINE MAIER², and CHRISTIAN NEISS¹ — ¹Lehrstuhl für Theoretische Chemie, Friedrich-Alexander-Universität Erlangen-Nürnberg, Egerlandstraße 3, 91058 Erlangen

— ²Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen

In the quest for complex structured functional materials, defect engineering and patterning in two-dimensional (2D) systems are critical for tuning material properties and enabling new functionalities. Herein, we report on intrinsically patterned 2D transition metal dihalides (TMDs) on a gold surface, featuring periodic halogen vacancies in the upper and bottom halide layers that result in alternating coordination of the transition metal atoms throughout the film.

We explore the formation pathways leading to periodic halogen vacancies and their role in modifying the electronic and magnetic structure of TMDs. Our calculations also explore the possibility of non-collinear magnetic textures through the magnetic anisotropy calculations. The excellent match between the experimental findings and the DFT calculations, confirms the intrinsic vacancy lattice. By coupling our theoretical results with experimental observations, we provide a comprehensive framework for understanding the structure formation and magnetic properties of 2D materials.

TT 7.5 Mon 10:30 POT/0351

Magnetic domain structure of holmium films at low temperatures — ●PATRICK HÄRTL¹, VIJAYALAXMI SANKESHWAR², and MATTHIAS BODE¹ — ¹Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — ²Indian Institute of Science Education and Research(IISER), Pune, Maharashtra 411008, India

Rare-earth metals play a central role in modern magnetism, with their behavior largely governed by the element-specific sign and oscillation period of the RKKY interaction. However, real-space investigations of their complex magnetic domain structures remain scarce. Here, we present a systematic study of the structural and magnetic properties of epitaxial holmium (Ho) films grown on W(110), using low-temperature spin-polarized scanning tunneling microscopy (SP-STM).

Bulk Ho crystallizes in a hexagonal close-packed structure and exhibits an exceptionally large magnetic moment of approximately 10 μ_B , forming a helical spin spiral below $T_C = 20$ K. In our films, we find predominantly ferromagnetic in-plane domains for thicknesses up to about 50 atomic layers (AL), with domain walls strongly pinned to crystalline defects. For coverages above 50 AL, additional out-of-plane stripe domains emerge, which we attribute to the uncompensated *c*-axis magnetization of the helical cone state. Domain wall analysis reveals Néel-capped Bloch-type walls with characteristic widths of roughly ≈ 1.2 nm (60°), ≈ 3 nm (120°), and ≈ 4 nm (180°). The stripe domains are suppressed by out-of-plane magnetic fields of $\mu_0 H = \pm 300$ mT.

Published in: P. Härtl et al., Phys. Rev. B 112, 174402 (2025).

TT 7.6 Mon 10:45 POT/0351

Electronic bounds in magnetic crystals — ●DANIEL PASSOS¹ and IVO SOUZA^{1,2} — ¹Centro de Física de Materiales, Universidad del País Vasco, 20018 San Sebastián, Spain — ²Ikerbasque Foundation, 48013 Bilbao, Spain

A quantum system in its ground-state must display non-negative optical absorption. This simple statement forms the basis for a string of inequalities between moments of the absorptive conductivity. Through the use of sum rules, these inequalities provide bounds on quantities of physical interest. Recent discoveries include new constraints on the

electronic localization length in insulators, and an upper bound on the bandgap of topological insulators. Current research focuses on finding inequalities relating ground-state properties such as the quantum metric to more directly measurable quantities.

We present a systematic study of bound relations between different electronic properties of magnetic crystals: electron density, effective mass, orbital magnetization, localization length, Chern invariant, and electric susceptibility. New results include a lower bound on the electric susceptibility of Chern insulators, and an upper bound on the sum-rule part of the orbital magnetization. In addition, bounds involving the Chern invariant are generalized from two dimensions (Chern number) to three (Chern vector). Bound relations are established for metals as well as insulators, and are illustrated for model systems. The manner in which they approach saturation in a model Chern insulator with tunable flat bands is analyzed in terms of the optical absorption spectrum.

15 min break

TT 7.7 Mon 11:15 POT/0351

Hidden Dirac-Like Crossings in a Prototypical Topological Insulator — •WEI-SHENG CHIU^{1,2}, INA MARIE VERZOLA³, YING-JIUN CHEN¹, ROVI ANGELO BELOYA VILLAS³, CLAUD MICHAEL SCHNEIDER^{1,2}, FENG-CHUAN CHUANG³, and CHRISTIAN TUSCHE^{1,2} — ¹Forschungszentrum Jülich, Germany — ²Universität Duisburg-Essen, Germany — ³National Sun Yat-sen University, Taiwan

The prototypical topological insulator Bi_2Se_3 has been extensively studied for its topological surface state characterized by a \mathbb{Z}_2 topological invariant. By using spin-resolving momentum microscopy with an Au passivated Ir(100) imaging spin filter, we simultaneously recorded the spin-resolved momentum maps (k_x, k_y) over entire surface Brillouin zone of Bi_2Se_3 . In addition to the well-known Dirac cone near Fermi energy, we observe a sequence of several Dirac-like spin textures and crossings spanning binding energies down to 4 eV at the $\bar{\Gamma}$ point. Moreover, a Dirac-like crossing is also found at a binding energy 2.3 eV at the \bar{M} point. Our first-principles calculations indicate that those overlooked bands are attributed to surface states. The Dirac-like crossing at the \bar{M} point arises from crystalline-symmetry-enforced degeneracy at the high symmetry point, showing that Bi_2Se_3 has a more complex surface electronic structure than previously expected.

TT 7.8 Mon 11:30 POT/0351

Single domain spectroscopic signatures of a magnetic Kagome metal — •LUKASZ PLUCINSKI¹, GUSTAV BIHLMAYER¹, YURIY MOKROUSOV¹, YISHUI ZHOU², YIXI SU², JONATHAN DENLINGER³, AARON BOSTWICK³, CHRISTOPHER JOZWIAK³, ELI ROTENBERG³,

DMITRIY USACHOV⁴, and CLAUD M. SCHNEIDER¹ — ¹FZ Jülich — ²JCNS/MLZ Garching — ³ALS/LBNL Berkeley — ⁴DIPC San Sebastian

We investigate the magnetic Kagome metal DyMn_6Sn_6 using high-resolution micro-focused circular-dichroic angle-resolved photoemission (μ -CD-ARPES) to probe its magnetic and electronic properties. By tuning the kinetic energy to various features of the Dy 4f multiplet, we resolve magnetic domains in samples cryo-cooled down to 20 K. Smaller, but clear signatures are detected in the Mn 3p levels. The behavior of both Dy 4f and Mn 3p features are in remarkable agreement with our modeling based on the Hartree-Fock method, revealing ferrimagnetic alignment of Dy and Mn local moments, and further strengthening our interpretation. Adjusting the energy to the Mn 3d-dominated valence bands reveals signatures which we relate to the orbital magnetization through a comparison to *ab initio* electronic structure calculations. Our study establishes the spectroscopic access to a single magnetic domain in a Kagome metal, paving the way for further research into imaging magnetic phases of novel magnetic materials using μ -CD-ARPES. Preprint is available at <https://arxiv.org/abs/2507.12085>.

TT 7.9 Mon 11:45 POT/0351

Topologically non-trivial Kondo insulating state in graphene nanoribbons — •AMOGH KINIKAR^{1,2}, GUANGZE CHEN³, YANWEI GU⁴, DAVID JACOB^{5,6}, JOAQUÍN FERNÁNDEZ-ROSSIER⁷, GONÇALO CATARINA², ANTÓNIO T. COSTA⁷, OLIVER GRÖNING², CARLO ANTONIO PIGNEDOLI², KLAUS MÜLLEN⁴, PASCAL RUFFIEUX², JOSE L. LADO⁸, AKIMITSU NARITA⁴, and ROMAN FASEL^{2,9} — ¹KIT, Karlsruhe, Germany — ²Empa, Dübendorf, Switzerland — ³Chalmers University of Technology, Gothenburg, Sweden — ⁴MPIP, Mainz, Germany — ⁵UPV/EHU, San Sebastián, Spain — ⁶Basque Foundation for Science, Bilbao, Spain — ⁷INL, Braga, Portugal — ⁸Aalto University, Espoo, Finland — ⁹University of Bern, Bern, Switzerland

Metallic rare-earth alloys display characteristic correlated electron phenomena due to interactions between electrons which give rise to a narrow heavy-fermion band near the Fermi level that hybridizes with the metallic band and opens a hybridization gap. When the Fermi level falls within this gap the system forms a Kondo insulator, which can also acquire a topologically non-trivial character. Here we provide evidence for a topological Kondo insulating state in a specific atomically precise graphene nanoribbon synthesized on Au(111) by on surface methods and characterized by scanning probe microscopy. We observe a sharp resonance near the Fermi level and a pronounced zero-bias peak at the ribbon termini. We show that these spectroscopic signatures are a fingerprint of a topological Kondo insulating state in this graphene nanoribbon.

TT 8: Topical Talk Wulfhekel (joint session O/TT)

Time: Monday 9:30–10:15

Location: TRE/PHYS

Topical Talk

TT 8.1 Mon 9:30 TRE/PHYS

Vortices, inter-band coupling and inelastic QPI in two band superconductors — •WULF WULFHEKEL — Physikalisches Institut, Karlsruhe Institute of Technology

The majority of superconductors have more than one Fermi surface, on which the electrons pair below the critical temperature, yet their behavior can be well described by a single-band Bardeen-Cooper-Schrieffer theory. This is mostly due to interband scattering, especially in superconductors in the dirty limit, rigidly linking the pairing amplitude of the bands. We here lift this constrain and study the behavior of the ultra-pure two-band superconductor Pb. We show that at low temperatures, it is neither of type I nor type II and superconducting

vortices of arbitrary flux quanta can be formed. We show that on the non-spherical Fermi surfaces, a modified index theory is needed for the description of in gap states in vortices. Further, the two condensates are only weakly coupled and can be individually manipulated. By studying stacking fault tetrahedra, we demonstrate local tuning of interband coupling ranging from weak to strong and the modification of the superconducting order parameters from two well separated gaps to one merged gap around defects. The experiments critically test the theory of multiband superconductors and give a route to access a wide range of predicted quantum effects in these systems. Finally, we demonstrate that quasi particle interference is also possible in the inelastic tunneling channel enabling the imaging of standing phonons with STM.

TT 9: 2D Materials: Electronic structure, excitations, etc. I (joint session O/HL/TT)

Time: Monday 10:30–12:30

Location: TRE/MATH

Invited Talk

TT 9.1 Mon 10:30 TRE/MATH

Magnetic Order in 2D Materials Beyond Bulk Constraints — ●JEISON FISCHER — II. Physikalisches Institut, Universität zu Köln

Even though exfoliated microflakes remain widely used in 2D magnetism research, their bulk origin restricts access to many potentially interesting phases, an obstacle that molecular beam epitaxy (MBE) can overcome. MBE enables the controlled synthesis of single-layer materials directly related to, yet often distinct from, their bulk counterparts.

In my talk, I will present structural characterization and discuss the mechanisms behind the formation of such novel 2D materials grown via MBE on graphene. [1-2] The emerging magnetic properties of these new 2D materials will be exemplified with two cases: Cr_2S_3 -2D and Fe_2S_2 -2D. Cr_2S_3 forms a covalently bonded NiAs-type structure without van der Waals gaps. Using spin-polarized scanning tunneling microscopy (STM) and X-ray magnetic circular dichroism (XMCD), we show that it hosts ferromagnetic coupling within the plane with magnetic moments pointing out-of-plane, combined with A-type antiferromagnetic coupling between different Cr planes. Fe_2S_2 exhibits a unique hexagonal phase, in which Fe atoms occupy tetragonally coordinated sites. Spin-polarized STM reveals that the moments are noncollinear within the plane. We map the in-plane components of two distinct magnetic configurations and find that the moments are confined to the 2D plane, forming a Néel state and a 2Q state.

[1] Knispel et al. Small, 2025 21, 2408044.

[2] Safer et al. Adv. Funct. Mater. 2025, 202500907.

TT 9.2 Mon 11:00 TRE/MATH

Ab initio modeling of magnons and magnon-phonon coupling in 2D magnetic materials — ALI ESQUEMBRE-KUCUKALIC¹, KHOA LE², HSIAO-YI CHEN³, IVAN MALIYOV², JIN-JIAN ZHOU⁴, DAVIDE SANGALLI⁵, and ●ALEJANDRO MOLINA-SÁNCHEZ¹ — ¹ICMUV, University of Valencia, Valencia, Spain — ²CALTECH, California, USA — ³Tohoku University, Japan — ⁴Beijing Institute of Technology, Beijing, China — ⁵ISM-CNR, Roma, Italy

Understanding spin-wave excitations in two-dimensional magnetic materials is essential for advancing spintronic and quantum information technologies. Chromium trihalides and related 2D magnets provide a platform where the choice of halide influences on the magnetic behavior, yet its impact on magnon properties is not completely understood. We present first-principles calculations of magnon dispersions and wave functions in monolayer Cr trihalides using the Bethe-Salpeter equation (BSE), resolving key features such as the topological gap at the Dirac point. The BSE analysis reveals that magnons originate from electronic transitions spanning a wider energy range than excitons, offering new insight magnon character and enabling the extraction of Heisenberg exchange parameters. Building on this framework, we develop an ab initio description of mag-ph coupling by deriving BSE-based mag-ph interaction matrices and applying them to monolayer CrI_3 and hydrogenated graphene. We show that mag-ph and electron-phonon couplings differ markedly, identifying specific phonon modes that dominate magnon scattering.

TT 9.3 Mon 11:15 TRE/MATH

Electron-phonon interaction in transition-metal dichalcogenides — ●GERRIT JOHANNES MANN, THORSTEN DEILMANN, and MICHAEL ROHLFING — Institute of Solid State Theory, University of Münster, Germany

Electron-phonon interaction is a crucial effect in solid state physics, in particular in two-dimensional materials. We developed a generally applicable ab-initio implementation on top of density functional theory using a basis set of localized Gaussian orbitals. It combines finite differences calculations with the perturbative Allen-Heine-Cardona framework in order to calculate the temperature-dependent renormalization of the electronic bandstructure due to electron-phonon interaction. Our implementation circumvents the limiting problems of previous implementations and allows to evaluate Debye-Waller contributions beyond the rigid-ion approximation [1], which are usually neglected.

In addition to the renormalization of the electronic bands, electron-phonon interaction introduces a line broadening due to finite-lifetime effects, which have recently been incorporated into our implementation. In this presentation, we discuss our results, including those with

finite-lifetime effects, for two-dimensional transition-metal dichalcogenides, where the renormalization of the electronic bandstructure due to electron-phonon interaction can be as large as several hundreds of meV.

[1] Mann et al., Phys. Rev. B **110**, 075145 (2024)

TT 9.4 Mon 11:30 TRE/MATH

Surface-state engineering for nonlinear charge and spin photocurrent generation — ●JAVIER SIVIANES¹, PEIO GARCIA-GOIRICELAYA², DANIEL HERNÁNDEZ-PÉREZ³, and JULÉN IBÁÑEZ-AZPIROZ^{1,4,5} — ¹Centro de Física de Materiales (CSIC-UPV/EHU), Donostia, Spain — ²University of the Basque Country UPV/EHU, Leioa, Spain — ³CIC nanoGUNE BRTA, San Sebastián, Spain — ⁴IKERBASQUE, Basque Foundation for Science, Bilbao, Spain — ⁵Donostia International Physics Center (DIPC), Donostia, Spain

We systematically explore the generation of nonlinear charge and spin photocurrents using spin-orbit-split surface states. This mechanism enables net DC flow along the surface plane even in centrosymmetric bulk environments like the Rashba prototype $\text{Au}(111)$, where we characterize the main quadratic contributions by combining model predictions with density functional calculations. We further identify the $\text{Ti/Si}(111)$ surface as a prime scenario for experimental verification; with slight doping, it develops metallic surface states featuring remarkable relativistic properties deviating from the Rashba paradigm, while the bulk remains semiconducting. Its nonlinear charge photocurrent reveals a distinct angular signature and a magnitude comparable to bulk ferroelectrics, highlighting the potential of surface-state photocurrents for low-bias optoelectronic applications. Moreover, the non-trivial spin texture of its surface states enables the generation of pure out-of-plane spin-polarized currents, offering a highly versatile nonlinear spin-filtering functionality beyond the conventional spin Hall effect.

TT 9.5 Mon 11:45 TRE/MATH

Influence of Vanadium Doping on WSe_2 , as seen through ARPES — ●JANA KÄHLER^{1,2}, FLORIAN K. DIEKMANN^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, TIM RIEDEL^{1,2}, ADINA TIMM^{1,2}, ANJA YALIM^{1,2}, JENS BUCK^{1,2}, MENG-JIE HUANG², JULES M. KNEBUSCH^{1,2}, LUKE HANSEN^{1,3}, JAN BENEDIKT^{1,3}, and KAI ROSSNAGEL^{1,2,3} — ¹Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — ³Kiel Nano, Surface and Interface Science KiNSIS, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany

Spintronics offers a compelling, energy-efficient alternative to traditional electronics with potential applications in communications, sensing, and information processing. The vanadium-doped layered transition metal dichalcogenide $2H\text{-WSe}_2$ is particularly promising as a room-temperature magnetic semiconductor with gate-tunable transport properties. Here, we use a combination of 11 eV laser, 21.2 eV He-lamp, and soft X-ray synchrotron ARPES to highlight the influence of a fairly small vanadium doping on the electronic structure of WSe_2 . Both the pristine and doped compounds were grown by chemical vapor transport in our own laboratory.

TT 9.6 Mon 12:00 TRE/MATH

Engineering sulfur vacancy dimers in monolayer WS_2 — ●DANIEL JANSEN¹, GUANGYAO MIAO¹, JAN KEIENBURG¹, JEISON FISCHER¹, THOMAS MICHEL¹, HANNU-PEKKA KOMSA², and WOUTER JOLIE¹ — ¹Institute of Physics II, University of Cologne, Cologne, Germany — ²Faculty of Information Technology and Electrical Engineering, University of Oulu, Oulu, Finland

Sulfur vacancies [1] and sulfur vacancy dimers in nearest-neighbor distance [2] in monolayer WS_2 have been experimentally proven to yield bright and stable photon emission, thus holding promises for the development of quantum technologies.

Here we investigate dimers of sulfur vacancies in different configurations in monolayer WS_2 created with the tip of a scanning tunneling microscope [3]. Scanning tunneling spectroscopy reveals strong hybridization of the sulfur vacancy electronic in-gap states, validated by density functional theory calculations. For dimers in nearest-neighbor configuration we find that inelastically tunneling electrons can induce sulfur atom migration, resulting in a rotary motion of the dimer. This

motion is studied in detail by analyzing the emerging telegraph noise in the junction. Lastly, we elaborate on scenarios to make use of the dimer motion for the design of vacancy structures and lattices.

- [1] Schuler et al., Sci. Adv. **6**, 38 (2020)
 [2] Sun et al., Nature Commun. **15**, 9476 (2024)
 [3] Jansen et al., Phys. Rev. B **109**, 195430 (2024)

TT 9.7 Mon 12:15 TRE/MATH

Alkali-metal doped transition metal chlorides confined in bilayer graphene: Insights from first-principles calculations — •MUNAWAR ALI¹, ARKADY V. KRASHENINNIKOV², GIOVANNI CANTELE¹, and MAHDI GHORBANI-ASL² — ¹Università degli Studi di Napoli "Federico II," Dipartimento di Fisica "Ettore Pancini," Complesso di Monte S. Angelo, via Cinthia, 80126 Napoli, Italy — ²Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany

The intercalation of atomic and molecular species into layered materials has emerged as a powerful strategy for synthesizing novel two-dimensional systems with tunable electronic, magnetic, and energy-storage properties. Encapsulating transition-metal halides into bilayer graphene has proven effective for stabilizing 2D magnetic phases that are otherwise thermodynamically unstable. Using density functional theory, we systematically investigate the intercalation of metal chlorides (TCl_3 , $T = \text{Fe, Cu, Mo, Al}$) doped with alkali metals (Li, Na, K, Rb, Cs) across a range of concentrations. Li- and Na-doped $FeCl_3$, $CuCl_3$, and $MoCl_3$ monolayers exhibit the highest thermodynamic stability, whereas $AlCl_3$ remains unstable even under doping. Bader charge analyses reveal substantial charge transfer from the graphene host to the intercalated layers, particularly in the case of $CuCl_3$, which also shows the strongest binding. These findings provide a theoretical framework for understanding the stability of these heterostructures and highlight alkali-metal-intercalated graphene systems as a platform for engineering tunable 2D magnetic materials.

TT 10: Correlated Electrons: Other Theoretical Topics

Time: Monday 11:00–12:45

Location: HSZ/0103

TT 10.1 Mon 11:00 HSZ/0103

Two site entanglement and maximal correlations in the Hubbard model — FREDERIC BIPPUS¹, ANNA KAUCH¹, •GERGO ROOSZ¹, CHRISTIAN MAYRHOFER¹, FAKHER ASSAAD^{2,3}, and KARSTEN HELD¹ — ¹Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria — ²Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg Germany — ³Würzburg-Dresden Cluster of Excellence ct.qmat, Am Hubland, 97074 Würzburg, Germany

The study of entanglement in strongly correlated electron systems typically requires knowledge of the reduced density matrix. Here, we apply the parquet dynamical vertex approximation to study the two-site reduced density matrix at varying distance, in the Hubbard model at weak coupling. This allows us to investigate the spatial structure of entanglement in dependence of interaction strength, electron filling, and temperature. We compare results from different entanglement measures and benchmark against quantum Monte Carlo. Using the two-site density matrix, we compute the fermionic entanglement negativity, the mutual information between the two sites. We determine the maximal correlation function between the two lattice points.

TT 10.2 Mon 11:15 HSZ/0103

Superconductor-Insulator transition in a two-orbital attractive Hubbard model with Hund exchange — •LAURA TORCHIA and MASSIMO CAPONE — International School for Advanced Studies (SISSA), via Bonomea 265, 34136 Trieste, Italy

We study a two-orbital attractive Hubbard model with a repulsive Hund exchange coupling J as an idealized model for a two-band superconductor. This framework is motivated by systems where a strong isotropic electron-phonon coupling drives the on-site Hubbard repulsion U negative while leaving the exchange term unaffected. We solve the model at $T = 0$ and half-filling using DMFT, focusing on the intra-orbital singlet superconducting phase and discarding other possible instabilities, as inter-orbital pairing and a charge-density wave ordering. Already at $J = 0$, the two-orbital model features a superconductor-insulator transition as $|U|$ grows, in contrast with the single-orbital case which remains superconducting for any $U < 0$. We find that a finite J strengthens the effect of the attractive U , both in the normal state and, even more significantly, in the superconducting state. However, this pushes the system towards an effectively stronger coupling, hence to a faster transition to the insulating state.

Similarly to the Mott transition in the repulsive model, the superconductor-insulator transition here is marked by a vanishing quasi-particle weight Z . This leads to a scenario that recalls strongly correlated superconductivity close to a Mott transition, where pairing is enhanced but phase coherence is rapidly lost, even though the present model is dominated by attractive interactions.

TT 10.3 Mon 11:30 HSZ/0103

Orbital Magnetic Field Driven Metal-Insulator Transition in Strongly Correlated Electron Systems — •GEORG ROHRINGER^{1,2} and ANTON MARKOV³ — ¹Theory and Simulation of Condensed Matter, Department of Physics, King's College London,

The Strand, London WC2R 2LS, United Kingdom — ²I. Institute of Theoretical Physics, University of Hamburg, 20355 Hamburg, Germany — ³Center for Nonlinear Phenomena and Complex Systems, Université Libre de Bruxelles, CP 231, Campus Plaine, B-1050 Brussels, Belgium

We study the effects of an orbital magnetic field on the Mott metal-insulator transition in the Hubbard-Hofstadter model. We demonstrate that sufficiently large magnetic fields induce a Mott insulator-to-metal phase transition supporting our claim with dynamical mean field theory (DMFT) numerical results. For both competing phases (metal and insulator) we observe a magnetic-field-induced metallization reflected in an enhancement of kinetic and potential energy. We demonstrate that this phenomenon originates from a field-driven redistribution of spectral weight due to the formation of magnetic minibands and the Aharonov-Bohm effect experienced by electrons virtually tunneling around an elementary plaquette. Our theoretical results might be relevant for recent experimental studies on magnetic field driven insulator-to-metal transitions in strongly correlated materials such as VO_2 , λ -type organic conductors, and moiré multilayers.

TT 10.4 Mon 11:45 HSZ/0103

Probing Green's Function Zeros by Cotunneling through Mott Insulators — •CARL LEHMANN^{2,3,1}, LORENZO CRIPPA^{4,2,3}, GIORGIO SANGIOVANNI^{2,3}, and JAN BUDICH^{1,2,5} — ¹Technische Universität Dresden, 01069 Dresden, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, 97074 Würzburg, Germany — ³Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany — ⁴I. Institute of Theoretical Physics, University of Hamburg, Notkestrasse 9, 22607 Hamburg, Germany — ⁵Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany

Quantum tunneling experiments have provided deep insights into basic excitations occurring as Green's function poles in the realm of complex quantum matter. However, strongly correlated quantum materials also allow for Green's functions zeros (GFZs) that may be seen as an antidote to the familiar poles and have so far largely eluded direct experimental study. Here, we propose and investigate theoretically how cotunneling through Mott insulators enables direct access to the shadow band structure of GFZs. In particular, we derive an effective Hamiltonian for the GFZ that is shown to govern the cotunneling amplitude and reveal fingerprints of many-body correlations clearly distinguishing the GFZ structure from the underlying free Bloch band structure of the system. Our perturbative analytical results are corroborated by numerical data for a one-dimensional model system consisting of a Su-Schrieffer-Heeger-Hubbard model coupled to two single-level quantum dots.

TT 10.5 Mon 12:00 HSZ/0103

Conformal elastic zero modes at isostructural transitions — •LARS FRANKE¹, NICK SANDER¹, and MARKUS GARST^{1,2} — ¹Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²Institute for Quantum Materials and Technology, Karlsruhe Institute of Technology, 76131

Karlsruhe, Germany

In correlated materials the coupling of the itinerant electrons to the crystal lattice can induce an isostructural instability where the bulk modulus vanishes. This occurs for example at the endpoint of a line of first order Mott metal-insulator transitions or metamagnetic transitions [1]. Interestingly, at such an isostructural instability the acoustic phonons remain non-critical and their velocities are finite. Consequently, the isostructural transition is a genuine mean-field transition without critical microscopic fluctuations. Nevertheless, we demonstrate that four elastic macroscopic zero modes exist. In addition to a soft mode given by a macroscopic volume change, there are three further zero modes corresponding to special conformal transformations. We discuss the consequences for the critical dynamics close to isostructural instabilities as well as realizations in dilational metamaterials.

[1] M. Zacharias, L. Bartosch, M. Garst, PRL 109 (2012) 176401

TT 10.6 Mon 12:15 HSZ/0103

Stabilization of sliding ferroelectricity through exciton condensation — •MATTEO D'ALESSIO^{1,2}, DANIELE VARSANO², ELISA MOLINARI^{1,2}, and MASSIMO RONTANI² — ¹University of Modena and Reggio Emilia, Department of Physics, Informatics and Mathematics, Modena, Italy — ²CNR Nanoscience Institute, Modena, Italy

Sliding ferroelectricity is a phenomenon that arises from the insurgence of spontaneous electronic polarization perpendicular to the layers of two-dimensional (2D) systems upon the relative sliding of the atomic layer constituents. Because of the weak van der Waals (vdW) interactions between layers, sliding and the associated symmetry breaking can occur at low energy cost in materials such as transition-metal dichalcogenides. Here we discuss theoretically this phenomenon by focusing on a prototype structure, the WTe₂ bilayer, where sliding ferroelectricity was first experimentally observed. We compute the significant energy

band renormalizations of the ground state induced by excitonic effects and show that in the case of bilayer WTe₂ - as long as exciton coherence survives - relevant modifications result in the energetics of the system that contribute to stabilize ferroelectricity upon sliding displacement of the layers. We thus show that electron-hole interaction effects can play an important role in sliding ferroelectricity, where they have been neglected up to now.

TT 10.7 Mon 12:30 HSZ/0103

Ising Spin-Orbit Coupling in Three Dimensions — •TONGHUA YU, ELI GERBER, and BENJAMIN WIEDER — Institut de Physique Théorique, Université Paris-Saclay, CEA, CNRS, F-91191 Gif-sur-Yvette, France.

Ising-type spin-orbit coupling (SOC) that produces out-of-plane spin polarization has been extensively explored in nonmagnetic two-dimensional (2D) materials, and has been shown to give rise to intriguing phenomena such as Pauli-limit-violating and spin-triplet superconductivity, SOC-polarized (interacting) topological bands, and high-performance nonvolatile valley spin valve. For 2D systems lying in the *xy*-plane, Ising SOC enforces that the bulk is nearly *S_z*-symmetric, in sharp contrast to systems dominated by Rashba or Dresselhaus SOC. Though all known examples of Ising SOC occur in 2D mono- or few-layer systems, there is no mathematical obstruction that restricts three-dimensional (3D) crystals from exhibiting nearly perfect (Ising-like) SOC textures. Using Green's functions and the projected spin spectrum applied to first-principles calculations, we identify 3D materials with Ising SOC that do not decompose into simple van der Waals layers of 2D Ising SOC materials, and we characterize their associated topological properties. Our calculations expand the class of Ising SOC materials and reveal new venues for spintronics and unconventional superconductivity.

TT 11: PtBi₂

Time: Monday 11:15–12:30

Location: CHE/0091

TT 11.1 Mon 11:15 CHE/0091

Surface-confined fluctuating superconductivity in the topological semimetal γ -PtBi₂ — •MANASWINI SAHOO, LUMINITA HARNAGEA, MAHDI BEHNAMI, MICHELE CECCARDI, SEBASTIAN GASS, SABINE WURMEHL, ANJA UB WOLTER, and BERND BÜCHNER — Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany

PtBi₂ has recently emerged as a promising candidate for hosting superconducting topological surface states. While surface-sensitive probes have observed this unique superconductivity, it remains elusive in bulk thermodynamic measurements. Here, we present evidence of superconducting fluctuations at elevated temperatures through AC susceptibility measurements. The real component of the susceptibility exhibits a diamagnetic response below 20 K, accompanied by a finite imaginary component, both indicative of surface-confined superconducting fluctuations. The small superconducting volume fraction supports a surface rather than bulk origin. Complementary magnetoresistance measurements reveal anomalies below this characteristic temperature. These findings establish PtBi₂ as a robust platform for exploring topological superconductivity and provide strong motivation for future studies aimed at elucidating the superconducting bulk-surface interplay.

TT 11.2 Mon 11:30 CHE/0091

Engineering Weyl nodes in the nodal-line semimetal PtBi₂ — •ANKIT KUMAR^{1,2}, JOSEPH DUFOULEUR¹, and BERND BÜCHNER^{1,2} — ¹Leibniz Institute for Solid State and Materials Research (IFW) Dresden — ²Department of Physics, TU Dresden

The nonmagnetic Weyl and nodal-line semimetal PtBi₂ has recently been shown an anomalous planar Hall effect (APHE), a phenomenon generated purely by Berry curvature surrounding Zeeman-induced Weyl points. The location of Zeeman-split Weyl nodes along the nodal line can be tuned.

In this work, we investigate the tunability of Weyl physics in PtBi₂ through systematic APHE measurements performed under three-dimensional rotations of the magnetic field. By tilting the magnetic field out of plane, we are able to tune the amplitude of the anomalous Hall effect, obtaining a signal stronger or weaker than that measured in-plane. This behaviour provides evidence that the location of

Zeeman-induced Weyl nodes can be manipulated by controlling the field orientation.

Our results establish a new pathway to engineer Zeeman-induced Weyl nodes in nodal line semimetals by a magnetic field.

TT 11.3 Mon 11:45 CHE/0091

Low-temperature scanning tunneling spectroscopy on the superconducting Weyl semimetal t-PtBi₂ — •SEBASTIAN SCHIMMEL¹, JULIA BESPROSWANNY¹, XIAOCHUN HUANG², YANINA FASANO³, GRIGORY SHIPUNOV⁴, VICTOR FELIX CORREA³, JOSÉ ZABALA³, LUMINITA HARNAGEA⁵, SVEN HOFFMANN¹, BERND BÜCHNER⁵, MATTHIAS BODE², and CHRISTIAN HESS¹ — ¹Universität Wuppertal, 42119, Wuppertal, Germany — ²Universität Würzburg, 97074 Würzburg, Germany — ³Centro Atómico Bariloche and Instituto Balseiro, 8400, Bariloche, Argentina — ⁴University of Amsterdam, 1098 XH Amsterdam, The Netherlands — ⁵IFW Dresden, 01069, Dresden, Germany

Combining a topologically non-trivial Weyl semimetal nature and surface superconductivity with *T_c* > 5 K, trigonal PtBi₂ (t-PtBi₂) is a fascinating representative of quantum materials. Intriguingly, large superconducting gaps, comparable to those known from high-*T_c* superconductors, suggest elevated transition temperatures, and ARPES revealed that the surface superconductivity is confined to Weyl Fermi arcs exhibiting unconventional i-wave symmetry [1,2]. Via low-temperature scanning tunneling spectroscopy, we experimentally address the local electronic properties of the surface of t-PtBi₂. Here we report on the temperature dependence of the surface superconductivity and peculiar spectroscopic signatures of its spatially varying electronic structures. The presented results corroborate the unconventional non-trivial electronic properties of t-PtBi₂.

[1] A. Kuibarov et al., Nature(2024)

[2] S. Changdar et al., Nature(2025)

TT 11.4 Mon 12:00 CHE/0091

t-PtBi₂: Topological Fermi Arcs and Surface Superconductivity from Quasiparticle Interference — •JULIA BESPROSWANNY¹, SEBASTIAN SCHIMMEL¹, SVEN HOFFMANN¹, GRIGORY SHIPUNOV², SAICHARAN ASWARTHAM², JOAQUIN PUIG³, YANINA FASANO³, DANNY BAUMANN², RICCARDO VOCATURO², JORGE

I. FACIO³, OLEG JANSON², JEROEN VAN DEN BRINK², BERND BÜCHNER², and CHRISTIAN HESS¹ — ¹University of Wuppertal, 42119 Wuppertal, Germany — ²IFW Dresden, 01069 Dresden, Germany — ³Centro Atómico Bariloche, Instituto Balseiro, 8400 Bariloche, Argentina

Non-centrosymmetric trigonal PtBi₂ hosts a rich electronic structure that gives rise to several quantum phenomena. In particular, the co-existence of topological surface states and surface superconductivity suggests that it may be an intrinsic, possibly high-T_c, topological superconductor. ARPES [1] shows that superconductivity in t-PtBi₂ is both intertwined with and confined to its topological surface states.

By means of low-temperature scanning tunneling spectroscopy and quasi-particle interference investigations, we probe the local topological and superconducting properties and their interplay on the surface of t-PtBi₂. The revealed scattering channels originate from the topological Fermi arcs. These QPI signatures are suppressed in the superconducting state, while re-emerging above B_c – highlighting the close connection between superconductivity and topology.

[1] A. Kuibarov et. al., Nature 626, 294 (2024).

TT 11.5 Mon 12:15 CHE/0091

Phonon and Coulomb mechanism for nodal topological superconductivity on PtBi₂ surface — •KRISTIAN MAELAND, GIORGIO SANGIOVANNI, and BJÖRN TRAUZETTEL — Institute for Theoretical Physics and Astrophysics, University of Würzburg and Würzburg-Dresden Cluster of Excellence ct.qmat, D-97074 Würzburg, Germany

Experiments show that the Weyl semimetal PtBi₂ hosts unconventional superconductivity in its topological surface states. Hence, the material is a candidate for intrinsic topological superconductivity. Measurements indicate nodal gaps in the center of the Fermi arcs. We show that unusually anisotropic electron-phonon coupling on Weyl semimetal surfaces combined with statically screened Coulomb repulsion is a microscopic mechanism for the *i*-wave pairing. We solve the linearized gap equation close to the critical temperature and find nodal gaps when the surface state bandwidth is comparable to the maximum phonon energy, as is the case in PtBi₂.

TT 12: Focus Session: Tunable Correlations in van der Waals Quantum Materials I (joint session TT/DS/HL)

The library of strongly correlated layered materials has intensively grown, giving now access to the full breadth of symmetry broken emergent phases, ranging from excitonic, to magnetic, superconducting, or Mott insulating ground states. At the same time, also the ways of tuning these correlated phases in 2D are steadily developing, e.g, via twisting or stacking, engineered defects, or applied external fields. Taken together, this nowadays allows for sheer endless possibilities to tailor layered correlated quantum materials on demand opening unprecedented avenues towards both deep insights into emergent phenomena and novel functionalization routes based on many-body properties.

This focus session will highlight recent advancements and breakthroughs achieved in this field, which we expect to be of great interest to the broadest audience and to stimulate discussions crossing field boundaries.

Coordinators: Lennart Klebl (Uni Würzburg), Jonas Profe (Uni Frankfurt), Malte Rösner (Uni Bielefeld), Ursula Wurstbauer (Uni Münster)

Time: Monday 15:00–18:15

Location: HSZ/0003

Topical Talk TT 12.1 Mon 15:00 HSZ/0003

Charge confinement in twisted bilayer graphene — •CHRISTOPH STAMPFER — JARA-FIT and 2nd Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany

Twisted bilayer graphene (tBLG) near the magic angle is a unique platform where the combination of topology and strong correlations gives rise to exotic electronic phases. These phases are gate-tunable and related to the presence of flat electronic bands, isolated by single-particle band gaps. This enables charge confinement and allows to explore the interplay of confinement, electron interactions, band renormalisation and the moiré superlattice, potentially revealing key paradigms of strong correlations. In this talk we will present two experiments where we study charge confinement in tBLG. First, we report on the observation of negative electronic compressibility in tBLG for Fermi energies close to insulating states. To observe this negative compressibility, we take advantage of naturally occurring twist-angle domains that emerge during the fabrication of the samples, leading to the formation of charge islands. Second, we present gate-defined single-electron transistors (SETs) in near-magic-angle tBLG with well-tunable Coulomb blockade resonances. These SETs allow to study magnetic field-induced quantum oscillations in the density of states of the source-drain reservoirs, providing insight into gate-tunable Fermi surfaces of tBLG and open the door to quantum dots and Josephson junction arrays in tBLG.

Topical Talk TT 12.2 Mon 15:30 HSZ/0003

Tuning Coulomb interactions and Hubbard bands in 1T-TaS₂ — •ANNA GALLER — Institute of Theoretical and Computational Physics, TU Graz, Austria — Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Monolayer 1T-TaS₂ hosts a star-of-David charge-density wave (CDW) that stabilizes a low-temperature Mott-insulating state. Recent time-

resolved spectroscopies indicate a coupling between the CDW amplitude mode and the electronic correlation strength, yet the role of the screened Coulomb interaction remains unclear. Using the constrained random-phase approximation, we show that the CDW amplitude modifies the bare and screened on-site interactions, leading to sizable variations in the effective Hubbard U. Our combined density-functional and dynamical mean-field theory calculations reveal that the Hubbard bands shift in concert with the CDW amplitude, and that a reduced distortion drives a transition from a Mott insulator to a correlated metal. These results demonstrate a direct link between lattice distortions and Coulomb interactions in transition-metal dichalcogenides, providing a microscopic mechanism for light-induced control of correlated phases in two-dimensional quantum materials.

Topical Talk TT 12.3 Mon 16:00 HSZ/0003

Optical signatures of interlayer electron coherence in a bilayer semiconductor — •NADINE LEISGANG^{1,2}, XIAOLING LIU², PAVEL DOLGIREV², PHILIP KIM², and MIKHAIL LUKIN² — ¹Phillips-Universität Marburg, Germany — ²Harvard University, United States

Emergent strongly correlated electronic phenomena in atomically thin transition-metal dichalcogenides represent an exciting frontier in condensed matter physics, with examples ranging from bilayer superconductivity and electronic Wigner crystals to the ongoing search for exciton condensation. Here, we take a step towards the latter by reporting experimental signatures of unconventional coupling of interlayer excitons consistent with coherence between interlayer electrons in a transition-metal dichalcogenide bilayer. We investigate naturally-grown MoS₂ homobilayers integrated in a dual-gate device structure allowing independent control of the electron density and out-of-plane electric field. When the bilayer is electron-doped under conditions where tunnelling between layers is negligible, we observe that two interlayer excitons - which normally should not interact - hybridize in a way distinct from both conventional level crossing and anti-crossing. We show that these observations can be explained by quasi-static random

coupling between the excitons, which increases with electron density and decreases with temperature. We argue that this phenomenon is indicative of a spatially fluctuating order parameter in the form of interlayer electron coherence - a theoretically predicted many-body state that has yet to be unambiguously established experimentally outside the quantum Hall regime.

15 min. break

Topical Talk

TT 12.4 Mon 16:45 HSZ/0003

Faithful modeling of quantum geometry and electronic correlations in van der Waals heterostructures — ●AMMON FISCHER — Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — Center for Computational Quantum Physics, Flatiron Institute, New York, NY 10010, USA

Moiré materials - twisted stacks of two-dimensional materials - bridge between two influential paradigms of condensed matter research: non-trivial quantum geometry and strong electron-electron interactions. In this talk, I will outline how the construction of faithful low-energy models and their successive treatment by state-of-the-art many-body techniques allows to resolve electronic order in moiré and non-moiré heterostructures from first principles. In twisted bilayers of WSe_2 , functional renormalization group techniques allow to unravel the angle evolution of antiferromagnetic order and superconductivity in the crossover regime from weak-to-moderate interactions. In rhombohedral multilayer graphenes, the low-energy theory is naturally described in terms of supercell Wannier functions that span the effective $U(4) \times U(4)$ subspace of the spin, valley and layer degrees of freedom. Electronic correlations give rise to various iso-spin ordered regimes, superconductivity and charge density wave order at low electronic densities bridging to the physics of their twisted counterparts.

Topical Talk

TT 12.5 Mon 17:15 HSZ/0003

Mesoscale Atomic Engineering in a Crystal Lattice — ●JULIAN KLEIN — Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, 02319 MA, USA

Controlling the arrangement of individual atoms with lasers, ion traps, and scanning probe techniques has enabled quantum simulation and computing platforms that transcend naturally occurring configurations of matter. Yet achieving comparable atomic control within a solid and at scale remains a foundational challenge, one that could revolutionize the design of artificial matter. Here, I demonstrate atomic engineering of artificial matter inside a scanning transmission electron microscope. By developing strategies to position and move the electron beam with few-picometer accuracy, deterministic control over atomic motion in both space and time is achieved. Full automation of the microscope enables the creation of three-dimensional defect superlattices in many-nanometer thick CrSBr with user-defined lattice spacing and symmetry, spanning tens of thousands of engineered sites over fields of view exceeding one hundred nanometers, all generated in under an hour. Our results establish atomic engineering in the electron microscope as a practical reality, opening unprecedented opportunities to create quantum defects and quantum phases with tunable charge and spin interactions, and to control host-lattice excitations by arranging atoms in patterns that are commensurate or incommensurate with the under-

lying crystal over mesoscopic, and potentially micro- or macroscopic, length scales.

TT 12.6 Mon 17:45 HSZ/0003

Interlayer electrostatics of CDWs in van der Waals materials and heterostructures — ACHYUT TIWARI, RENJITH MATHEW ROY, MAXIM WENZEL, CHRISTIAN PRANGE, BRUNO GOMPF, and ●MARTIN DRESSEL — 1. Physikalisches Institut, Universität Stuttgart

Layered transition metal dichalcogenides such as 1T-TaS_2 , 2H-TaS_2 and their natural heterostructure $4\text{H}_b\text{-TaS}_2$ provide a platform for studying interlayer coupling, orbital hybridization, and charge transfer that determine collective electronic phenomena, such as unconventional superconductivity and strong electronic correlations. Temperature-dependent infrared measurements of the in-plane and out-of-plane optical response of 1T-TaS_2 across its CDW-driven metal-insulator transition are combined with DFT calculations. We find that a quasi-1D instability that induces interlayer dimerization is responsible for the MI-transition. Furthermore, spectroscopic ellipsometry combined with an anisotropic Bruggeman effective medium approximation reveals that metallic domains evolve in a strongly anisotropic way and often extend along the out-of-plane direction as the transition proceeds.

When 1T-TaS_2 is stacked between 1H-TaS_2 , forming a natural heterostructure of $4\text{H}_b\text{-TaS}_2$, charge transfer occurs between the layers, that can be tuned with temperature, and which is related to the CDW in 1T-TaS_2 layer. We conclude that the phase transition in 1T-TaS_2 is inherently three dimensional, despite its layered structure, and that interlayer coupling is essential for its electronic structure and phase behavior both individually and in heterostructures.

TT 12.7 Mon 18:00 HSZ/0003

Enhancing Plasmonic Superconductivity in Layered Materials via Dynamical Coulomb Engineering — ●YANN IN 'T VELD¹, MIKHAIL I. KATSNELSON^{2,3}, ANDREW J. MILLIS^{4,5}, and MALTE RÖSNER^{2,6} — ¹I. Institute of Theoretical Physics, Universität Hamburg, Hamburg, Germany — ²Institute for Molecules and Materials, Radboud University, Nijmegen, the Netherlands — ³Constructor Knowledge Institute, Constructor University, Bremen, Germany — ⁴Center for Computational Quantum Physics, Flatiron Institute, New York, United States of America — ⁵Department of Physics, Columbia University, New York, United States of America — ⁶Faculty of Physics, Bielefeld University, Bielefeld, Germany

Conventional Coulomb engineering, through controlled manipulation of the environment, offers an effective route to tune the correlation properties of atomically thin van der Waals materials via static screening. Here we present tunable *dynamical* screening as a method for precisely tailoring bosonic modes to optimize many-body properties. We show that “bosonic engineering” of plasmon modes can be used to enhance plasmon-induced superconducting critical temperatures of layered superconductors in metallic environments by up to an order of magnitude, due to the formation of interlayer hybridized plasmon modes with enhanced superconducting pairing strength. We determine optimal properties of the screening environment to maximize critical temperatures. We show how bosonic engineering can aid the search for experimental verification of plasmon mediated superconductivity.

TT 13: Correlated Electrons: Method Development I

Time: Monday 15:00–18:30

Location: HSZ/0101

TT 13.1 Mon 15:00 HSZ/0101

Real-Frequency Dynamical Mean-Field Theory Without Broadening Inside the Self-Consistency Cycle — ●ALEKSANDRS ZACINSKIS¹, FRANK T. EBEL², SINA SHOKRI¹, LUKAS HELLMAN¹, FABIAN B. KUGLER³, KARSTEN HELD², and MAURITS W. HAVERKORT¹ — ¹Institute for Theoretical Physics, Heidelberg University — ²Institute of Solid State Physics, TU Wien — ³Institute for Theoretical Physics, University of Cologne

Dynamical mean-field theory has become one of the central frameworks for studying strongly correlated electron systems. Real-frequency implementations offer a major advantage by providing direct access to spectral properties without the need for analytic continuation. Most current real-frequency implementations work slightly off the real axis and evaluate $G(\omega+i\Gamma)$ instead of $G(\omega)$, which introduces an artificial broadening and can lead to systematic errors. We present a strictly real-frequency method with zero broadening inside the self-consistency cycle, addressing both the Dyson equation and the "improved estimator" self-energy [PRB 105, 245132]. Our formulation allows the self-energy to be extracted directly from the continued-fraction representation of the impurity Green's function, as obtained from Krylov bases in Lanczos methods, Wilson chains in NRG, or Kernel Polynomial methods. This method completely removes the need for artificial broadening and is applicable to all real-frequency impurity solvers. We compare the zero-broadening self-energy to its finite-broadening counterpart obtained with Exact Diagonalization solver, demonstrating the impact of broadening on accuracy and various quantities.

TT 13.2 Mon 15:15 HSZ/0101

Bath parameterization and multi-orbital physics in cluster DMFT — ●DIEGO FLOREZ-ABLAN¹, CARLOS MEJUTO-ZAERA², and MASSIMO CAPONE¹ — ¹International School for Advanced Studies (SISSA), Via Bonomea 265, 34136 Trieste, Italy — ²Univ Toulouse, CNRS, Laboratoire de Physique Théorique, Toulouse, France.

Quantum embedding methods such as cluster dynamical mean-field theory (CDMFT) require accurate and reliable impurity solvers and a controlled treatment of the bath in order to be predictive for correlated materials. Building on an efficient selected configuration interaction impurity solver, a systematic analysis of bath discretization effects is presented for one- and two-orbital Hubbard models within Hamiltonian-based CDMFT, focusing on the impact of bath size and parameterization on the zero-temperature Mott transition and on possible tendencies towards symmetry-broken solutions. The study shows that, while large baths yield relatively robust results for the single-band half-filled Hubbard model, small baths can display a non-negligible dependence on parameterization, and that in the two-orbital case some quantitative sensitivity to bath parametrization persists.

Building on this benchmark, the same CDMFT machinery is applied to investigate the Hund metal regime of the two-band Hubbard model, which is relevant for the description infinite-layer nickelates, with the goal of assessing the effects of short-range spatial fluctuations on Hund-driven correlations and how they affect the stability of the Hund metal phase in the presence of a crystal-field splitting.

TT 13.3 Mon 15:30 HSZ/0101

Uncovering correlated topological phases via a cluster-diagrammatic approach — ●FÉLIX FOSSATI and EVGENY STEPANOV — CPHT, CNRS, École polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France

Topological phases exhibit remarkable properties, including protected conducting edge states and robustness against local perturbations. Most studies of topological phenomena have focused on the non-interacting limit, where complete topological classification can be done using a single-particle band structure. While topological properties are known to be robust against weak interactions and disorder, a fundamental question remains: can electronic correlations themselves induce topological phases starting from a trivial non-interacting system? In this work, we address this question by extending the diagrammatic D-TRILEX method to a two-site cluster DMFT reference system. This approach therefore enables capturing short-range correlations non-perturbatively, while treating long-range correlations diagrammatically beyond the cluster DMFT level. We apply our method to the one-dimensional Hubbard model and demonstrate that, by tun-

ing the strength of the non-local Coulomb interaction, our approach captures the formation of both the bond-order-wave (BOW) and the charge-density-wave (CDW) states. We show that the BOW phase can be mapped onto the Su-Schrieffer-Heeger model, while the combined CDW+BOW state corresponds to a Rice-Mele model. The non-trivial topological character of these interaction-induced phases is confirmed by the presence of localised edge states.

TT 13.4 Mon 15:45 HSZ/0101

Cluster extension of the DMF²RG and application to the 2d Hubbard model — ●MARCEL KRÄMER^{1,2,3}, MICHAEL MEIXNER³, KILIAN FRABOULET³, DEMETRIO VILARDI³, PIETRO BONETTI⁴, NILS WENTZELL⁵, ALESSANDRO TOSCHI², and SABINE ANDERGASSEN^{1,2} — ¹Institute of Information Systems Engineering, TU Wien, Vienna, Austria — ²Institute for Solid State Physics, TU Wien, Vienna, Austria — ³Max Planck Institute for Solid State Research, Stuttgart, Germany — ⁴Department of Physics, Harvard University, Cambridge, USA — ⁵Center for Computational Quantum Physics, Flatiron Institute, New York, USA

The DMF²RG has been introduced to overcome the weak-coupling limitation of the fermionic functional renormalization group (fRG). This approach builds on the idea of exploiting the dynamical mean-field theory (DMFT) as starting point for the fRG flow, thus capturing local non-perturbative correlations via DMFT together with perturbative non-local correlations generated during the flow. We show how non-local non-perturbative correlations can be incorporated in the DMF²RG scheme by employing solutions of non-local extensions of DMFT as a starting point of the flow. The one-loop fRG flow equations are formulated within the single-boson exchange decomposition (SBE), which classifies diagrams contributing to the two-particle vertex in terms of interaction reducibility and has been proven to be a powerful bosonization scheme. We illustrate the ability of this approach to capture non-local non-perturbative correlations in the 2d Hubbard model and summarize latest methodological advances.

TT 13.5 Mon 16:00 HSZ/0101

Exact t_{2g}^n super-exchange Hamiltonians for complex orbital ordering — ●AMIT CHAUHAN, XUE-JING ZHANG, and EVA PAVARINI — Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany

We present a general approach for studying complex orbital ordering in t_{2g}^n correlated systems. The first step consists in building exact super-exchange (SE) Hamiltonians [1-4], projected onto irreducible tensor components. The technique we adopt is suitable both for analytic and efficient numerical calculations. Next, we obtain the total energy- which includes SE, spin-orbit and crystal-field contributions- via a variational Ansatz for the many-body wavefunction. The total energy is then optimized in the chosen parametric space to find the spin and orbitally ordered ground state. Finally, SE theory is combined with DFT+DMFT calculations via an order parameter decomposition scheme. Results for paradigmatic cases are presented.

[1] X.-J. Zhang, E. Koch, E. Pavarini, PRB **105**, 115104 (2022).

[2] X.-J. Zhang, E. Koch, E. Pavarini, PRB **102**, 035113 (2020).

[3] X.-J. Zhang, E. Koch, E. Pavarini, PRB **106**, 115110 (2022).

[4] A. Chauhan, X.-J. Zhang, E. Pavarini (in preparation).

TT 13.6 Mon 16:15 HSZ/0101

Dimer Hubbard operators and their applications — ●JIE XIONG and SILKE BIERMANN — CPHT, Ecole Polytechnique, Palaiseau, France

Hubbard operators, introduced in the 1960s as projectors between atomic many-body eigenstates [1], serve as quasiparticle operators that naturally represent the lower and upper Hubbard bands. They also provide one of the earliest systematic approaches for calculating Green's functions in the Hubbard model. Extending this approach, we construct quasiparticle operators for the dimer Hubbard model and propose a general framework for analyzing quasiparticle operators in interacting many-body systems with periodic boundary conditions. As an application, we derive the equations of motion for the dimer Hubbard operators and compute Green's functions for finite benchmark models. Our findings suggest broad prospects for extending the quasiparticle-operator construction to larger correlated systems and

exploring its potential applications in topological phases.

[1] J. Hubbard, Proc. R. Soc. Lond. A 276, 238 (1963).

15 min. break

TT 13.7 Mon 16:45 HSZ/0101

Non-perturbative effects of short-range spatial correlations at the two-particle level — ●MICHAEL MEIXNER¹, MATTHIAS REITNER², THOMAS SCHÄFER^{1,3}, and ALESSANDRO TOSCHI² — ¹Max-Planck-Institute for Solid-State Research, Stuttgart, Germany — ²TU Wien, Vienna, Austria — ³University of Trieste, Trieste, Italy

Non-local correlations have a strong impact on the electronic dynamics of the square lattice Hubbard model. Specifically, the Mott metal-insulator transition (MIT) occurs at lower interactions when including spatial correlations to the local model via cellular dynamical mean field theory (CDMFT). We present the Bethe-Salpeter equation (BSE) of the charge response and corresponding Ward identities applicable to the CDMFT. The scheme is employed to study the impact of real space bosonic correlations between the impurity sites onto the lattice thermodynamic derivatives such as the charge response. Firstly, we report the occurrence of the break down of self-consistent perturbation theory in the charge channel by observation of the divergence of the irreducible vertex. This is, we find, a precursor of the thermodynamic instability of CDMFT and the corresponding suppression of the charge response at the metal-insulator transition. Secondly, for both phenomena, we underline the essential role of next-neighbour spin correlations.

TT 13.8 Mon 17:00 HSZ/0101

Promising properties of Ghost Gutzwiller Ansatz: from Mott insulators to correlated antiferromagnets — ●ANTONIO MARIA TAGLIENTE¹, MICHELE FABRIZIO¹, and CARLOS MEJUTO-ZAERA² — ¹International School for Advanced Studies (SISSA) — ²Laboratoire de Physique Théorique, CNRS, Université de Toulouse, UPS

The ghost Gutzwiller wavefunction is a recently proposed variational Ansatz that generalizes the traditional Gutzwiller wavefunction. It consists of a Slater determinant defined in an enlarged Hilbert space that is variationally projected into the physical one. This wavefunction is therefore naturally capable of describing Hubbard bands and coexisting quasiparticle peaks.

Here, we present several results obtained through this wavefunction treated with the so-called Gutzwiller approximation.

We begin by showing that the wavefunction can describe genuine paramagnetic Mott insulators, whose finite spin susceptibility has remained elusive using other methods. A metal lead in contact with such a Mott insulator can directly reveal the spinon excitations responsible for the paramagnetic behavior, which emerge at the interface as a heavy-fermion band.

We finally demonstrate that the ghost Gutzwiller wavefunction can stabilize a correlated antiferromagnet with spin-unpolarized Hubbard bands but polarized spinons. This solution contains much more entanglement than the conventional dynamical mean-field one, and might be more representative of an actual correlated antiferromagnet in finite dimensions.

TT 13.9 Mon 17:15 HSZ/0101

Fluctuating field theory description of collective instabilities in the doped Hubbard model — ●ERIK LINNÉR^{1,2}, LAURA TORCHIA¹, SILKE BIERMANN^{2,3,4}, and MASSIMO CAPONE^{1,5} — ¹International School for Advanced Studies (SISSA), Trieste, Italy — ²CPHT, CNRS, École Polytechnique, Institut Polytechnique de Paris, Palaiseau, France — ³Collège de France, Paris, France — ⁴European Theoretical Spectroscopy Facility, Palaiseau, France — ⁵CNR-IOM, Istituto Officina dei Materiali, Consiglio Nazionale delle Ricerche, Trieste, Italy

Fluctuating field theory is a recently developed method for the description of competing collective fluctuations in correlated electron systems, able to account for spin, charge, and superconducting instabilities. On the basis of a variational principle, the method allows to explicitly account for the leading collective modes and their interplay, with access to electronic and spectroscopic properties. Extending its prior application to the Hubbard model at half-filling, we investigate its description of the doped Hubbard model, accounting for various spin instabilities. Interestingly, unlike for Néel ordering which dominates near half-filling, we show that the phase structure of the fluctuating fields for collective instabilities with arbitrary ordering vector \mathbf{Q} become important. Within the method, the incommensurate spin ordering driven by dop-

ing is associated with a phase structure expressing the modulation of the ordering relative the underlying lattice geometry. Thus, we observe the method, despite its weak-coupling rot, gives an efficient tool to investigate the phase diagram beyond mean-field theory.

TT 13.10 Mon 17:30 HSZ/0101

Competing instabilities for models with non-local and retarded interactions: a functional renormalization group perspective — ●KILIAN FRABOULET^{1,2,3}, AÍMAN AL-ERYANI⁴, MARCEL GIEVERS⁵, SARAH HEINZELMANN³, FRIEDRICH KRIEN⁵, and SABINE ANDERGASSEN^{2,5} — ¹Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany — ²Institute of Information Systems Engineering, TU Wien, 1040 Vienna, Austria — ³Institute for Theoretical Physics and Center for Quantum Science, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — ⁴Institute for Theoretical Physics III, Ruhr-Universität Bochum, 44801 Bochum, Germany — ⁵Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria

The functional renormalization group is an established approach to study competing orders in many-electron systems in an unbiased manner, notably with a bosonization technique called single-boson exchange formalism. The resulting fRG approach, referred to as single-boson exchange fRG, is used to analyze competing orders in the 2D extended Hubbard model, especially the growth of the charge-density wave instability when the nearest-neighbor Coulomb repulsion increases. Finally, I will show how one can, using the single-boson exchange fRG, efficiently design a temperature flow (where the temperature is used as flow parameter) for models involving retarded interactions with electron-phonon couplings, such as the Hubbard-Holstein model.

TT 13.11 Mon 17:45 HSZ/0101

Finite-difference parquet method and the strong-coupling pseudogap — JAE-MO LIHM^{1,2}, DOMINIK KIESE³, SEUNG-SUP B. LEE², and ●FABIAN B. KUGLER^{4,3} — ¹Université Catholique de Louvain, Louvain-la-Neuve, Belgium — ²Seoul National University, Seoul, Korea — ³Flatiron Institute, New York, USA — ⁴University of Cologne, Cologne, Germany

We present the finite-difference parquet method [1], a two-particle diagrammatic approach with nonperturbative input. It takes the fully irreducible two-particle vertex from a reference solution while requiring only its full vertex explicitly. Using dynamical mean-field theory (DMFT) as a reference, this yields a reformulation of the parquet dynamical vertex approximation circumventing ill-behaved two-particle irreducible vertices. We use this method to investigate the pseudogap phase of the underdoped Hubbard model. Our numerical results are consistent with diagrammatic Monte Carlo simulations and shed new light on the microscopic mechanism of the strong-coupling pseudogap: With dominant short-ranged antiferromagnetic spin fluctuations, we find an enhanced electron-paramagnon scattering amplitude crucial for the pseudogap opening. The form of this enhancement, reflected in the real part of the Hedin vertex, requires strong local correlations from DMFT as well as nonlocal correlations in multiple two-particle channels from solving the parquet equations.

[1] <https://arxiv.org/abs/2505.20116>

TT 13.12 Mon 18:00 HSZ/0101

Strong-coupling functional renormalization group: non-Fermi liquid physics in the infinite-U Hubbard model — JONAS ARNOLD, PETER KOPIETZ, and ●ANDREAS RÜCKRIEGEL — Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue Straße 1, 60438 Frankfurt, Germany

Exact functional renormalization group (FRG) flow equations for quantum systems can be derived directly within an operator formalism without using functional integrals. This simple insight allows us to apply unbiased FRG methods directly to strongly correlated electron systems with projected Hilbert spaces. Here, we use this approach to compute the electronic spectral function of the Hubbard model at infinite on-site repulsion where many-body states involving doubly occupied lattice sites are eliminated from the physical Hilbert space. For a square lattice with nearest-neighbor hopping we find that the finite-temperature electronic spectrum evolves from a Fermi liquid at low densities to an incoherent non-Fermi liquid at larger densities. Both at high and low densities, the volume of the Fermi surface is not constrained by Luttinger's theorem.

TT 13.13 Mon 18:15 HSZ/0101

Nagaoka kinetic ferromagnetism in the infinite-U Hubbard model — ●JONAS ARNOLD, PETER KOPIETZ, and ANDREAS RÜCKRIEGEL — Institut für Theoretische Physik, Universität Frankfurt, Max-von-Laue Straße 1, 60438 Frankfurt, Germany

We present a study of the infinite-U Hubbard model using an extension of the functional renormalization group (FRG) that works directly with non-canonical fermionic operators. Thus the projected Hilbert space is incorporated exactly, yielding an unbiased diagrammatic method

that works in the thermodynamic limit, suitable to capture the long range physics of the strongly correlated electrons. We discuss the magnetic phase diagram for the full range of hole doping. Upon increasing the density, we identify a paramagnetic ground-state, followed by an antiferromagnetic stripe order and finally Nagaoka's kinetic ferromagnetism at high densities. The dynamical susceptibilities reveal the evolution of a paramagnon band into a diffusive continuum with increasing electron density.

TT 14: Superconductivity: Properties and Electronic Structure

Time: Monday 15:00–18:15

Location: HSZ/0103

TT 14.1 Mon 15:00 HSZ/0103

Tuning the superconducting dome in granular aluminum thin films — ANIRUDDHA DESHPANDE, JAN PUSSKEILER, CHRISTIAN PRANGE, UWE ROGGE, MARTIN DRESSEL, and ●MARC SCHEFFLER — 1. Physikalisches Institut, Universität Stuttgart, Stuttgart, Germany

The peculiar superconducting properties of granular aluminum, which consists of nanometer-sized aluminum grains separated by aluminum oxide, are attractive for applications in quantum circuitry, and they are interesting from a fundamental materials physics view. The phase diagram of granular aluminum as a function of normal-state resistivity features a superconducting dome with a maximum critical temperature T_c well above the $T_c = 1.2$ K of pure aluminum. We show how the maximum of this superconducting dome grows if the substrate temperature during deposition is lowered from 300 K to cooling with liquid nitrogen (150 and 100 K) and liquid helium (25 K). The highest T_c that we observe is 3.27 K [1]. These results highlight that granular aluminum is a model system for complex phase diagrams of superconductors and demonstrate its potential in the context of high kinetic inductance applications, where materials properties can be carefully tuned by optimized thin-film growth [2]. This is augmented by our observation of comparably sharp superconducting transitions of high-resistivity samples grown at cryogenic temperatures and by a thickness dependence even for films substantially thicker than the grain size [1].

[1] A. Deshpande *et al.*, J. Appl. Phys. **137** (2025) 013902

[2] A. Deshpande *et al.*, Physica C **634** (2025) 1354709

TT 14.2 Mon 15:15 HSZ/0103

Two facets of kinetic inductance in Corbino reflectometry on disordered and granular superconductors — ●JAN PUSSKEILER¹, MARTIN DRESSEL¹, THOMAS VALENTIN², AMEYA NAMBIAN², SIMON GEISERT², IOAN POP^{1,2}, CHRISTOPH STRUNK³, DENNIS RIEGER⁴, and MARC SCHEFFLER¹ — ¹1. Physikalisches Institut, Universität Stuttgart — ²Physikalisches Institut und IQMT, KIT — ³Institut für Experimentelle und Angewandte Physik, Universität Regensburg — ⁴Qinu GmbH, Karlsruhe

Kinetic inductance L_{kin} manifests as a linear-in-frequency contribution to the reactance, which determines the low-temperature electrodynamic of superconducting microwave circuitry. We directly probe this inductive response from MHz- to GHz-frequencies, $\text{Im}(Z) = \omega \cdot L_{\text{kin}}$, by broadband microwave reflectometry on superconducting granular aluminum and titanium nitride in the Corbino geometry. Furthermore, we identify an unconventional collective mode with a phase velocity governed by L_{kin} . We observe an acoustic dispersion relation for up to 10 harmonics, which enables us to obtain the kinetic inductance independently for both phenomena observed in one spectrum.

We report low-temperature kinetic inductances ranging from 20 pH/□ to 2 nH/□ for granular aluminum and up to 6.2 nH/□ for titanium nitride thin films, with critical temperatures T_c ranging from 1 K to 3 K. We calculate the low-temperature superfluid stiffness J_0 and observe its suppression with increased normal-state resistivity ρ_n . For both materials in regimes with large ρ_n , we find that J_0 converges to T_c , consistent with a phase-driven superconducting transition.

TT 14.3 Mon 15:30 HSZ/0103

Strange metals studied by EELS and RIXS — ●JÖRG FINK — IFW-Dresden, Dresden, Germany

Strange metal behavior, which occurs above the dome of unconventional superconductivity is characterized by a linear temperature dependence of the resistivity. This signals a breakdown of the quasiparticle concept used in normal Fermi liquids. In the phenomenological marginal Fermi liquid (MFL) theory the behavior is related to a con-

tinuum of low-energy electronic excitations. Holographic theories have predicted that this continuum causes an overdamping of plasmon excitations. On the other hand, our EELS and RIXS experiments reveal well pronounced optical and acoustic plasmons in cuprates and ruthenates. The contradiction can be explained by an energy-dependent effective mass related to a strong coupling of the charge carriers to an oscillator at about 0.4 eV also detected in ARPES experiments. Moreover, this energy is used as a cutoff energy in the MFL theory. The oscillator energy is well below the plasmon energies which leads to resilient quasiparticles at high energy. Possibly, the oscillator is related to a coupling of the charge carriers to spin fluctuations.

TT 14.4 Mon 15:45 HSZ/0103

ARPES and RIXS combined in the recently designed "TOF-PAX-RIXS" spectrometer — ●CHAFIC FAWAZ¹, TOM LACMANN¹, OLENA TKACH², SERGI CHERNOV³, LUIS FILSINGER¹, YARYNA LYTUVYENKO², JAN SCHUNCK⁴, OLENA FEDCHENKO², SIEGMAR ROTH¹, HARSHIT AGARWAL², MARKUS SCHOLZ³, JAYJIT DEY³, KAI ROSSNAGEL⁵, MARTIN BEYE⁴, MORTIZ HOESCH³, GERD SCHÖNHENSE², HANS-JOACHIM ELMERS², and MATTHIEU LE TACON¹ — ¹Karlsruher Institut für Technologie (KIT), Germany — ²Johannes Gutenberg Universität Mainz, Germany — ³Deutsches Elektronen-Synchrotron DESY, Germany — ⁴Stockholm University, Sweden — ⁵Christian-Albrechts-Universität zu Kiel (CAU), Germany

The TOFPAXRIXS instrument, recently commissioned on the P04 beamline at DESY, offers a compact design that uniquely combines Angle-Resolved Photoemission Spectroscopy (ARPES) with a Time-of-Flight (ToF) detector and Resonant Inelastic X-ray Scattering (RIXS) using the Photoelectron spectrometry for Analysis of X-rays (PAX) approach [1]. This enables direct correlation between electronic properties measured by ARPES and collective excitations probed by RIXS, an essential step toward understanding electronic order in quantum materials, including unconventional superconductors, antiferromagnets, and van der Waals heterostructures.

In this talk, I will briefly introduce the ToF-PAX-RIXS concept and show first results combining ARPES and RIXS on the same sample.

[1] G. L. Dakovski *et al.*, J Synchrotron Rad. **24** (2017) 1180

TT 14.5 Mon 16:00 HSZ/0103

On-site two-hole Coulomb energy in CuO and La₂CuO₄ from coincidence electron spectroscopy — ●DANILO KÜHN¹, SWARNSHIKHA SINHA^{1,2}, FREDRIK O. L. JOHANSSON³, KATARZYNA SIEWIRSKA¹, ANTONELLO TEBANO⁴, NILS MÄRTENSSON³, ANDREAS LINDBLAD³, DANIELE DI CASTRO⁴, and ALEXANDER FÖHLISCH^{1,2} — ¹Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — ²Universität Potsdam, Potsdam, Germany — ³Uppsala University, Uppsala, Sweden — ⁴Università di Roma Tor Vergata, Roma, Italy

The high temperature superconductivity in layered cuprates is likely driven by strong electron correlations, though not fully understood. Here, Auger photoelectron coincidence spectroscopy (APECS) data of undoped La₂CuO₄ and CuO from the COESCA station at the BESSY II storage ring will be shown [1]. O 1s/ KVV and Cu 2p/ LVV coincidence measurements allow to disentangle the various structures in the Auger spectra and give detailed information of site specific multi-hole valence states. The Auger spectra are analysed with Cini-Sawatzky and atomic multiplet models, in order to extract electronic parameters such as on-site Coulomb energy in O 2p and Cu 3d orbitals. Dynamics of the core excited states and delocalization of the multi-hole states are investigated. Our unique setup with ARTOF 2 time-of-flight spectrometers in combination with the tailored photon-pulse structure of

a soft x-ray undulator beam line enables APECS with unprecedented information rate.

[1] D. Kühn et al., Nat. Commun. 16, 9748 (2025)

TT 14.6 Mon 16:15 HSZ/0103

Signatures of the Fermi surface reconstruction of a doped Mott insulator in a slab geometry — ●GREGORIO STAFFIERI and MICHELE FABRIZIO — International School for Advanced Studies (SISSA), Via Bonomea 265, I-34136 Trieste, Italy

In the underdoped regime of high- T_c superconductors, the Fermi surface consists of small pockets coexisting with a pseudogap at the antinodal points, while in the overdoped regime it becomes large and electron-like. Evidence for this doping-driven reconstruction has been found in the two-dimensional single-band Hubbard model using various numerical methods.

We study the reconstruction of the Fermi surface in a hole-doped Mott insulator with slab geometry using the Dynamical Cluster Approximation (DCA). We show that enhanced correlations at the surface lead to a strong layer dependence of the Fermi surface: hole-like pockets appear in the superficial layers and gradually evolve into a single electron-like surface in the innermost layers. We also investigate Friedel oscillations induced by the surface as a function of hole doping and identify clear signatures of the reconstruction in their periodicity. In addition, we introduce a computationally tractable quantity that diagnoses the same variation through a concurrent breakdown of Luttinger's theorem. Together, these observables provide reliable indicators of Fermi surface topology without requiring momentum-space periodization.

15 min. break

TT 14.7 Mon 16:45 HSZ/0103

How to activate and detect the Higgs mode in superconductors — ●DIRK MANSKE — Max Planck Institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart, Germany

Higgs Spectroscopy is a new and emergent field [1-3] that allows to classify and determine the superconducting order parameter by means of ultra-fast optical spectroscopy. There are two established ways to activate the Higgs mode in superconductors, namely a single-cycle *quench* or an adiabatic, multicycle *drive* pulse. In the talk I will review and report on the latest progress on Higgs spectroscopy, in particular on the role of the third-harmonic-generation (THG) [4-6,9] and the possible IR-activation of the Higgs mode by impurities or external dc current [7,8]. Finally, I discuss recent results on Non-Equilibrium Anti-Stokes Raman Scattering (NEARS) [10,11], where the Higgs mode, for the first time, has been observed directly.

- [1] L. Schwarz, D. Manske et al., Nat. Commun. 2020
- [2] L. Schwarz and D. Manske, Phys. Rev. B 2020
- [3] H. Chu, S. Kaiser, D. Manske et al., Nat. Commun. 2020
- [4] L. Schwarz, R. Haenel, and D. Manske, Phys. Rev. B 2021
- [5] H. Chu, S. Kaiser, D. Manske et al., Nature Commun. 2023
- [6] M.-J. Kim, S. Kaiser, D. Manske et al., Sci. Adv. 2024
- [7] M. Puviani, L. Schwarz, X.-X. Zhang, S. Kaiser, and D. Manske, Phys. Rev. B 2020
- [8] R. Haenel, P. Froese, D. Manske, and L. Schwarz, Phys. Rev. B 104, 2021
- [9] L. Schwarz, B. Fauseweh, and D. Manske, Phys. Rev. B 2020
- [10] T. Glier, D. Manske et al., Nature Comm. 2025
- [11] M. Puviani, R. Haenel, and D. Manske, Phys. Rev. 2023

TT 14.8 Mon 17:00 HSZ/0103

Probing Charge Density Wave in Superconductors via Phase-resolved Higgs Spectroscopy — ●LIWEN FENG¹, IGOR ILYAKOV², JAN-CHRISTOPH DEINERT², HAO CHU³, and STEFAN KAISER¹ — ¹TUD Dresden University of Technology, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf, Germany — ³Shanghai Jiao Tong University, China

Superconductivity (SC) and charge density wave (CDW) orders often coexist in high- T_c superconductors, and their interplay is essential for understanding these correlated systems. Using high-field terahertz radiation, we coherently drive collective modes and investigate third-harmonic generation (THG) in superconductors exhibiting both CDW amplitude fluctuations and Higgs oscillations. In 2H-NbSe₂ and hole-doped La_{2-x}Sr_xCuO₄, we identify a clear Fano interference between CDW fluctuations and Higgs oscillations [1, 2]. In contrast, electron-doped La_{2-x}Ce_xCuO₄ shows distinct coupling behavior, revealing not

only a weak Higgs-CDW interaction but also signatures of an intrinsic, field-depinned CDW [3]. These results establish THz phase-resolved Higgs spectroscopy as a powerful method for probing CDW dynamics and intertwined orders in superconductors.

- [1] H. Chu et al., Nat Commun. 14 (2023) 1343
- [2] L. Feng et al., Phys Rev B 108 (2023) L100504
- [3] L. Feng et al., arXiv:2504.11947 (2025)

TT 14.9 Mon 17:15 HSZ/0103

Probing the intermediate state of the type-I topological superconductor SnAs using Muon Spin Spectroscopy — ●SHASHANK SRIVASTAVA¹, OMKAR KULKARNI¹, ARUSHI ARUSHI¹, DEEPAK SINGH², ADRIAN D. HILLIER², and RAVI PRAKASH SINGH¹ — ¹Indian Institute of Science Education and Research, Bhopal 462066, India — ²ISIS Facility, STFC Rutherford Appleton Laboratory, Didcot OX11 0QX, United Kingdom

The possibility of topological superconductivity in a type-I superconductor embraces exotic physics. The topological semimetal SnAs shows superconductivity below 3.6 K, but there is ambiguity in the nature of superconductivity. Some reports claim type-I superconductivity in SnAs, but recent studies contradict it. We have resolved this enigma using a thorough microscopic analysis of the superconducting ground state.

In this work, we report the muon spin rotation/relaxation (μ SR) study of the possible topological superconductor SnAs. The zero-field (ZF) μ SR data reveal that this system is a time-reversal-invariant superconductor. The systematic transverse field (TF) μ SR measurements unveil the type-I superconductivity and the intermediate state using the superconducting phase diagram for SnAs. Moreover, ab initio calculations of band structure and phonons were performed, which correlate with the basic experimental characterization. Our study opens a platform for understanding the underlying physics behind the origin of topological superconductivity in type-I superconductors.

TT 14.10 Mon 17:30 HSZ/0103

Layer-selective Cooper pairing in an alternately stacked transition metal dichalcogenide — HAOJIE GUO¹, ●SANDRA SAJAN¹, IRIÁN SÁNCHEZ-RAMÍREZ¹, TARUSHI AGARWAL², ALEJANDRO BLANCO PECES¹, CHANDAN PATRA², MAIA G. VERGNIORY¹, RAFAEL M. FERNANDES³, RAVI PRAKASH SINGH², FERNANDO DE JUAN¹, MARIA N. GASTIASORO¹, and MIGUEL M. UGEDA¹ — ¹Donostia International Physics Center, Paseo Manuel de Lardizábal 4, 20018 San Sebastián, Spain — ²Department of Physics, Indian Institute of Science Education and Research Bhopal, 462066 Bhopal, India — ³Department of Physics, The Grainger College of Engineering, University of Illinois Urbana-Champaign, Urbana, Illinois 61801, USA

Multigap superconductivity occurs when different superconducting gaps form on separate Fermi surfaces. In the layered material 4Hb-TaS₂, made of alternating trigonal (H) and octahedral (T) polymorph layers, we demonstrate the presence of two weakly coupled and spatially separated superconducting condensates. Using quasiparticle tunneling and Andreev reflection spectroscopy on each polymorph layer, we identify two gaps that differ in magnitude and internal structure. Their responses to temperature and magnetic field also differ: each gap opens at a distinct temperature and shows opposite resilience to magnetic fields, enabling selective external tuning of each condensate. A theoretical model supported by ab-initio calculations reproduces these features and accounts for the unusually high critical field in the T-layer, highlighting TMD polymorphs as tunable multigap superconductors.

TT 14.11 Mon 17:45 HSZ/0103

Probing hidden vortices and geometrical effect via surface-projected quasiparticle states — ●RUIJUN XI and HAO ZHENG — Tsung-Dao Lee Institute, Shanghai Jiao Tong University, Shanghai, China

Vortices host quasiparticle excitations such as Caroli-de Gennes-Matignon (CdGM) or Majorana states. Understanding how these states are modulated by various geometrical structures is essential for both fundamental superconductivity research and quantum device design. Yet, this relationship remains challenging to elucidate. Here, using a scanning tunneling microscope equipped with a dilution refrigerator, we clearly resolve coherent quasiparticle states from lateral vortices buried beneath the surface of NbSe₂ under in-plane magnetic fields. Our combined spectroscopic visualization and model calculation uncover a depth-dependent quantum coupling behavior between vortices and the superconductor surface: shallow vortices (depth of ~ 1.5 coherence lengths) exhibit anomalous split quasiparticle states

accompanied by a pseudogap, while deeper vortices (> 4 coherence lengths) restore the conventional CdGM characteristics. Our findings establish a rescaling law of vortex bound states under geometrical effect and identify a critical length scale relevant for superconducting devices aimed to utilize intrinsic vortex quasiparticles.

TT 14.12 Mon 18:00 HSZ/0103

Crystal Structure Effects on Vortex Dynamics in Superconducting MgB_2 Films — ●CLEMENS SCHMID¹, CORENTIN PFAFF², THEO COURTOIS², ANTON POKUSINSKY³, ALEXANDER KASATKIN⁴, KARINE DUMESNIL², STEPHANE MANGIN², THOMAS HAUET², and OLEKSANDR DOBROVOLSKIY³ — ¹Faculty of Physics and Vienna Doctoral School in Physics, University of Vienna, Austria — ²Institute Jean Lamour, Université de Lorraine-CNRS, Vandoeuvre-lès-Nancy, France — ³Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany — ⁴G.V. Kurdyumov Institute for Metal Physics, NAS Ukraine, Kyiv, Ukraine

stitute for Metal Physics, NAS Ukraine, Kyiv, Ukraine

MgB_2 offers one of the highest critical temperatures among non-cuprate superconductors. However, its dynamic phase diagram at high vortex velocities remains unexplored, and the film structure and interface quality are expected to affect the current-driven resistive transition. Here, we investigate two different structures incorporating MgB_2 thin films sputtered on sapphire (Al_2O_3) substrates. The difference between the films is in the inclusion of an additional MgO layer between the substrate and MgB_2 , resulting in a single crystal structure, as opposed to an MgO -free textured one. We find that the activation energy for vortex motion is a factor of two higher for the single-crystal film. Current-voltage measurements reveal multiple jumps, suggesting that the transition to the normal state is driven by the formation of normal domains. Additionally, a lower instability current in the textured film suggests less efficient heat removal, which agrees with the results of an HRTEM inspection of the film-substrate interface.

TT 15: Topology: Majorana Physics

Time: Monday 15:00–18:30

Location: HSZ/0105

TT 15.1 Mon 15:00 HSZ/0105

Negative hybridization: a potential cure for braiding with imperfect Majorana modes — COLE PEETERS, THEMBA HODGE, and ●STEPHAN RACHEL — School of Physics, University of Melbourne, Australia

Majorana zero modes, the elementary building blocks for the quantum bits of topological quantum computers, are known to suffer from hybridization when they get too close to each other. In that case, their wavefunctions start to overlap and the energy of the Majorana zero modes is pushed to finite energies. This breaking of the ground-state degeneracy leads to an accumulation of error during a braid—the fundamental process which encodes topological quantum gates. Here we show that, in certain situations, the energy splitting of the Majorana wavefunctions can become *negative* which can be utilized to reduce the average hybridization energy of the total braid. We discuss two instructive examples where *negative hybridization* improves the braiding performance to the point where imperfect Majorana modes have their non-Abelian statistics restored, resulting in successfully operated quantum gates. The upshot is that negative hybridization as an intrinsic property of Majorana modes has the potential to bring a Majorana-based quantum computer closer to reality.

TT 15.2 Mon 15:15 HSZ/0105

Distinguishing Majorana bound states from accidental zero-energy modes with a microwave cavity — SARATH PREM¹, ●OLESLIA DMYTRUK², and MIRCEA TRIF¹ — ¹International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, PL-02668 Warsaw, Poland — ²CPHT, CNRS, Ecole polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France

Detecting Majorana bound states (MBSs) in hybrid nanowires is challenging as their transport measurement signatures can be mimicked by trivial zero-energy Andreev bound states (ABSs) or zero-energy quasi-Majorana bound states (QMBSs). We propose an alternative approach that relies on microwave absorption visibility that is extracted from parity-dependent cavity-nanowire susceptibility measurements. We study a one-dimensional Rashba spin-orbit nanowire with an s-wave superconductor-covered proximitized region and an uncovered quantum dot region subjected to a magnetic field with spatially varying capacitive coupling to a single-mode cavity. True MBSs yield a visibility extremum only when both Majorana modes at superconducting edges simultaneously couple to the cavity exhibiting their nonlocal characteristics. In contrast, the zero-energy ABSs or QMBSs show a visibility extremum even when the cavity couples only locally to part of the nanowire. Owing to the recent experiments on poor man's Majoranas, we show that the visibility retains the nonlocal detection features.

[1] S. Prem, O. Dmytruk, and M. Trif, arXiv:2509.13194

TT 15.3 Mon 15:30 HSZ/0105

Scaling up a quantum dot Kitaev chain — CHUN-XIAO LIU, SEBASTIAN MILES, ALBERTO BORDIN, SEBASTIAAN TEN HAAF, GREG MAZUR, MERT BOZKURT, and ●MICHAEL WIMMER — QuTech and Kavli Institute of Nanoscience, TU Delft, The Netherlands

Superconducting quantum dot devices can be used to implement a Kitaev chain, and tuned reliably into a topological phase. Recent experiments have successfully implemented two- and three-site Kitaev chains [1,2]. In this talk, I discuss challenges of scaling up to longer chains and how to overcome them. To this end, I will show that the relative phase between sites in a quantum dot Kitaev chain can be adjusted by electrostatic means only. Finally, I will compare our theory to recent experiments.

[1] T. Dvir *et al.*, Nature **614** (2023) 445

[2] S.L.D. ten Haaf *et al.*, Nature **641** (2025) 890

TT 15.4 Mon 15:45 HSZ/0105

Experiments on hybrid topological insulator superconductor nanostructures — ●JAKOB SCHLACK, ELLA NIKODEM, and YOICHI ANDO — Institute of Physics II, University of Cologne

Hybrid structures of topological insulators and conventional s-wave superconductors are predicted to generate topological superconductivity, which can host Majorana zero modes [1]. These quasiparticle excitations display non-Abelian exchange statistics and hold great potential for quantum computation [2]. Recently, we studied for the first time the phase-tunable density of states in topological insulator Josephson junctions via tunneling measurements [3]. The periodic gap closing and reopening can be interpreted as a signature of a topological phase transition. Furthermore, we established a new platform for experiments on topological superconductivity, the topological nano-SQUID [4]. By contacting top and bottom surface of the topological insulator simultaneously, we realize a scenario, where an in-plane magnetic field is sufficient to reliably reach the topological regime. In my talk, I will focus on the ongoing experimental efforts building on these achievements.

[1] L. Fu and C. L. Kane, Phys. Rev. Lett. **100** (2008) 096407

[2] C. Nayak *et al.*, Rev. Mod. Phys. **80** (2008) 1083

[3] J. Schlack *et al.*, arXiv:2406.08265v2

[4] E. Nikodem *et al.*, arXiv:2412.07993v3

TT 15.5 Mon 16:00 HSZ/0105

Characterization of side-contacted topological-insulator-nanowire junctions — ●ELLA NIKODEM, JAKOB SCHLACK, and YOICHI ANDO — II. Physikalisches Institut, Universität zu Köln

Superconducting hybrid devices based on topological insulator (TI) nanowires are a promising platform for realizing topological superconductivity and hosting Majorana zero modes (MZMs). We report our recent efforts to realize high-quality Josephson junctions based on etched BiSbTeSe_2 nanowires laterally sandwiched with superconducting Nb. This device architecture enables full surface proximitization and forms an intrinsic columnar nano-SQUID, in which the top and bottom surfaces act as parallel SNS junctions. Upon threading a magnetic flux, we observe two key phenomena: (1) robust SQUID-like oscillations of the critical current with the periodicity of the superconducting flux quantum, confirming surface-dominated supercurrent [1]; and (2) a large gate- and field-tunable Josephson diode effect [2]. Conceptually, this device geometry allows for individual tuning of the phase difference of the top and bottom junctions, enabling the cre-

ation of a discrete vortex at the end of the nanowire that hosts a MZM [3]. This is substantiated by theoretical considerations based on both a phenomenological approach and full 3D tight-binding simulations. Preliminary tunnel spectroscopy results further pave the way towards detecting Majorana bound states in this platform.

[1] E. Nikodem et al., <https://arxiv.org/abs/2412.07993>

[2] E. Nikodem et al., *Sci. Adv.* 11 (2025) eadw4898

[3] L. Fu and C. Kane, *Phys. Rev. Lett.* 100 (2008) 096407

TT 15.6 Mon 16:15 HSZ/0105

Towards microwave measurements of topological insulator nano-SQUID devices — ●JORGE ESTEBAN BOLIO, LUCAS MARTEN JANSSEN, ELLA NIKODEM, JAKOB SCHLUCK, CHRISTIAN DICKEL, and YOICHI ANDO — Physics Institute II, University of Cologne, Zùlpicher Str. 77, 50937 Köln, Germany

A topological insulator (TI) nanowire side contacted by superconducting leads gives rise to a TI nano-SQUID formed by the two parallel S-N-S Josephson junctions of the top and bottom surface. This platform is expected to exhibit a robust topological phase. While DC measurements in this platform have been performed [1,2], microwave measurements can also illuminate the junction quality and open a path for fast and robust detection of Majorana zero-modes (MZMs) [3]. We describe the integration of the TI nano-SQUID into a 3D transmon setup, and report our progress in the development of a dual nano-SQUID device where the overlap between two MZMs could be gate controlled.

[1] Nikodem et al. *arXiv:2412.07993* (2024)

[2] Nikodem et al. *Sci. Adv.* 11 (2025) eadw4898

[3] E. Ginossar & E. Grosfeld, *Nat. Commun.* 5 (2014) 4772

TT 15.7 Mon 16:30 HSZ/0105

Poor man's Majorana bound states in quantum dot based Kitaev chain coupled to a photonic cavity — ●FRANCESCO BUONEMANI¹, ALVARO GOMEZ-LEON², MARCO SCHIRO³, and OLESIA DMYTRUK¹ — ¹CPHT, CNRS, Ecole polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ²Institute of Fundamental Physics IFF-CSIC, Calle Serrano 113b, 28006 Madrid, Spain — ³JEIP, UAR 3573 CNRS, College de France, PSL Research University, 11, place Marcelin Berthelot, 75231 Paris Cedex 05, France

Majorana bound states (MBSSs) in topological superconductors, given their robustness against external perturbations, are the ideal building blocks for quantum computation. In light of this, poor man's Majorana bound states (PMMBSs), isolated zero-energy bound states, promise to engineer Majorana bound states in a highly tunable setup consisting of a chain of quantum dots that are connected via superconductors.

We analyze the interaction between the minimal microscopic dot chain with proximity-induced superconductivity for PMMBSs and a single mode photonic cavity. We showed how the coupling to the light in the microscopic model leads to a different phenomenology compared to the case where the coupling was introduced in the two-site Kitaev chain model. Thus, we demonstrated that even starting from the microscopic quantum dot model coupled to photons, it is possible to control the sweet spot condition, for the emergence of PMMBSs, through the cavity parameters.

15 min. break

TT 15.8 Mon 17:00 HSZ/0105

Proximity-induced superconducting states in high Chern number quantum anomalous Hall heterostructures — ALEJANDRO S. GÓMEZ^{1,2}, RAFAEL A. MOLINA³, PABLO BURSET^{1,2,4}, and ●YURIKO BABA^{2,3} — ¹Universidad Autónoma de Madrid, Madrid, Spain — ²IFIMAC-UAM, Madrid, Spain — ³Instituto de Estructura de la Materia IEM-CSIC, Madrid, Spain — ⁴Instituto Nicolás Cabrera-UAM, Madrid, Spain

Multilayer stackings of magnetically doped and undoped topological insulators can host multiple chiral channels forming a high Chern number quantum anomalous Hall (QAH) state [1]. This topological state does not require an external magnetic field. Therefore, a single channel QAH proximized by an s-wave superconductor has been proposed as a promising platform to achieve topological superconductivity and chiral Majorana modes [2,3]. In this work, we generalize these proposals to the case of heterostructures with multiple chiral states proximized by a superconductor. We theoretically study the topological phases of the bulk system and the appearance of zero-energy states due to the bulk-boundary correspondence in the band inversion regime. Finally,

we discuss the nature and topological protection of the zero-energy states against disorder and finite-size confinement effects.

[1] Y.F. Zhao et al. *Nature* 588 (2020) 419

[2] X.L. Qi, T.L. Hughes, S.C. Zhang *Phys. Rev. B* 82 (2010) 184516

[3] A. Udayet al., *Nat. Phys.* 20 (2024) 1589

TT 15.9 Mon 17:15 HSZ/0105

Braiding of Majorana wave packets at surfaces of noncentrosymmetric superconductors — ●GEORG HEEDT¹, CLARA JOHANNA LAPP^{1,2}, JULIA MONIKA LINK^{1,2}, and CARSTEN TIMM^{1,2} — ¹TU Dresden, 01062 Dresden, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, 01062 Dresden, Germany

Broken inversion symmetry in noncentrosymmetric superconductors causes singlet-triplet mixing of Cooper pairs. If the triplet pairing is sufficiently strong flat zero-energy Majorana surface bands are expected. We describe such a system in terms of a finite concentration of localized Majorana wave packets, which may be promising for quantum computation. Moving Majorana wave packets along closed paths leads to braiding of Majorana modes. We determine the non-Abelian phase associated with this braiding. To that end, we construct an exact time-dependent many-particle Hamiltonian that describes the desired motion and show that the phase can efficiently be evaluated in an effective single-particle picture.

TT 15.10 Mon 17:30 HSZ/0105

Phase dynamics and parity effects in quantum spin Hall Josephson junctions with coupled edges — ●CAJETAN HEINZ¹, PATRIK RECHER^{1,2}, and FERNANDO DOMINGUEZ³ — ¹Technische Universität Braunschweig, D-38106 Braunschweig, Germany — ²Laboratory for Emerging Nanometrology, D-38106 Braunschweig, Germany — ³Universität Würzburg, D-97074 Würzburg, Germany

We investigate a novel backscattering mechanism in quantum spin Hall N'SNSN' Josephson junctions in the presence of time-reversal symmetry. This extended geometry allows for the interplay between two types of Andreev bound states (ABS): the usual phase-dependent ABS localized at the edges of the central SNS junction and phase-independent ABS localized at the edges of the N'S regions. Crucially, the latter arise at discrete energies E_n and mediate a backscattering process between opposite edges of the SNS junction, opening gaps whenever both types of ABS are at resonance. In this scenario, the 4π -periodic ABS decouples from the rest of the 2π -periodic spectrum. Using the parameters extracted from the microscopic calculation, we construct an RSJ model that incorporates the 4π -periodic ABS, the remaining 2π -periodic part of the spectrum and the quasi-particle continuum. Here, two types of parity changes can arise: transitions between the 4π - and 2π -periodic ABS, and parity leakage from the 2π -periodic ABS into the continuum. Our results show different dynamical regimes depending on the rate of non-adiabatic transitions, ranging from Shapiro steps at integer multiples of $\hbar\omega_{ac}/2e$, over non-integer steps, to steps only at even integers, with ω_{ac} as the external ac driving frequency.

TT 15.11 Mon 17:45 HSZ/0105

Manipulating the topological spin of Majoranas — ●STIJN DE WIT¹, EMRE DUMAN², MERT BOZKURT³, ALEXANDER BRINKMAN¹, and INANC ADAGIDELI^{1,2} — ¹MESA+ Institute for Nanotechnology, University of Twente, The Netherlands — ²Faculty of Engineering and Natural Sciences, Sabanci University, Istanbul, Turkey — ³QuTech, Delft University of Technology, Delft 2600 GA, The Netherlands

The non-Abelian exchange statistics of Majorana zero modes make them interesting for both technological applications and fundamental research. Unlike their non-Abelian counterpart, the Abelian contribution is often neglected in the discussion of Majorana braiding. We consider Majoranas bound to vortices in topological superconductors. Here, the Abelian exchange phase originates from the Majoranas so-called topological spin, and it is interpreted as an Aharonov-Casher phase arising from a vortex encircling an $e/4$ charge. In this work, we show how this fractional charge and hence the topological spin of Majoranas can be manipulated, introducing an additional knob for braiding operations in topological quantum computing. Finally, we propose a vortex interference experiment to probe the presence of this fractional $e/4$ charge.

TT 15.12 Mon 18:00 HSZ/0105

Ab Initio Exploration of Material Platforms for Majorana Zero Modes in Magnetic Chains on Superconductors — ●ANDRÁS LÁSZLÓFFY^{1,2}, BENDEGÚZ NYÁRI³, LEVENTE RÓZSA², LÁSZLÓ SZUNYOGH³, and BALÁZS ÚJFALUSSY² — ¹Pázmány Péter

Catholic University, Budapest, Hungary — ²HUN-REN Wigner Research Centre for Physics, Budapest, Hungary — ³Budapest University of Technology and Economics, Budapest, Hungary

In magnetic chains on superconductors, Shiba bands are formed within the superconducting gap. Spin-orbit coupling or a spin-spiral configuration can lead to the hybridization of Shiba bands which can open a topologically non-trivial gap around the Fermi energy. To have a quantitative and realistic description of these systems, we solve the Kohn-Sham-Dirac Bogoliubov-de Gennes equations within the Korringa-Kohn-Rostoker multiple scattering theory. Elementary superconducting surfaces rarely support the appearance of a topological superconducting state, since either the superconducting gap or the spin-orbit coupling strength is small.[1] By adding a non-magnetic overlayer between the superconductor and the chain, we explore the topological properties of a large variety of systems in terms of varying the type of magnetic atoms in the chain and its crystallographic direction. We demonstrate that the formation of a spin spiral state has a larger impact on the robustness of the topologically non-trivial band structure than the enhanced spin-orbit coupling.

[1] Nyári et. al., PRB 112 (2025) 115414

TT 15.13 Mon 18:15 HSZ/0105

Ab initio band structure of magnetic chains on superconductors — ●BENDEGÚZ NYÁRI^{1,3}, ANDRÁS LÁSZLÓFFY², BALÁZS ÚJFALUSSY², LÁSZLÓ SZUNYOGH³, and LEVENTE RÓZSA^{2,3} — ¹HUN-REN-BME Condensed Matter Research Group — ²HUN-REN Wigner Research Centre for Physics — ³Budapest University of Technology and Economics

The detection of band topology and the reliability of Majorana Zero Mode (MZM) observations based only on real space quantities is a long standing problem. Due to the bulk edge correspondence the appearance of MZMs in a finite chain is related to the properties of the band structure, or more precisely the topological invariant, however these quantities can not be measured directly. In this work I present an ab initio approach which provides direct access to the band structure of magnetic chains on superconductors. The method relies on a 1D embedding scheme and includes the effect of the infinite host to the chain. The method was applied to Mn chains on Nb(110) and Ta(110) where the topological properties and symmetry aspects of the band structure were studied together showing the coexistence of trivial and non-trivial bands in the band structure [1].

[1] B. Nyári et al., Phys. Rev. B 112 (2025) 115414

TT 16: 2D Materials beyond graphene: Growth, structure and substrate interaction (joint session O/HL/TT)

Time: Monday 15:00–17:45

Location: HSZ/0204

TT 16.1 Mon 15:00 HSZ/0204

A virtual super-moiré: MnBr₂ on graphene on Ir(110) — AFFAN SAFEER¹, OKTAY GÜLERYÜZ¹, NICOLAE ATODIRESEI², ●THOMAS MICHELY¹, and JEISON FISCHER¹ — ¹II. Physikalisches Institut, Universität zu Köln, Germany — ²Peter Grünberg Institut, Forschungszentrum Jülich, Germany

MnBr₂ on Gr/Ir(110) constitutes a three lattice system, giving rise to a super-moiré pattern – a moiré of moirés. The super-moiré of Gr/MnBr₂/Ir(110) is unique, as it involves a virtual moiré of MnBr₂ with the Ir(110) surface lattice – two lattices not in contact with each other. Using a careful Fourier analysis of the bias dependence of scanning tunneling microscope topographs, scanning tunneling spectroscopy, the known properties of Gr/Ir(110), and the results of ab initio calculations, the origin of the virtual moiré is uncovered and related to the inhomogeneous binding of Gr to Ir(110). Comparative experiments with MnBr₂ on Gr/Ir(111) show similar growth and structure as on Gr/Ir(110), but highlight the unique properties of the MnBr₂/Gr/Ir(110) super-moiré.

TT 16.2 Mon 15:15 HSZ/0204

Magnetism of monolayers of FeCl₂ and FeBr₂ Epitaxially Grown on Bi₂Se₃ — ●SEBASTIEN E. HADJADJ¹, WEIBIN LI², PIERLUIGI GARGIANI², CINTHIA PIAMONTEZE³, OLEKSANDR STETSOVYCH⁴, PAVEL JELÍNEK⁴, MAXIM ILYN¹, and CELIA ROGERO¹ — ¹Materials Physics Center(MPC - CFM), Donostia, Spain — ²ALBA Synchrotron Light Source, Barcelona, Spain — ³Paul Scherrer Institut, Villigen, Switzerland — ⁴FZU - Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic

Two-dimensional transition metal dihalides exhibit novel magnetic and electronic properties. By combining 2D magnetic semiconductors with topological insulators (TIs) novel quantum and spintronic phenomena can be investigated. Here, we report the uniform and epitaxial growth of monolayer FeCl₂ and FeBr₂ on the TI Bi₂Se₃. Structural and electronic characterization via LEED, STM, and STS measurements revealed a material-specific moiré pattern resulting from lattice mismatch, as well as a position-independent bandgap of 4 eV. Synchrotron-radiation-based XAS and XMCD measurements confirm robust ferromagnetic order down to the monolayer limit, with an intrinsic reduction of the effective spin magnetic moment by 40-50%. These magnetic vdW heterostructures provide a platform for investigating magnetic proximity effects and moiré-induced modifications of topological surface states. [1] S. E. Hadjadj et al., Chem. Mater., 35, 23, 9847*9856,(2023) [2] S. Kerschbaumer et al., Adv. Science, e08262,(2025)

TT 16.3 Mon 15:30 HSZ/0204

Rise and fall of 1T-TaS₂: Epitaxial growth of monolayer TaS₂ on Au(111) — ●LARS BUSS¹, CATHY SULAIMAN¹, RAQUEL SÁNCHEZ-BARQUILLA¹, IULIA COJOCARIU², MARCIN SZPYTMA³, TEVFIK ONUR MENTEŞ², ANDREA LOCATELLI², JENS FALTA⁴, and JAN INGO FLEGE¹ — ¹Applied Physics and Semiconductor Spectroscopy, BTU Cottbus-Senftenberg, Cottbus, Germany — ²Elettra-Sincrotrone Trieste S.C.p.A, Basovizza, Trieste, Italy — ³Faculty of Physics and Applied Computer Science, AGH University of Krakow, Poland — ⁴Institute of Solid State Physics, University of Bremen, Germany

Two-dimensional TaS₂ has attracted extensive research interest due to its ability to exhibit electron correlation effects, including charge density waves (CDWs). In particular, 1T-TaS₂ is of interest as it shows a CDW at room temperature. However, when grown on metal substrates, only 2H-TaS₂ has been reported. To elucidate the reasons for the apparent lack of 1T-TaS₂ growth in the literature, we have investigated the growth of TaS₂ on Au(111) employing *in situ* low-energy electron microscopy (LEEM) and micro-diffraction (μ LEED) as well as X-ray photoemission electron microscopy (XPEEM) [1]. We show that at elevated temperatures TaS₂ nucleates and grows in the metastable 1T-TaS₂ phase, which transforms into the stable 2H-TaS₂ phase via a temperature-activated process and then continues to grow at a considerably lower rate. Furthermore, we observe CDW-like ordering in 1T-TaS₂/Au(111), though it is suppressed in 2H-TaS₂/Au(111).

[1] L. Buß et al. Phys. Rev. Materials 9, 074006 (2025).

TT 16.4 Mon 15:45 HSZ/0204

Band-Like Transport and its Modulation by Nitrogen Doping in Transferable Semi-Conducting 2D-imine Covalent Organic Framework — ●VIJAY BAHADUR YADAV, DIKSHA SRIVASTAVA, SATYA VEER SINGH, ITU PANDEY, MANABENDRA CHANDRA, and THIRUVANCHERIL G. GOPAKUMAR — Indian Institute of Technology Kanpur

Two-dimensional (2D) imine-based covalent organic frameworks (COFs) are promising semiconductors for thin-film electronics and sensing due to their extended in-plane π -conjugation, enabling efficient charge transport. Here, we investigate two highly crystalline 2D imine COF films synthesised via quasi-equilibrium Schiff base condensation. By selecting molecular precursors, we tuned the nitrogen content, producing COFs with ten and six nitrogen atoms per unit cell (10N-COF and 6N-COF). The films are chemically stable in organic solvents and water, mechanically robust, and transferable onto various substrates, allowing fabrication over areas of tens of square centimeters. Electrical measurements using silver electrode arrays show linear current*voltage behaviour, indicating band-like transport, with consistent responses across multiple regions. The conductivity of 10N-COF is ~36 times higher than that of 6N-COF. Density functional theory

calculations reveal similar band gaps but enhanced band dispersion near the Fermi level in 10N-COF, improving charge carrier mobility. Nitrogen incorporation thus effectively tunes charge transport in 2D COFs.

TT 16.5 Mon 16:00 HSZ/0204

Co₂S₂: a new 2D material and its phase transitions — ●ABDALLAH KARAKA, MAX WOLFERTZ, AFFAN SAFEER, GUANGYAO MIAO, WOUTER JOLIE, THOMAS MICHELY, and JEISON FISCHER — II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Cologne, Germany

Using molecular beam epitaxy under ultra high vacuum conditions, 2D materials can be synthesized under conditions far from equilibrium for which no bulk parent compound exists.

Co₂S₂-2D is such an example. Using scanning tunneling microscopy and low energy electron diffraction we characterize this new single-layer 2D material crystallizing in the CuI structure (space group: P3m1 trigonal), when grown on graphene on Ir(111) using molecular beam epitaxy. We found it can be synthesized phase pure upon low temperature growth and moderate annealing with a lattice constant of 3.66 ± 0.05 Å and a height of 6.2 Å. Beyond the single-layer limit it transforms into a new hexagonal crystal structure with a distinctly different lattice parameter of 3.52 ± 0.05 Å and a height of 11.7 Å. This transition typically occurs between 650 and 750 K, although the exact temperature depends on the annealing conditions. The phase transition is accompanied by the emergence of a 2x2 superstructure in the high temperature phase.

TT 16.6 Mon 16:15 HSZ/0204

Tailored growth of 2D alloy transition metal dichalcogenides with tunable optical and electrical properties using liquid precursors — ●MD TARIK HOSSAIN¹, AXEL PRINTSCHLER¹, NHAT LAM DUONG¹, JULIAN PICKER¹, RAHUL SHARMA¹, CHRISTOF NEUMANN¹, MONA SEDIGHI², JOHANNES BISKUPEK², MUHAMMAD SUFYAN RAMZAN¹, CATERINA COCCHI¹, UTE KAISER², and ANDREY TURCHANIN¹ — ¹Friedrich Schiller University Jena, Jena, Germany — ²University of Ulm, Ulm, Germany

Doping or alloying of two-dimensional (2D) transition metal dichalcogenides (TMDs) provides a promising route to tune the optical, magnetic, and electronic properties. Here, we present a liquid-precursor-based chemical vapor deposition (CVD) for the controlled growth of large-area monolayer (V_xW_zMo_{1-x-y})S₂ alloys with tunable optical and electrical properties. Comprehensive characterization using atomic force microscopy, transmission electron microscopy, Raman spectroscopy, photoluminescence (PL) spectroscopy, and ab initio calculations confirms the structural and optical quality. Notably, PL shows a noticeable defect exciton peak at room temperature in the V-doped monolayer. Furthermore, by adjusting the composition, we modulate the carrier type of these monolayers from n-type to p-type or even make the monolayers metallic for high vanadium concentrations, which is deduced from electrical transport measurements and density functional theory calculations. This work demonstrates high potential of liquid-precursor CVD as a platform for the tailored growth of complex 2D TMD alloys for next-generation optoelectronic devices.

TT 16.7 Mon 16:30 HSZ/0204

CVD growth and characterization of WSe₂ monolayers on Au(111) and their conversion to Janus SeWS — ●JULIAN PICKER¹, JONAS BRANDHOFF², MAXIMILIAN SCHAAL², FELIX OTTO², CHRISTOF NEUMANN¹, TORSTEN FRITZ², and ANDREY TURCHANIN¹ — ¹Institute of Physical Chemistry, Friedrich Schiller University Jena, Germany — ²Institute of Solid State Physics, Friedrich Schiller University Jena, Germany

Transition metal dichalcogenides (TMDs) exhibit distinctive optical and electronic properties in the two-dimensional monolayer limit. Recently, Janus TMDs have attracted significant attention because their asymmetric chalcogen composition breaks the out-of-plane symmetry and enables properties not attainable in conventional TMDs. In this work, we initially investigate the structural and electronic characteristics of WSe₂ monolayers grown on Au(111) via ambient-pressure chemical vapor deposition (CVD). Surface-sensitive techniques - including scanning tunneling microscopy (STM), low-energy electron diffraction (LEED), X-ray photoelectron spectroscopy (XPS), and angle-resolved photoelectron spectroscopy (ARPES) - were employed to characterize the properties of these monolayers. Subsequently, the WSe₂ monolayers were transformed into Janus SeWS monolayers through selective chalcogen replacement at the WSe₂/Au interface. A comparative anal-

ysis reveals the structural and electronic differences between the two systems.

TT 16.8 Mon 16:45 HSZ/0204

Controlling polymorphism in the growth of 2D manganese sulfide on graphene via substrate interaction — ●MAX WOLFERTZ, ABDALLAH KARAKA, NICOLAS GEORGOPOULOS, OKTAY GÜLERİYÜZ, AFFAN SAFEER, THOMAS MICHELY, and JEISON FISCHER — II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Cologne, Germany

We investigate the epitaxial growth of single-layer manganese sulfide on graphene/Ir substrates grown via molecular beam epitaxy. Morphology, crystal structure and electronic properties are examined using scanning tunneling microscopy and - spectroscopy and low energy electron diffraction. While bulk MnS exists in the three polymorphs, α -(rock-salt structure), β -(zincblende structure), and γ -MnS (wurtzite structure), its structure in a single-layer is unknown, as fabrication using exfoliation methods cannot be applied. We find that when grown by molecular beam epitaxy on Gr/Ir substrates manganese sulfide grows in two competing phases: manganese sulfide in trigonal CuI-structure (space group P-3m1) and MnS in thin platelets of a cubic rock-salt structure (space group Fm-3m). Their in-plane lattice parameters are 4.16 Å, and 3.63 Å respectively. We show that the substrate exerts a strong influence on the phase selected. While the growth on Gr/Ir(111) results in a large share of cubic MnS, the Gr/Ir(110) substrate favors the formation of single layer trigonal manganese sulfide. Also, the use of seeding methods for avoiding loss of Mn into the bulk Ir crystals is discussed.

TT 16.9 Mon 17:00 HSZ/0204

Low Temperature MOCVD Growth of two-dimensional InSe and InSe/WS₂ Heterostructures — ●ROBIN GUENKEL, NILS LANGLOTZ, MATVEI KISLITSYN, JUERGEN BELZ, and KERSTIN VOLZ — mar.quest|Marburg Center for Quantum Materials and Sustainable Technologies, Philipps University Marburg, Germany

Two-dimensional van der Waals heterostructures offer powerful opportunities for engineered optoelectronic functionality, particularly when type-II band alignment enables efficient charge separation and interlayer transitions. InSe and WS₂ are especially promising in this regard because their band structures allow for the formation of a type-II interface at the Γ point, which avoids momentum mismatch. This is an essential requirement for robust radiative processes in 2D stacks. This talk presents a low-temperature metal-organic chemical vapor deposition (MOCVD) approach for synthesizing high-quality InSe and vertically integrated InSe/WS₂ heterostructures. Using DTBSe and TMIn at 350 °C, we synthesize homogeneous, single-phase InSe films on 2-inch sapphire substrates and extend the process to directly grow on monolayer WS₂. Atomic force microscopy, Raman spectroscopy, and energy-dispersive X-ray spectroscopy provide insight into the morphology, crystallinity, and composition of the films, offering a detailed understanding of the growth behavior and the influence of the substrate surface chemistry.

TT 16.10 Mon 17:15 HSZ/0204

Synthesis of Vertically Stacked 2D-hBN/Borophene Heterostructures on Ir(111) via Intrinsic Segregation — ●MARKO KRIEGEL, KARIM OMAMBAC, SMRUTI MOHANTY, BIRK FANKE, FRANK-J. MEYER ZU HERINGDORF, and MICHAEL HORN-VON HOEGEN — University Duisburg-Essen and Center for Nanointegration Duisburg-Essen (CENIDE), Lotharstr. 1, 47057 Duisburg, Germany

Research efforts on 2D materials increasingly target complex architectures built from high-quality heterostructures. A key challenge remains the reliable and scalable in-situ fabrication of such systems. In this work, we use high-resolution spot-profile analysis LEED (SPA-LEED) and -microscopy (LEEM) to investigate a synthesis route for an hBN/borophene heterostructure on Ir(111) based on *intrinsic segregation*. At elevated temperatures, boron dissolves into the Ir subsurface region during exposure to the borazine precursor B₃N₃H₆ in a CVD process [1], thereby creating a boron reservoir. Increasing the precursor pressure drives the chemical balance toward formation of a complete hBN layer across the Ir surface [2]. Upon cooldown, the decreasing boron solubility induces segregation, resulting in the growth of a continuous borophene layer beneath the hBN overlayer. This one-step CVD approach establishes a promising, scalable pathway for the controlled synthesis of high-quality 2D heterostructures. [1] K. Omambac et al., ACS Nano **15** (2021) 7421 [2] K. Omambac et al., ACS Nano **17** (2023) 17946

TT 16.11 Mon 17:30 HSZ/0204

MBE growth and characterization of high-quality mono-layer MoS₂ on stepped Au surface — ●SAYAN DEBNATH, RAM PRAKASH PANDEYA, KONSTANTIN SHCHUKIN, PATRIK STAUDENMAYER, and ALEXANDER GRÜNEIS — Optoelektronische Materialien Institut für Festkörperelektronik, TU Wien, 1040 Wien, Austria

In the present work, we investigate the growth of sub-monolayer MoS₂ on Au(788) and Au(111), using molecular beam epitaxy. Sample growth quality is characterized using low-energy electron diffraction, X-ray photoemission spectroscopy, and scanning electron microscopy. Furthermore, a comparative study of the electronic properties was performed by studying the band structure using angle-resolved photoe-

mission spectroscopy (ARPES), and the vibrational properties were measured by angle-resolved polarized Raman (ARPR) spectroscopy.

Our study reveals superior crystalline quality, with fewer S deficiencies, and better azimuthal order of MoS₂ grown on the stepped Au(788) substrate compared to the Au(111). In the case of ARPES, we observed more resolved band dispersion on MoS₂/Au (788), confirmed by probing the spin-orbit splitting at the Brillouin zone boundary (K point). On the other hand, ARPR of the first Raman mode E_{2g} on MoS₂/Au (788) deviates from the symmetry of freestanding MoS₂, suggesting the effect of the stepped surface on the vibrational properties. We discuss the role of increased catalytic activity at step edges in promoting the growth of high-quality TMDCs, such as MoS₂ and WS₂, on stepped surfaces.

TT 17: Quantum Manybody Systems (joint session QI/TT)

Time: Monday 15:00–18:30

Location: BEY/0245

Invited Talk

TT 17.1 Mon 15:00 BEY/0245

Reducing Noise, Complexity, and Optimization Barriers in Quantum Simulations of Strongly Correlated Systems — ●WERNER DOBRAUTZ — Center for Advanced Systems Understanding (CASUS), Görlitz, Germany — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany — Center for Scalable Data Analytics and Artificial Intelligence (ScaDS.AI) Dresden/Leipzig, Dresden, Germany — Technical University Dresden, Dresden, Germany

Near-term quantum hardware poses severe constraints for quantum chemistry and quantum many-body simulations due to noise, limited coherence, and challenging optimization landscapes. We present a unifying set of algorithmic strategies to address these bottlenecks, combining transcorrelated Hamiltonians, spin-adapted representations, and advanced variational optimization techniques. By embedding electronic correlations directly into the Hamiltonian, transcorrelated methods yield compact, noise-resilient quantum circuits and improved convergence for both molecular systems and lattice models. Spin-adapted formulations further reduce Hilbert space complexity and enable efficient simulations of correlated spin systems. To enhance robustness and trainability, we introduce multireference error mitigation strategies and qBang, a momentum-aware variational optimization scheme that effectively navigates flat and ill-conditioned energy landscapes. Together, these approaches establish a scalable and hardware-aware framework for accurate quantum simulations of strongly correlated systems on current and near-term quantum devices.

TT 17.2 Mon 15:30 BEY/0245

Hybrid superconducting devices — ●ANAMARIA GHIHOR¹, YEJIN LEE¹, HAOLIN JIN¹, MARKUS KÖNIG¹, ANDREAS LEITHE-JASPER¹, ROEMER HINLOPEN^{1,2}, CARSTEN PUTZKE², PHILIP MOLL², URI VOOL¹, and ETERI SVANIDZE¹ — ¹MPI CPfS - Nothnitzer Str. 40, Dresden, Germany — ²MPI MPSD - Luruper Chaussee 149, Hamburg, Germany

Superconducting resonators are highly tunable, low-loss coherent macroscopic devices, making them ideal for quantum technology and sensing applications. Recently, these resonators have been paired with van der Waals (vdW) materials to explore their microwave losses, dielectric properties and kinetic inductance. However, creating a hybrid device that only integrates a superconducting resonator with a vdW flake limits the range of materials that can be used. To overcome this limitation, we fabricate a lamella using a focused ion beam (FIB), effectively replicating the flake. This approach offers the added benefit of precise dimensional control, something that is difficult to achieve with exfoliated flakes. The lamella can then be attached in situ to the resonator using a micro-manipulator. In this talk we will show preliminary hybrid devices with lamella developed from conventional and unconventional superconductors. This approach greatly expands the range of materials that can be explored and enables detailed studies of their superfluid density.

TT 17.3 Mon 15:45 BEY/0245

Hybrid Monte Carlo enhanced by exact diagonalization: simulating interacting Hubbard systems — ●MARTINA GISTI¹, FINN TEMMEN², THOMAS LUU¹, DAVID LUITZ², and JOHANN OSTMEYER³ — ¹Institute of Physics, University of Bonn, Nufallee 12, 53115 Bonn — ²Forschungszentrum Jülich GmbH Wilhelm-Johnen-Straße 52428

Jülich — ³Helmholtz Institute for Radiation and Nuclear Physics, University of Bonn

We present a hybrid simulation framework that integrates the hybrid Monte Carlo method with exact diagonalization techniques to study Hubbard chains coupled through many-body interactions. Within a path integral formulation, thermal expectation values are expressed and evaluated exactly along the chains. We study the impact of the hybrid method on persistent challenges in the application of stochastic simulations, such as the sign problem and ergodicity violations. The approach mitigates the sign problem that hampers conventional simulations, providing a feasible path for studying strongly correlated quantum systems beyond one dimension.

TT 17.4 Mon 16:00 BEY/0245

Topological properties of coupled superconducting chains in the presence of interactions — ●FREDERICK DEL POZO — aboratoire Kastler Brossel, Sorbonne Université, CNRS, ENS-PSL Research University, Collège de France; 4 Place Jussieu, 75005 Paris, France

We investigate the topological and critical properties of coupled and interacting superconducting wires.

As a prototype of superconductors with topological order, the Kitaev chain model is a perfect testing ground for novel theoretical and numerical tools, including the density-matrix-renormalization-group (DMRG) algorithm and bi-partite entanglement entropy.

In the following talk we report on the results of several recent works, which have lead to a deeper understanding of the topological and critical properties of coupled and interacting Kitaev chains, also in the presence of real-space disorder. We reveal that the usual topological invariant, defined in the absence of interactions, remains a sensible marker for the topology when two wires are brought into close proximity of each other where interaction effects and inter-wire hopping processes become relevant. We also reveal the appearance of a many-body entangled ground state, and interaction reinforced critical region in the wires' phase diagram.

Our results highlight the rich physics present in quasi one-dimensional quantum systems, and motivates the further research into properties relevant for applications in superconducting qubits and topological quantum computation protocols.

TT 17.5 Mon 16:15 BEY/0245

Quantum Assisted Ghost Gutzwiller Ansatz — ●PV SRILUCKSHMY, FRANCOIS JAMET, and FEDOR SIMKOVIC — IQM Quantum Computers, Georg-Brauchle-Ring 23-25, 80992 Munich, Germany

The ghost Gutzwiller ansatz (gGut) technique was shown to achieve accuracy comparable to dynamical mean-field theory at a much lower computational cost. However, gGut is limited by the bottleneck of computing the density matrix. We develop a hybrid quantum-classical gGut technique that computes ground state properties of embedding Hamiltonians on a quantum computer using the quantum-selected configuration interaction (QSCI) algorithm. We find that the ground states of interest become sufficiently sparse as the number of ghost orbitals increases. We investigate QSCI's performance using local unitary cluster Jastrow (LUCJ) ansatz with circuit cutting on IQM's quantum hardware for up to 24 qubits. Our converged gGut calculations correctly capture the metal-to-insulator phase transition in the Fermi-Hubbard model. This was achieved using quantum samples to

build a basis with as little as 1% of the total CI states.

30min. break

TT 17.6 Mon 17:00 BEY/0245

Measurement-Based Quantum Computation in Symmetry-Enriched Topological Phases — ●PAUL HERRINGER^{1,2,3}, VIR B. BULCHANDANI^{4,5}, YOUNES JAVANMARD¹, DAVID T. STEPHEN^{6,7}, and ROBERT RAUSSENDORF^{1,3} — ¹Leibniz Universität Hannover, Hannover, Germany — ²University of British Columbia, Vancouver, Canada — ³Stewart Blusson Quantum Matter Institute, Vancouver, Canada — ⁴Rice University, Houston, USA — ⁵National University of Singapore, Singapore — ⁶University of Colorado Boulder, Boulder, USA — ⁷California Institute of Technology, Pasadena, USA

We present the first examples of topological phases of matter with uniform power for measurement-based quantum computation. This is possible thanks to a new framework for analyzing the computational properties of phases of matter that is more general than previous constructions, which were limited to short-range entangled phases in one dimension. We show that ground states of the toric code in an anisotropic magnetic field yield a natural, albeit non-computationally-universal, application of our framework. We then present a new model with topological order whose ground states are universal resources for MBQC. Both topological models are enriched by subsystem symmetries, and these symmetries protect their computational power. Our framework greatly expands the range of physical models that can be analyzed from the computational perspective.

TT 17.7 Mon 17:15 BEY/0245

Many-body localization in the Sherrington-Kirkpatrick model — ●GERGO DÉNES¹, BALÁZS HETÉNYI¹, MÁRTON KORMOS¹, ANGELO VALLI¹, PASCU MOCA^{1,2}, and GERGELY ZARÁND¹ — ¹Department of Theoretical Physics, Institute of Physics, Budapest University of Technology and Economics, Muegyetem rkp. 3., H-1111 Budapest, Hungary — ²Department of Physics, University of Oradea, Str. Universitatii nr. 1 Oradea, 410087, Romania

The Sherrington-Kirkpatrick (SK) model has been extensively studied for more than 50 years [1]. In the context of optimization problems, it represents one of the most difficult paradigmatic optimization problems, the MAXCUT problem. Its quantum extension, the transverse field SK model (TFSK model) is therefore a paradigmatic model for the Quantum Adiabatic Optimization Approach (QAOA).

We performed extensive finite-size numerical simulations of the TFSK model at different transverse field strengths to extract various many-body localization (MBL) indicators, such as inverse participation ratio, Shannon entropy, and level spacing ratio. Our numerical and analytical analysis suggest the presence of an MBL transition as a function of the transverse field at certain energy densities, different from the spin-glass transition, and in contrast to the findings of Ref. [2]. In the MBL phase, states do not seem to be exponentially localized, rather, our data suggest the presence of power-law MBL.

[1] M. Mezard, G. Parisi, M. A. Virasoro Spin Glass Theory and Beyond, ISBN: 978-9971-5-0116-7 (1986).

[2] S. Mukherjee, S. Nag, A. Garg, Phys. Rev. B 97, 144202 (2018).

TT 17.8 Mon 17:30 BEY/0245

Typical entanglement entropy of anyon chains — YALE YAU^{1,2}, ●ALEXANDER HAHN^{1,3,2}, and LUCAS HACKL^{4,5} — ¹Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, D-85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstraße 4, D-80799 Munich, Germany — ³Technical University of Munich, TUM School of Natural Sciences, Physics Department, D-85748 Garching, Germany — ⁴School of Mathematics and Statistics, The University of Melbourne, Parkville, VIC 3010, Australia — ⁵School of Physics, The University of Melbourne, Parkville, VIC 3010, Australia

Random-state entanglement serves as a key probe of quantum chaos, thermalization, and information scrambling, but its behavior in topologically ordered systems remains unclear. Here we study the statistical properties of bipartite entanglement in one-dimensional anyon chains, where the Hilbert space is constrained by the fusion rules. In such systems, the conventional trace must be replaced by the quantum trace, requiring a consistent redefinition of density matrices and entanglement measures that incorporates topological data. We compute the average bipartite entanglement entropy and its variance for both open and periodic boundary conditions. The resulting average anyonic en-

tanglement entropy reproduces the Page curve exactly, revealing that topological constraints modify the normalization but not the universal form of typical entanglement. Despite topological charge conservation, the average entanglement shows no symmetry-related correction of the kind that appears in systems with Lie group symmetries.

TT 17.9 Mon 17:45 BEY/0245

Thermal Entanglement and Out-of-Equilibrium Thermodynamics in 1D Bosonic Systems — ●JULIA MATHE, NICKY KAI HONG LI, PHARNAM BAKHSHINEZHAD, and GIUSEPPE VITAGLIANO — TU Wien, Atominstitut, Stadionallee 2, 1020 Vienna, Austria

We investigate entanglement in- and out-of equilibrium in harmonic chains, with direct relevance to low-energy descriptions of paradigmatic models, like 1D Bose-Einstein condensates. Working in a regime where all states are Gaussian, we employ the logarithmic negativity and the covariance matrix criterion (CMC) as known entanglement quantifiers. For thermal states, we extensively characterize entanglement and its scaling behaviour, including in the massless (critical) limit. We extract the optimal entanglement witness coming from the CMC and uncover a simple mode-resolved structure underlying the entanglement-to-separability transition. At finite temperature, the optimal witnesses are diagonal in the normal-mode basis, allowing to characterize entanglement from a few normal mode uncertainties, which are physically related to static susceptibilities. We then investigate out-of-equilibrium dynamics arising from a time-dependent coupling and analyze entanglement growth, suppression, and transport. Based on this, we construct a full Gaussian framework for studying entanglement in thermodynamic cycles. Our results give a unified and physically intuitive picture of how entanglement emerges and evolves in 1D Gaussian many-body systems and show that thermal separability and entanglement are mainly governed by the low-energy (infrared) sector that also underlies the continuum field-theory description.

TT 17.10 Mon 18:00 BEY/0245

Symmetry-preserving warm starts for variational ground state preparation — ●IVANA MIHÁLIKOVÁ — Matej Bel University, Národná ulica 12, Banská Bystrica, 97401, Slovakia — Institute of Physics, Slovak Academy of Sciences, Bratislava 84511, Slovakia

Enforcing physical symmetries can dramatically simplify ground-state preparation in the variational quantum eigensolver (VQE). This work considers a 12-spin all-to-all neutrino-inspired model and a 4×3 Heisenberg lattice. In both systems, simple product states are projected onto symmetry subspaces with fixed total spin J and J_z (and, for the Heisenberg lattice, translation and mirror symmetries), then refined using swap-based entangling layers that generate only symmetry-compatible correlations. The resulting warm starts lie well within previously established worst-case upper bounds on the energy error normalized by system size and interaction-graph degree, showing that symmetry-aware initialization can substantially outperform generic guarantees. For the Heisenberg lattice, the symmetry-preserving construction reduces the relevant search space from 4096 basis states to just 9 symmetry-compatible states and increases the effective spectral gap from about 7 to about 28 energy units. Within a VQE setting this yields a smoother optimization landscape and faster convergence with shallow circuits. In practice, the neutrino-inspired model reaches $\sim 98.8\%$ fidelity within the $J = 0$ subspace, and the Heisenberg lattice exceeds 98.0% fidelity once translation and mirror symmetries are enforced.

TT 17.11 Mon 18:15 BEY/0245

An emerging generator of rotations for a 1- or many-particle Hofstadter problem on a lattice pierced by magnetic field — ●ARABI SESHAPPAN^{1,2}, TANGI MORVAN², ALBERTO NARDIN², and LEONARDO MAZZA² — ¹Department of Physics, University of California, Merced, CA 95343, USA — ²Université Paris-Saclay, CNRS, LPTMS, 91405, Orsay, France

Topological quantum computation is an exciting direction for development of fault-tolerant qubits—a quintessential example being manipulation of excitations in fractional quantum Hall (FQH) systems. As recent cold-atom and photonic experiments have realized few-particle FQH states in small lattices, and theoretical results have shown spectra of specific lattice sizes to exhibit exactly flat-bands in momentum space, we have theoretically studied similar FQH lattices for 1- and many-particle bosonic cases. Our construction is that of a two-dimensional (2D) square lattice, with nearest-neighbor hopping, pierced by a perpendicular, uniform magnetic field. We vary the magnetic field such that, for lattice edge length L , the flux per plaquette

ranges between $\alpha = 1/L$ and $\alpha = 1/4$, and analyze the resultant spectra. We have found that, for low energy levels, measurements of density are an excellent proxy for defining a gauge-invariant generator

of rotations (GIGR) and can make order in the spectra. This removes any need for assumption of circular droplet invariance, and provides a useful characterization technique for cold-atom experiments.

TT 18: Focus Session: Relaxation Timescales in Open Quantum Systems (joint session TT/DY)

In the quantum year 2025 many applications of quantum systems are revisited for their actual physical implementability. Realizing that no quantum system is truly isolated from its environment highlights the need for a thorough understanding of the coupling between an open system and its environment. While many standard treatments lead to Lindblad equations, the underlying approximations are not always applicable and require detailed case-by-case studies. This theoretical focus session provides a platform discussing modern developments in the field in the regime of strongly interacting or driven open systems and their impact on relaxation timescales. We aim to enhance attention and trigger also experimental activity in the field of system-environment interactions and the induced relaxation timescales.

Coordinators: Gernot Schaller (Helmholtz-Zentrum Dresden-Rossendorf), Nikodem Szpak (Universität Duisburg-Essen)

Time: Monday 15:00–18:00

Location: CHE/0089

Topical Talk TT 18.1 Mon 15:00 CHE/0089

Markovian and non-Markovian approaches to quantum relaxation — •HEINZ-PETER BREUER — Institute of Physics, University of Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

Relaxation and decoherence processes in open quantum systems are often approximated by means of a Markovian evolution in which the open system irretrievably loses information to its surroundings, expressing the memoryless nature of the dynamics. However, strongly coupled open systems often exhibit a pronounced non-Markovian behavior distinguished by a flow of information from the environment back to the open system. This information backflow implies the presence of memory effects and represents the key feature of non-Markovian quantum dynamics. In the talk we will discuss fundamental physical concepts used to characterize and quantify non-Markovian relaxation dynamics in open systems, and present some applications to irreversibility and entropy production in nonequilibrium quantum thermodynamics.

Topical Talk TT 18.2 Mon 15:30 CHE/0089

Asymptotic relaxation in quantum Markovian dynamics — •SUSANA HUELGA — Institute of Theoretical Physics, Ulm University, Germany

We investigate the long-time dynamics of generic time-dependent GKLS master equations and provide sufficient conditions such that the dynamics is asymptotically independent of the initial state. These conditions represent a natural extension of the Spohn-Friggerio theorem to the case of a time-dependent generator. To illustrate our results, we analyze a specific master equation for driven systems and connect our conditions to the microscopic Hamiltonian of system and environment. The case of a 3-level system is also treated in detail. A brief mention of the non-Markovian case is included, with specific focus on time-local master equations which are asymptotically in Lindblad form. These findings pave the way for the development of a more general theory of relaxation beyond the Markovian case.

Topical Talk TT 18.3 Mon 16:00 CHE/0089

Floquet engineering of open quantum Systems — •ANDRÉ ECKARDT — Institut für Physik und Astronomie, TU Berlin, Berlin

In recent years, we have seen tremendous progress in the control of quantum systems by means of time-periodic driving. This includes the realization of effective time-independent Hamiltonians with interesting properties, such as artificial magnetic fields coupling to the motion of charge neutral particles in quantum simulators (e.g. of ultracold atoms in optical lattice or photons in superconducting circuits). Also phenomena without equilibrium counterpart, like chiral edge modes connecting Bloch bands with zero Chern number, have been investigated. Another paradigm for the control of quantum systems is reservoir engineering. Here a system is coupled to a controlled environment that is designed to either cool the system or to stabilize a non-equilibrium steady state of interest. I will report on recent theoretical work, where we combine both approaches in open Floquet systems. One motivation is to use dissipation in order to counteract unwanted heating, as it

necessarily occurs in Floquet engineered systems, e.g. for the preparation of Floquet engineered topological states of matter. The other motivation is the stabilization of interesting non-equilibrium steady states beyond the strict constraints of thermal equilibrium. Here I will discuss driving-induced non-equilibrium Bose condensation in high-temperature environments. Finally, I will also briefly address challenges arising when simulating open many-body quantum systems out of equilibrium and ideas how to tackle them.

15 min. break

Topical Talk TT 18.4 Mon 16:45 CHE/0089

Nonequilibrium thermodynamics of time-dependent quantum transport — •JANINE SPLETTSTOESSER — Chalmers University of Technology, Gothenburg, Sweden

Quantum transport induced by time-dependent driving fields is not only of interest when considering the conductor's charge response. On the contrary, in recent years there has been strong interest in the thermodynamics and energetic properties of quantum conductors. By applying time-dependent driving fields to a conductor cyclic quantum heat engines can be implemented and quantum properties can be used to rapidly load and discharge so-called quantum batteries.

In this presentation, I will first show how different time-scales in the response of a quantum dot impact the (energy) decay of a quantum dot brought out of equilibrium. This is visible both in the relative entropy, where Coulomb interaction results in an anomalous decay referred to as Mpemba effect [1], as well as in the geometric properties of a slowly driven cyclic engine [2]. I will then show how the precision of time-dependently driven engines is bounded by the produced or dissipated power [3].

[1] J. Graf, J. Splettstoesser, J. Monsel, J. Phys.: Condens. Matter 37, 195302 (2025)

[2] J. Monsel, J. Schulenburg, Th. Baquet, J. Splettstoesser, Phys. Rev. B 106, 035405 (2022)

[3] L. Tesser, J. Balduque, J. Splettstoesser, arXiv:2509.07583 (2025)

Topical Talk TT 18.5 Mon 17:15 CHE/0089

Connecting time-nonlocal and time-local quantum master equations — •MAARTEN WEGEWIJS — Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — Institute for Theory of Statistical Physics, RWTH Aachen, 52056 Aachen, Germany

A perhaps puzzling feature of open-system dynamics is that it admits both a retarded description via a *time-nonlocal* memory-kernel \mathcal{K} and an *equivalent* time-convolutionless description by a *time-local* generator \mathcal{G} . This leads to a split in approaches to the problem of time scales in open quantum systems.

In this talk I discuss an elegant fixed-point relation $\mathcal{G} = \hat{\mathcal{K}}(\mathcal{G})$ that connects these two approaches directly, without first solving the respective quantum master equations for the dynamics ultimately of interest. As applications, I connect the distinct results (!) obtained when expanding in the same perturbation parameter and relate distinct time-

scales (!) obtained by approximations approaching the same, exact stationary state. The fixed-point relation is also explicitly related to quantum Markovianity as defined by completely-positive divisibility of the dynamics (Huelga, Rivas, Plenio): What generates the retardation of the memory kernel turns out to be precisely what defines the Markovian divisibility of the dynamics. Exact solutions of simple models of electron transport (resonant level) and atomic-decay (dissipative Jaynes-Cummings) illustrate these findings.

- [1] SciPost Phys. 7, 012 (2019)
- [2] Phys. Rev. X 11, 021041 (2021)
- [3] Phys. Rev. B 104, 155407 (2021)
- [4] SciPost Phys. 12, 121 (2022)
- [5] J. Chem. Phys. 161 (2024)

TT 18.6 Mon 17:45 CHE/0089

Coupling-energy driven pumping through quantum dots: The role of coherences — ●LUKAS LITZBA¹, GERNOT SCHALLER²,

JÜRGEN KÖNIG¹, and NIKODEM SZPAK¹ — ¹Universität Duisburg-Essen, Duisburg, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

We study the impact of off-resonant tunneling and coherences on the electron transport through quantum dots. We focus on two electron pump setups where first-order tunneling processes are suppressed and the pumping mechanism is exclusively driven by modulations of the coupling energy. For calculations we use an exact solution for a non-Coulomb interacting situation. The first setup is driven by a coupling and decoupling procedure of the quantum dot and the environment and the second setup by measurement-induced effects resembling the anti-Zeno effect. We show that both electron pumps are based on decoherence operations and modulations of the coupling energy and there is quantitative and qualitative agreement between them. Furthermore, we show that non-Markovian effects can increase the performance of the devices and are signatures for the importance of coherences in electron transport.

TT 19: Focus Session: New Routes to Localization and Quantum Non-Ergodicity II (joint session TT/DY)

Time: Monday 15:00–17:30

Location: CHE/0091

TT 19.1 Mon 15:00 CHE/0091

Localized obstructed pairs with zero superfluid stiffness from doping an antiferromagnetic insulator — ●TAMAGHNA HAZRA¹, NISHCHAL VERMA², and JÖRG SCHMALIAN¹ — ¹Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, Karlsruhe, Germany — ²Department of Physics, Columbia University

Doping a Mott antiferromagnet is widely expected to yield mobile Cooper pairs whose kinetic energy sets the superfluid stiffness. We show instead that, when doped charges propagate on the line graph of a lattice with strong antiferromagnetic exchange, they bind into *obstructed* Cooper pairs, which are compact localized bosons that possess *zero* superfluid stiffness at leading order in the strong-coupling expansion. The pair-hopping Hamiltonian generates an exactly flat bosonic band whose compact localized states dominate the low-energy Hilbert space, yielding a ground-state manifold with extensive degeneracy and a phase stiffness that vanishes anomalously as the *third* inverse power of the pairing strength in the strong-coupling limit. At quarter filling, the frustrated dynamics maps onto a quantum dimer model at the Rokhsar-Kivelson point, realizing a d-wave resonating-valence-bond spin liquid with topological ground-state degeneracy and deconfined holon excitations. Our results establish a mechanism for interaction-driven localization without disorder, in which strong magnetically-mediated pairing produces Cooper pairs whose kinetic energy collapses to zero, revealing a distinct failure mode of unconventional superconductivity in strongly-correlated materials.

TT 19.2 Mon 15:15 CHE/0091

Disorder-free localization from mass-imbalanced fractionalization — ●SHI FENG, JOHANNES KNOLLE, and MICHAEL KNAP — Technical University of Munich, Garching, Germany

We report disorder-free localization of Majorana fermions over intermediate timescales in an emergent gapless non-integrable Z_2 quantum liquid. A large density of heavy visons induced by an external magnetic field provides coherent disorder that localizes the light fermions while preserving translation symmetry. Compelling evidence of the localization within intermediate time scale is provided by the time evolution of the local energy density, which shows negligible spreading after a local quench on its ground state; and a vanishing energy current response despite the gapless energy spectrum. These results demonstrate that the disorder-free localization can also occur near equilibrium at low energy, and offer an explanation to the thermal paradox in recent experiments where a linear specific heat coexists with vanishing thermal transport in frustrated Mott insulators with disorder-free gapless quantum magnets.

TT 19.3 Mon 15:30 CHE/0091

Fock space fragmentation in quenches of disordered interacting fermions — ●ISHITA MODAK¹, RAJESH NARAYANAN², FERDINAND EVERS³, and SOUMYA BERA¹ — ¹Department of Physics, Indian Institute of Technology Bombay, Mumbai, India. — ²Department of Physics, Indian Institute of Technology Madras, Chennai, India —

³Institute of Theoretical Physics and Halle-Berlin-Regensburg Cluster of Excellence CCE, University of Regensburg, Regensburg, Germany

Hilbert space fragmentation primarily originates from specific kinematic constraints or emergent conservation laws in many-body systems with translation invariance. It leads to non-ergodic dynamics and breakdown of the eigenstate thermalization hypothesis. We demonstrate that also in disordered systems (e.g. random-field XXZ model), fragmentation appears as a natural concept offering fresh perspectives on many-body delocalization (MBdL). We split the Fock-space into potential-energy shells, which contain the accessible phase space for the relaxation of a quenched initial state. In this construction, dynamical observables reflect properties of the shell geometry, e.g., the drastic sample-to-sample fluctuations observed in the weak disorder regime, $W < W_c$, represent fluctuations of the shell-mass. Upon crossing over to strong disorder, $W > W_c$, the potential-energy shell decays into fragments; we argue that, unlike percolation, fragmentation is a strong-coupling scenario with turn-around flow: $W_c(L)$ diverges with increasing system size. We conjecture that the slowing down of the relaxation dynamics reported in traditional MBdL studies is a manifestation of Fock-space fragmentation introduced here.

TT 19.4 Mon 15:45 CHE/0091

Non-ergodic one-magnon magnetization dynamics of the Kagome lattice antiferromagnet — HENRIK SCHLÜTER, ●JANNIS ECKSELER, and JÜRGEN SCHNACK — Bielefeld University

The present view of modern physics on non-equilibrium dynamics is that generic systems equilibrate or thermalize under rather general conditions, even closed systems under unitary time evolution. The investigation of exceptions thus not only appears attractive, in view of quantum computing where thermalization is a threat it also seems to be necessary. Here, we present aspects of the one-magnon dynamics on the Kagome lattice antiferromagnet as an example of a non-equilibrating dynamics due to flat bands. Similar to the one-dimensional delta chain localized eigenstates also called localized magnons lead to disorder-free localization and prevent the system from thermalization [1].

[1] H. Schlüter, J. Schnack and J. Ecksele, Zeitschrift für Naturforschung A (2025) doi:10.1515/zna-2025-0249

TT 19.5 Mon 16:00 CHE/0091

Cooling dynamics of a disorder-free localized Kitaev model — ●ARKADEEP MITRA, FRANCESCO PIAZZA, and MARKUS HEYL — Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

The Kitaev spin-1/2 model on a 2D honeycomb lattice has a Z_2 gauge symmetry that translates to an effective picture of free Majorana fermions on a background static charge field. This yields a ground state that realizes a quantum spin liquid (QSL) with fractional excitations. At high temperatures, however, it has recently been observed to enter a disorder-free localized phase, so that any experimental cooling of a Kitaev material has to cross this localized and associated phase

transition. Motivated from this, we study theoretically the cooling dynamics upon coupling the Kitaev model to phonons with a symmetry breaking interaction. We envisage that signatures obtained from this dynamics could act as probes for QSL.

15 min. break

TT 19.6 Mon 16:30 CHE/0091

Scrambling signature of scars — •THOMAS MICHEL¹, MATHIAS STEINHUBER², JUAN DIEGO URBINA², and PETER SCHLAGHECK¹ — ¹Université de Liège, Liège, Belgique — ²Universität Regensburg, Regensburg, Germany

We study signatures of scrambling, such as out-of-time-ordered correlators, that are associated with weakly unstable periodic orbits in a mixed or chaotic classical phase space, fulfilling Heller's criterion [1] for the existence of scars. As verified within generic dynamical systems like the kicked rotor and the driven pendulum, evaluating scrambling observables for coherent states centred in phase space about such periodic orbits gives rise to characteristic scar features both in the short and long time regimes, the latter amounting to a significant amendment of the characteristic growth exponent with respect to the generic semiclassical prediction [2,3]. Extensions to many-body scars in Bose-Hubbard rings [4] are discussed.

[1] E. J. Heller, Phys. Rev. Lett. 53, 1515 (1984).

[2] J. Rammensee, J.-D. Urbina, and K. Richter, Phys. Rev. Lett. 121, 124101 (2018).

[3] T. R. Michel, J. Diego Urbina, and P. Schlagheck, J. Phys. A: Math. Theor. 58, 275303 (2025).

[4] Q. Hummel, K. Richter, and P. Schlagheck, Phys. Rev. Lett. 130, 250402 (2023).

TT 19.7 Mon 16:45 CHE/0091

Many-Body Cages - Flat bands on the state graph — •TOM BEN-AMI^{1,2}, MARKUS HEYL¹, and RODERICH MOESSNER² — ¹University of Augsburg, D-86135 Augsburg, Germany — ²Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, Dresden 01187, Germany

We identify the many-body counterpart of flat bands, which we term many-body caging, as a general mechanism for non-equilibrium phenomena such as a novel type of glassy eigenspectrum order and many-body Rabi oscillations in the time domain. We focus on constrained systems of great current interest in the context of Rydberg atoms and synthetic or emergent gauge theories. We find that their state graphs host motifs which produce flat bands in the many-body spectrum at a particular set of universal energies. Basis states in Fock space exhibit Edwards-Anderson type order in the absence of quenched disorder, with an intricate, possibly fractal, distribution over Fock space. This is reflected in a distinctive structure of a non-vanishing post-quench

long-time Loschmidt echo, an experimentally accessible quantity. In general, phenomena familiar from single-particle flat bands manifest themselves in characteristic many-body incarnations, such as a reentrant 'Anderson' delocalisation, offering a rich ensemble of experimental signatures in the abovementioned quantum simulators. The variety of single-particle flat band types suggests an analogous typology—and concomitant phenomenological richness to be explored—of their many-body counterparts.

TT 19.8 Mon 17:00 CHE/0091

Dynamics in the presence of local symmetry-breaking impurities — •YAHUI LI^{1,2}, PABLO SALA^{3,4}, FRANK POLLMANN^{1,2}, SANJAY MOUDGALYA^{1,2}, and OLEXEI MOTRUNICH^{3,4} — ¹Technical University of Munich, Germany — ²Munich Center for Quantum Science and Technology, Germany — ³California Institute of Technology, USA — ⁴Walter Burke Institute for Theoretical Physics, USA

Continuous symmetries lead to universal slow relaxation of correlation functions in quantum many-body systems. In this talk, I will show how local symmetry-breaking impurities affect the dynamics of these correlation functions using Brownian quantum circuits. While explicitly breaking the symmetry is generally expected to lead to eventual restoration of full ergodicity, we find that approximately conserved quantities that survive under such circumstances can still induce slow relaxation. This can be understood using a super-Hamiltonian formulation, where low-lying excitations determine the late-time dynamics. We show that in one dimension, symmetry-breaking impurities modify diffusive and subdiffusive behaviors associated with U(1) and dipole conservation at late times, e.g., by increasing power-law decay exponents of the decay of autocorrelation functions. On the other hand, for an impurity that disrupts strong Hilbert space fragmentation, it leads to prethermal plateaus in autocorrelation functions. Overall, our approach systematically characterizes how symmetry-breaking impurities affect relaxation dynamics in symmetric systems.

TT 19.9 Mon 17:15 CHE/0091

Late time dynamics of quantum entanglement — •FELIX DUSEL^{1,2}, FRANK POLLMANN^{1,2,3}, TOBIAS MICKLITZ⁴, and ALEXANDER ALTLAND⁵ — ¹Department of Physics, Technical University of Munich, 85748 Garching, Germany — ²Munich Quantum Valley, 80807 Munich, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Schellingstraße 4, 80799 Munich, Germany — ⁴Centro Brasileiro de Pesquisas Físicas, Rua Xavier Sigaud 150, 22290-180 Rio de Janeiro, Rio de Janeiro, Brazil — ⁵Institut für Theoretische Physik, Universität zu Köln, Zùlpicher Straße 77, 50937 Cologne, Germany

We study entanglement spreading in quantum circuits composed of local qudits with large Hilbert space dimension, and single-particle dynamics relaxing slower than the characteristic timescale for entangling of neighboring qudits.

TT 20: 2D Materials II – Electronic and Transport Properties (joint session HL/TT)

Time: Monday 15:00–16:30

Location: POT/0081

TT 20.1 Mon 15:00 POT/0081

Ballistic electrostatic graphene superlattices using He ion-milled etching masks — •REBECCA HOFFMANN¹, GIULIA PICCININI¹, JULIEN BARRIER¹, DAVID BARCONS RUIZ¹, HANAN HERZIG SHEINFUX¹, TAKASHI TANIGUCHI², KENJI WATANABE³, ADRIAN BACHTOLD^{1,4}, and FRANK H.L. KOPPENS^{1,4} — ¹ICFO-Institut de Ciències Fotoniques, Castelldefels, Spain. — ²International Center for Materials Nanoarchitectonics, NIMS, Tsukuba, Japan — ³Research Center for Functional Materials, NIMS, Tsukuba, Japan — ⁴ICREA-Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

An electrostatic superlattice is created by applying a periodic electrostatic potential to a material using patterned gates or dielectrics, leading to tunable band structure reconstruction. This approach enables free design of the superlattice geometry and lattice period. While high mobility has been observed, signatures of ballistic transport (e.g. negative resistance in cross geometry, transverse magnetic focusing) remain to be reported. Here, we present a nanofabrication technique combining Helium ion milling of etching masks with damage-free etching of graphite gates [1]. Using these gates in a graphene heterostructure

creates an electrostatic superlattice which preserves graphene's high mobility. We report superlattice features. The high electronic quality is confirmed by transverse magnetic focusing and device-size limited mean free path.

[1]D. Barcons Ruiz, et al., Nat. Commun. 13, 6926 (2022)

TT 20.2 Mon 15:15 POT/0081

Tomographic flow regime in the 2D Corbino disk geometry — •GRIGORI STARKOV — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

2D materials offer a unique test ground to study electron transport regimes dominated by the electron-electron collisions. This makes them the perfect platform to observe the electron hydrodynamic flows.

Not so long ago, it has been realized that precisely in 2D, the electron collisions constrained due to Pauli blocking result in the appearance of the long lived collective modes with odd angular character. The corresponding novel transport regime has been dubbed "tomographic".

In the recent experiment [2], magnetoresistance in Corbino-shaped graphene devices was used to disentangle different contributions to the electron transport and to determine viscosity. The obtained

temperature-dependence thereof has been linked to the tomographic flow. However, the analysis is based on the bulk expressions for the conductivity and does not treat boundary corrections in detail. At the same time, boundary layers have been shown to be anomalously large in the tomographic flow regime [3].

To take into account the boundary effects, I analyze the magnetoresistance in the 2D Corbino disk geometry across different regimes, using the linearized Boltzmann equation.

[1] P. Ledwith et al, Phys. Rev. Lett. 123, 116601 (2019) [2] Y. Zeng et al, arXiv:2407.05026 (2025) [3] N. Ben-Schachar, J. Hoffmann, arXiv:2503.14431 (2025)

TT 20.3 Mon 15:30 POT/0081

Pulsed-gate spectroscopy of the electron-hole blockade in bilayer graphene double quantum dots — •LARS MESTER^{1,2}, HUBERT DULISCH^{1,2}, KATRIN HECKER^{1,2}, KONSTANTINOS KONTAGEORGIOU³, SAMUEL MÖLLER^{1,2}, LEON STECHER¹, KENJI WATANABE⁴, TAKASHI TANIGUCHI⁵, FABIAN HASSLER³, CHRISTIAN VOLK^{1,2}, and CHRISTOPH STAMPFER^{1,2} — ¹JARA-FIT and 2nd Institute of Physics, RWTH Aachen University, Aachen, Germany — ²PGI-9, Forschungszentrum Jülich, Jülich, Germany — ³JARA-Institute for Quantum Information, RWTH Aachen University, Aachen, Germany — ⁴Research Center for Functional Materials, National Institute for Materials Science, Namiki, Japan — ⁵International Center for Materials Nanoarchitectonics, National Institute for Materials Science, Namiki, Japan

Pauli blockade is an established read-out mechanism for quantum-dot (QD) spin qubits. Using bilayer graphene (BLG) as a platform offers advantages such as a tunable valley degree of freedom. Recently, a strong spin-valley blockade was demonstrated in an electron-hole BLG double quantum dot (DQD) using time-averaged transport measurements. Here, we employ pulsed-gate spectroscopy by pulsing between the (0e, 0h) and (1e, 1h) charge configurations. Comparison with simulations allows us to identify unconventional higher-order tunneling as the dominant blockade-lifting mechanism, with timescales governed by QD-lead coupling and the number of accessible states. Our results provide direct access to blockade-lifting dynamics in a BLG DQD, offering relevant insights for the development of future BLG-based qubits.

TT 20.4 Mon 15:45 POT/0081

Temperature Dependent Electrical Transport in Thin SnSe₂ — •LARS THOLE¹, AARTI LAKHARA², PREETI A. BHOBE², and ROLF J. HAUG¹ — ¹Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — ²Department of Physics, Indian Institute of Technology Indore, Khandwa Road, Indore, Simrol, 453552, India

The two-dimensional material SnSe₂ shows special temperature dependent behavior [1], which has not been understood to its full capacity as of now.

We fabricated thin samples of SnSe₂ and investigated its electrical transport behavior in regards to its temperature dependence [2]. These samples show a metal-insulator transition with a metallic state for higher temperatures. The low-temperature transport regime is dominated by variable-range hopping. Additionally, the influence of defect states in these samples is investigated by looking at the thickness dependence for different samples [3].

[1] C. Guo, et al., Appl. Phys. Lett. 109, 203104 (2016).

[2] A. Lakhara, L. Thole, R. J. Haug, and P. Bhoobe. arXiv: 2507.14536 (2025).

[3] A. Lakhara, L. Thole, R. J. Haug, and P. Bhoobe. Phys. Rev. B 112, 235401 (2025).

TT 20.5 Mon 16:00 POT/0081

Polarization resolved Electron Spin Resonance in two-dimensional electron systems — •DANIAR KHUDAIBERDIEV¹, ALEXEY SHUVAEV¹, MICHAIL GLAZOV², ANTON SHCHEPETILNIKOV³, VIACHESLAV MURAVEV³, CHRISTIAN REICHL⁴, WERNER WEGSCHEIDER⁴, and ANDREI PIMENOV¹ — ¹Institute of Solid State Physics, Technische Universität Wien, 1040 Vienna, Austria — ²St. Petersburg, Russia — ³Chernogolovka, Russia — ⁴Laboratory for Solid State Physics, ETH Zurich, CH-8093 Zurich, Switzerland

Electron spin resonance (ESR) has long served as a powerful probe of g-factor anisotropy, spin-orbit interactions, hyperfine coupling, and collective many-body spin phenomena in two-dimensional electron systems (2DESs). Most prior studies detect ESR in the photoresistance of Hall bars, where the excitation-field distribution and polarization are distorted, complicating the analysis of the excitation conditions.

In contrast, we report polarization-resolved ESR in sub-THz transmission using a quasi-optical setup and large-area samples that ensure high polarization purity. First we study the 2DES hosted in a 4.5-nm AlAs quantum well with a single isotropic valley. The selection rules indicate that Dresselhaus spin-orbit coupling mediates the electric-dipole-active spin absorption. Further we examine systems with more complex spectra such as wide AlAs wells with an active pseudospin, HgTe and InAs quantum wells with low effective mass and strong spin-orbit coupling enhancing the effects.

TT 20.6 Mon 16:15 POT/0081

First-Principles Investigation of Electronic Transport in 2D GaSe: Backward Diodes, p-i-n FETs, and Double-Gate MOSFETs — •DOĞUKAN HAZAR OZBEY and ENGİN DURGUN — UNAM - National Nanotechnology Research Center and Institute of Materials Science and Nanotechnology, Bilkent University, Ankara, Turkey

In this study, we present a comprehensive first-principles investigation of charge transport in monolayer GaSe nanodevices by combining density functional theory with the nonequilibrium Green's function (DFT + NEGF) formalism. Three representative architectures, namely p-n junctions, p-i-n field-effect transistors (FETs), and double-gate MOSFETs, are systematically analyzed. Our calculations reveal that GaSe p-n junctions display an unconventional backward diode response, in which reverse currents within the ± 1 V window exceed forward currents owing to tunneling-assisted transport, as evidenced by the projected local density of states. When configured as p-i-n FETs, electrostatic gating allows selective control over tunneling conduction. Moderate gate biases suppress the reverse current, whereas stronger gating reactivates and amplifies it. Finally, double-gate GaSe MOSFETs with channel lengths of approximately 5 nm exhibit competitive figures of merit that meet or surpass the ITRS-2028 high-performance benchmarks, achieving an on/off ratio of 1.2×10^4 , intrinsic delay time of 0.24 ps, and power-delay product of only $0.06 \text{ fJ} \cdot \mu\text{m}^{-1}$. Our results highlight GaSe as a single 2D semiconductor capable of integrating backward-diode behavior with high-speed transistor operation.

TT 21: Electron Theory of Magnetism and Correlations (joint session MA/TT)

Time: Monday 15:00–18:00

Location: POT/0151

TT 21.1 Mon 15:00 POT/0151

Origin of pressure-induced anomalies in the nodal-line ferromagnet $\text{Mn}_3\text{Si}_2\text{Te}_6$ — VARUN VENKATASUBRAMANIAN¹, MAKOTO SHIMIZU², DANIEL GUTERDING³, and HARALD O. JESCHKE¹ — ¹Research Institute for Interdisciplinary Science, Okayama University, Okayama, Japan — ²Department of Physics, Graduate School of Science, Kyoto University, Kyoto, Japan — ³Technische Hochschule Brandenburg, Brandenburg an der Havel, Germany

The nodal-line ferromagnet $\text{Mn}_3\text{Si}_2\text{Te}_6$ exhibits a pressure-induced insulator-to-metal transition (IMT), which coincides with pronounced anomalies in its magnetic ordering temperature and anomalous Hall conductivity. We employ density functional theory (DFT) in combination with classical Monte Carlo simulations to elucidate the origin of these effects. Pressure-dependent Heisenberg Hamiltonians extracted from DFT reveal a strong evolution of exchange couplings across the structural transition from the trigonal to the monoclinic phase, producing a dome-shaped variation of the ferrimagnetic ordering temperature in quantitative agreement with experiment. While our simulations capture the pressure-driven IMT and magnetic evolution, the anomalous Hall response cannot be fully explained by intrinsic Berry curvature effects, indicating additional extrinsic contributions.

[1] V. Venkatasubramanian, M. Shimizu, D. Guterding, and H. O. Jeschke, *Origin of pressure-induced anomalies in the nodal-line ferromagnet $\text{Mn}_3\text{Si}_2\text{Te}_6$* , arXiv:2509.18238

TT 21.2 Mon 15:15 POT/0151

Near Room-Temperature Ferromagnetism and Insulator-Metal Transition in van der Waals Material CrGeTe_3 — DANIEL GUTERDING¹, JIHAAN EBAD-ALLAH², GILI SCHARF³, HAN-XIANG XU⁴, MAKOTO SHIMIZU⁵, JUNYA OTSUKI⁶, ALON RON³, CHRISTINE KUNTSCHER², and HARALD O. JESCHKE⁶ — ¹Technische Hochschule Brandenburg, Brandenburg an der Havel, Germany — ²Augsburg University, Augsburg, Germany — ³Tel Aviv University, Tel Aviv, Israel — ⁴Chinese Academy of Sciences, Beijing, China — ⁵Kyoto University, Kyoto, Japan — ⁶Research Institute for Interdisciplinary Science, Okayama University, Okayama, Japan

We investigate how pressure tunes the electronic and magnetic properties of the van der Waals ferromagnet CrGeTe_3 , a promising material for near room-temperature applications. Using DFT+DMFT, we trace the transition from semiconducting to metallic ferromagnet [1]. Optical conductivity reveals a mid-infrared feature, signalling orbital-selective correlations, while a double-exchange mechanism stabilizes high-temperature ferromagnetism [2]. The anomalous Hall effect shows extrinsic behaviour beyond pure Berry curvature effects [3]. These results highlight the interplay of magnetism and electronic correlations in achieving tunable ferromagnetism in CrGeTe_3 , suggesting that pressure and charge carrier doping offer promising routes to control magnetism and transport in layered materials.

[1] H.-X. Xu *et al.*, Phys. Rev. B **108**, 125142 (2023)

[2] J. Ebad-Allah *et al.*, Phys. Rev. B **111**, L140402 (2025)

[3] G. Scharf *et al.*, Phys. Rev. Res. **7**, 013127 (2025)

TT 21.3 Mon 15:30 POT/0151

Ground State of the Topological Insulator Candidate Eu_2AuGe_3 — VINICIUS ESTEVO SILVA FREHSE¹, ALEKSANDR SUKHANOV¹, ARTEM KORSHUNOV², EUGEN WESHCKE³, ALY ABDELDAIM⁴, PRISCILA ROSA⁵, and MAREIN RAHN¹ — ¹Universität Augsburg, Augsburg, Germany — ²Donostia International Physics Center, San Sebastián, Spain — ³Helmholtz Zentrum Berlin, Berlin, Germany — ⁴Diamond Light Source, Didcot, UK — ⁵Los Alamos National Laboratory, Los Alamos, USA

Eu_2AuGe_3 is an unusual rare earth germanide in which quasi-trigonal europium sheets are interleaved with Au-Ge honeycomb layers, where high-throughput calculations indicate potential for topological band inversions. Bulk and transport data have revealed a series of (re-)ordering transitions upon cooling, as well as metamagnetic transitions at low temperature. Recently, we identified a broad transition around $T_{CDW} = 130$ K as the continuous freezing-out of a buckling mode of the honeycomb layers.

Here, we present preliminary evidence from neutron and resonant elastic X-ray scattering, which hints at helical magnetic order below $T_N = 11$ K. Unexpectedly for the nominally spin-only divalent eu-

ropium, the magnetic order also appears to be accompanied by a modulated orbital order parameter. This phase is preceded by a transition at 23 K, where we observe a subtle doubling of the *ab*-plane, possibly related to the charge density wave formed during T_{CDW} .

TT 21.4 Mon 15:45 POT/0151

Electronic structure, magnetic and optical properties of antiferromagnetic 3d-oxides from a Wannier-localized optimally-tuned screened range-separated hybrid functional — ALEXANDER SHICK^{1,2}, GUY OHAD², JEFFREY NEATON^{3,4}, and LEEOR KRONIK² — ¹FZU-Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic — ²Weizmann Institute of Science, Rehovoth, Israel — ³University of California, Berkeley, USA — ⁴Lawrence Berkeley National Laboratory, Berkeley, USA

We apply the recently developed Wannier-localized, optimally tuned, screened range-separated hybrid (WOT-SRSH) functional to prototypical bulk antiferromagnetic insulators — MnO , NiO , and hematite (Fe_2O_3). Comparison to calculations based on well-established functionals, namely PBE0, and HSE06, as well as to self-consistent quasiparticle GW and dynamic mean field theory calculations, and to experiment, shows that the WOT-SRSH functional provides a good quantitative description of band gaps, spin magnetic moments, photoemission, and optical absorption spectra. This establishes WOT-SRSH as a uniform, non-empirical framework for band theory of electronic, magnetic, and optical properties of magnetic insulators.

TT 21.5 Mon 16:00 POT/0151

Spectroscopic evidence of Kondo resonance in 3d van der Waals ferromagnets — DEEPAI SHARMA^{1,2}, NEERAJ BHATT¹, ASIF ALI¹, RAJESWARI ROY CHOWDHURY¹, CHANDAN PATRA¹, RAVI PRAKASH SINGH¹, and RAVI SHANKAR SINGH¹ — ¹IISER Bhopal, Bhopal, India — ²TU Dortmund, Dortmund, Germany

Two-dimensional van der Waals (vdW) ferromagnets drive the advancement in spintronic applications and enable the exploration of exotic magnetism in low-dimensional systems. The entanglement of the dual-localized and itinerant-nature of electrons lies at the heart of the correlated electron systems giving rise to exotic ground state properties such as complex magnetism, heavy fermionic behavior, Kondo lattice formation, etc. Through temperature-dependent electronic structure of vdW ferromagnets, Co substituted Fe_3GeTe_2 , probed using high-resolution photoemission spectroscopy and density functional theory combined with dynamical mean field theory (DFT + DMFT), we provide direct evidence of the emergence of Kondo resonance peak driven by complex interplay between localized and itinerant electrons. Further, in overall agreement with the experimental electronic structure and magnetic properties, DFT + DMFT also reveals non-Stoner magnetism. The findings provide a way forward to the understanding of complex interplay between electronic structure, exotic magnetism, and heavy fermionic behavior leading to the Kondo scenario in 3d vdW ferromagnets.

TT 21.6 Mon 16:15 POT/0151

T-linear and quadratic transport across the Cuprate and Nickelate phase diagram : pseudogap, strange-metal and Fermi-liquid — DONGWOOK KIM¹, MOTOHARU KITATANI², JURAJ KRŠNIK³, and KARSTEN HELD⁴ — ¹Wiedner Hauptstraße 8-10, 1040 Wien — ²3-2-1 Koto, Kamigori-cho, Ako-gun, Hyogo 678-1297, Japan — ³Trg Republike Hrvatske 14. HR-10000 Zagreb Croatia — ⁴Wiedner Hauptstraße 8-10, 1040 Wien

We investigate DC resistivity and nodal quasiparticle (QP) scattering in hole-doped cuprates-nickelate type superconductors by ladder dynamical vertex approximation (LDΓA). In the pseudogap regime of doping $\delta = 0.1$ -0.175, we observe a crossover from *T*-linear to *T*² resistivity at low *T*. For dopings $\delta = 0.2$ -0.25, the resistivity remains fully *T*-linear down to the lowest temperatures, indicating strange-metal behavior associated with a nearby quantum critical point (QCP). At higher doping of $\delta = 0.3$ the *T*² recovery reappears, signaling exit from the quantum-critical regime. The nodal QP scattering rate and the first-Matsubara-frequency rule analysis independently confirm the same FL*NFL crossover, providing consistent support for the *T*-dependent transport obtained within LDΓA

15 min break

TT 21.7 Mon 16:45 POT/0151

Toward ab-initio simulation for resonant inelastic X-ray scattering in strongly correlated materials — ●YUN YEN^{1,2}, MATTHIAS KRACK², and MICHAEL SCHÜLER^{2,3} — ¹Institute for Theoretical Physics, Bremen Center for Computational Materials Science, University of Bremen, Bremen, Germany — ²PSI Center for Scientific Computing, Theory and Data, Villigen PSI, Switzerland — ³Department of Physics, University of Fribourg, Fribourg, Switzerland

X-ray absorption spectroscopy (XAS) and resonant inelastic X-ray scattering (RIXS) can be used to study low-energy excitations in complex materials, which are challenging to interpret due to strong correlations during the photoexcitation processes. We aim to develop ab-initio methods for XAS and RIXS, by constructing Anderson impurity models using Wannier-based tight-binding parameters and constrained random phase approximation. The spectrums are then computed via exact diagonalization and Krylov subspace methods. We will show a benchmark on spin spiral materials, where the d-d excitation intensity dependence can be related to the onset of magnetic order with the support of our methods.

TT 21.8 Mon 17:00 POT/0151

Magnetic Persistence in PrAlGe via RIXS and XAS modeling — ●JUAN FELIPE PULGARIN MOSQUERA^{1,2}, YUN YEN³, TIAN-LUN YU⁴, YEONG-AH SOH⁴, THORSTEN SCHMITT⁴, and MICHAEL SCHUELER^{1,2} — ¹PSI Center for Scientific Computing, Theory and Data, Villigen PSI, Switzerland — ²University of Fribourg, Department of Physics, University of Fribourg, Fribourg, Switzerland — ³Institute for Theoretical Physics and Bremen Center for Computational Materials Science, University of Bremen, Bremen, Germany — ⁴PSI Center for Photon Sciences, Villigen-PSI, Switzerland

The interplay between topological electronic states and magnetism is in the spotlight of condensed matter for potential applications. PrAlGe is a prime candidate in this context, with several works reporting it as a magnetic Weyl semimetal. However, the microscopic relationship between the magnetic ordering, anomalous Hall effect and local spectroscopic signatures remains an open question. We study this phenomenon based on a combination of X-ray spectroscopy and first-principle calculations. We present our ab-initio approach to computing X-ray absorption spectroscopy and resonant inelastic X-ray scattering based on accurate Anderson Impurity model derived from density-functional theory with Hubbard corrections. This comparison is crucial for understanding the experimental finding that the ferromagnetic transition occurs at $T_c \sim 16$ K, significantly lower than the temperature scale at which the AHE and circular dichroism vanish ($T_{AHE} \sim 35$ K). The survival of circular dichroism above T_c serves as a local probe for the persistence of local magnetic moments.

TT 21.9 Mon 17:15 POT/0151

Ab initio spin Hamiltonians and magnetism of Ce and Yb triangular-lattice compounds — LEONID V. POUROVSKII^{1,2}, ●RAFAEL D. SOARES³, and ALEXANDER WIETEK³ — ¹CPHT, CNRS, École polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ²Collège de France, Université PSL, 11 place Marcelin Berthelot, 75005 Paris, France — ³Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

We calculate the crystal-field splitting, ground-state Kramers doublet and intersite exchange interactions within the ground-state doublet manifold for a representative set of Ce and Yb triangular-lattice compounds. These include the putative quantum spin liquids (QSL) RbCeO₂ and YbZn₂GaO₅ and the antiferromagnets KCeO₂ and KCeS₂. The calculated nearest-neighbor (NN) couplings are antiferromagnetic and exhibit noticeable anisotropy. The next-nearest-neighbor

(NNN) couplings are ferromagnetic in the Ce systems and dominated by classical dipole-dipole interactions in the Yb case. Solving the resulting effective spin-1/2 models by exact diagonalization up to $N = 36$ sites, we predict ordered magnetic ground states for all systems, including the two QSL candidates. We explore the phase space of an anisotropic NN + isotropic NNN triangular-lattice model finding that a significant antiferromagnetic NNN coupling is required to stabilize QSL phases, while the NN exchange anisotropy is detrimental to them. Our findings highlight a possibly important role of deviations from the perfect triangular model in real materials.

TT 21.10 Mon 17:30 POT/0151

Transition metal dihalides: from band structure to magnetic properties — ●ALEXANDER YARESKO¹, SEBASTIEN HADJADJ², and MAXIM ILYN² — ¹Max Planck Institute for Solid State Research, Stuttgart, Germany — ²Centro de Física de Materiales, Donostia-San Sebastián, Spain

Transition metal dihalides TX₂ (T=Fe, Ni, X=Cl, Br) have recently attracted attention because of successful growth of monolayer-thick TX₂ films on various substrates, such as Au or NbSe₂, allowing to study 2D magnetism. We compare results of band structure calculations for bulk and monolayer FeX₂ and NiX₂. By mapping the total energies calculated for helical spin structures with various q to the Heisenberg model we show that the change of magnetic order within a layer from ferro- in NiCl₂ to helimagnetic in NiBr₂ can be explained by the increased strength of antiferromagnetic (AF) 3-rd neighbor exchange interaction J_3 which competes with FM nearest neighbor J_1 . We found that inter-layer coupling J_{2c} stabilizes FM order within a layer. Thus, one can expect stronger tendency to a helimagnetic state in a NiX₂ monolayer.

In contrast to NiX₂, J_1 estimated from LDA+U spin-spiral calculations for FeX₂ is weak but shows substantial dependence on the strength of the Coulomb repulsion U . In agreement with experimental findings, calculations including spin-orbit coupling result in appreciable easy axis anisotropy with Fe magnetic moments normal to layers.

We also discuss various microscopic contributions to intra- and inter-layer exchange interactions.

TT 21.11 Mon 17:45 POT/0151

Coexistence of charge order and antiferromagnetism in three-dimensional Hubbard-Holstein model: A study (exploring phases) at and away from half-filling — ●SANDIP HALDER and MOSHE SCHECHTER — Ben-Gurion University of the Negev, Beer-Sheva, Israel

The physics of correlated electron systems has long been explored through the Hubbard model and its extensions, including models with long-range hopping. Likewise, phenomena arising from electron-phonon coupling- such as charge order and superconductivity- have been extensively studied within the Holstein model, though largely in lower dimensions. In transition-metal oxides, however, both electron correlations (U) and electron-phonon coupling (V) coexist intrinsically, motivating a comprehensive study of the Hubbard-Holstein model in three dimensions.

Using an exact diagonalization-based semi-classical Monte Carlo (s-MC) method, we investigate the intriguing properties of this model. At half-filling, the system undergoes a first-order transition between a charge-ordered (CO) phase and an antiferromagnetic (AF) phase as U and V are varied. In the AF regime, near the phase boundary, hole doping drives the system from the AF state ($n=1$) to a CO state ($n=0.5$), and eventually to a disordered phase at low densities. Notably, a robust coexistence of AF and CO emerges around $x=0.35$ ($n=0.65$), with T_{CO} exceeding T_N , consistent with experiments on $La_{2-x}Sr_xNiO_4$. The study provides new insight into correlated materials and guiding future experimental explorations.

TT 22: Superconductivity – Poster I

Time: Monday 18:00–20:00

Location: P1

TT 22.1 Mon 18:00 P1

Sextets in four-terminal Josephson junctions — ●MIRIAM R. EBERT¹, DAVID C. OHNMACHT¹, WOLFGANG BELZIG¹, and JUAN C. CUEVAS^{2,3} — ¹Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany — ²Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, 28049 Madrid, Spain — ³Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain

Multiterminal superconducting junctions have revitalized the investigation of the Josephson effect. One of the most interesting aspects of these hybrid systems is the occurrence of multi-Cooper pair tunneling processes that have no analog in two-terminal devices. Such correlated tunneling events are also intimately connected to the Andreev bound states (ABSs) supported by these structures. Josephson junctions with four superconducting terminals have attracted special attention because they are predicted to support ABSs with nontrivial topological properties. Here, we present a theoretical study of sextets, which are correlated tunneling processes involving three Cooper pairs and four different superconducting terminals [1]. We investigate how sextets can be identified from the analysis of the current-phase relation and show how sextets are connected to the hybridization of ABSs. Furthermore, we discuss their existence in recent experiments on four-terminal devices realized in hybrid Al/InAs heterostructures [2].

[1] M. R. Ebert et al., Phys. Rev. B 112, 195430 (2025)

[2] T. Antonelli et al., Phys. Rev. X 15, 031066 (2025)

TT 22.2 Mon 18:00 P1

Superconducting proximity effect in non-collinear antiferromagnets — ●ANSHUMAN PADHI¹, PRAJWAL RIGVEDI MADHUSUDAN RAO¹, AJIN JOY², AJESH K GOPI¹, JIHO YOON¹, JAECHUN JEON¹, BANABIR PAL¹, and STUART S. P. PARKIN¹ — ¹Max Planck Institute of Microstructure Physics, 06120, Halle (Saale), Germany — ²Indian Institute of Science, 560012, Bengaluru, India

Triplet Cooper-pair generation in superconducting hybrids is typically achieved using multilayer ferromagnetic structures with non-collinear magnetization, but such systems restrict material flexibility and can introduce vortex-related artefacts. Non-collinear antiferromagnets (NCAFM) provide a promising alternative: their intrinsic spin textures and residual uncompensated moments can support long-range superconducting correlations without complex magnetic stacking. Here, we interface superconducting thin films (thickness lesser than the coherence length) with two magnetic phases of a Mn-based antiperovskite and track how their critical temperature evolves under magnetic fields of various orientations. The symmetry and spin configuration of the NCAFM are expected to modify the Andreev spectrum at the interface and thereby affect the robustness of the superconducting condensate, a common indicator of triplet pairing. We further attempt to study the interface using tunneling spectroscopy and explore possible signatures of spin-dependent Andreev states.

TT 22.3 Mon 18:00 P1

RF-Driven Josephson Dynamics in an STM-Defined Pb-NbS₂ Junction — ●AJLA KARIC, RIAN LIGTHART, ALEXANDER LAFLEUR, KEVIN HAUSER, BENJAMIN FROELICH, and FABIAN D. NATTERER — Department of Physics, University of Zurich, Winterthurerstrasse 190, CH-8057, Switzerland

We use a scanning tunneling microscope to form an ultrasmall Josephson junction between a Pb tip and an NbS₂ sample at 1.5 K and investigate how its electromagnetic environment shapes the Josephson response. We apply radio-frequency (RF) driving up to 40 GHz and track the evolution of dI/dV spectra as a function of RF amplitude. The measurements reveal pronounced photon-assisted tunneling features and a strong modulation, suppression, and reemergence of the zero-bias Josephson peak, consistent with a phase-diffusive regime dominated by environmental fluctuations. In ongoing work, we increase the effective junction capacitance to directly probe how controlled changes in the junction capacitance modify the Josephson dynamics. Understanding these environmental effects is essential for identifying the conditions under which STM-based Josephson junctions can be pushed toward more coherent operation relevant for qubit applications.

TT 22.4 Mon 18:00 P1

prediction of SJTM observables in putative PDW state in cuprates — ●MONIKANA GOPE, SHASWAT CHATURVEDI, and PEAYUSH CHOUBEY — Department of Physics, Indian Institute of Technology Roorkee, Roorkee-247667, Uttarakhand, India

The coexistence of competing electronic phases, such as pair-density wave (PDW) and charge-density wave (CDW), in high-temperature superconductors remains unresolved. These phases originate from distinct mechanisms, exhibit spatial modulations, and influence superconductivity differently. Scanning Josephson Tunnelling Microscopy (SJTM) enables atomic-scale probing of these modulations by measuring Josephson and quasiparticle tunnelling currents between a superconducting tip and a superconducting sample, thus serving as a direct local probe of the superconducting gap order parameter. Using this technique, we aim to distinguish PDW signatures from other competing orders in cuprates. Starting with the tJ model, which captures strong electron correlations and the interplay between electron hopping, exchange interactions, and strong correlation effects in cuprate superconductors, we stabilise a metastable PDW phase under specific doping and fixed-temperature conditions. We then compute the critical current for a superconducting s-wave tip in both PDW and PDW + dSC states, finding distinct modulations in I_c and abs(I_c). Finally, we employ a Wannier-function-based continuum approach to calculate the critical current and predict characteristic SJTM signatures of the PDW state.

TT 22.5 Mon 18:00 P1

Theory of ESR-STM in superconducting hybrids — ●MARCEL POLÁK and BJÖRN TRAUZETTEL — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

The electron spin resonance scanning tunneling microscopy (ESR-STM) is a technique that has emerged in the last few years and is a focus of both experimental and theoretical studies. It combines tunneling with an external rf field to probe magnetic adatoms with high resolution in energy and space. Such tunneling problems can be studied in the presence of superconducting electrodes. This leads to the presence of Yu-Shiba-Rusinov states, Andreev reflection and Shapiro steps. We employ the Green's function approach, to study the effect of an external rf driving on the tunneling current in superconducting hybrids in the presence of driven spins.

TT 22.6 Mon 18:00 P1

Schrieffer-Wolff-transformation approach to Josephson junctions: quasiparticle effects and Josephson harmonics — ●ÁDÁM BÁCSI^{1,2}, TEODOR ILIČIN^{3,4}, and ROK ŽITKO³ — ¹Széchenyi István University, Győr, Hungary — ²MTA-BME Lendület "Momentum" Open Quantum Systems Research Group, Institute of Physics, Budapest University of Technology and Economics, Budapest, Hungary — ³Jožef Stefan Institute, Ljubljana, Slovenia — ⁴University of Ljubljana, Ljubljana, Slovenia

We use the Schrieffer-Wolff transformation (SWT) to analyze Josephson junctions between superconducting leads described by the charge-conserving BCS theory. Starting from the single-electron tunneling terms, we directly recover the conventional effective Hamiltonian proportional to $\cos \phi$, with an operator-valued phase bias ϕ . The SWT approach has the advantage that it can be systematically extended to more complex scenarios. We show that if a Bogoliubov quasiparticle is present its motion couples to that of Cooper pairs, introducing correlated dynamics that reshape the energy spectrum of the junction. Furthermore, higher-order terms in the SWT naturally describe Josephson harmonics, whose amplitudes are directly related to the microscopic properties of the superconducting leads and the junction. We derive expressions that could facilitate tuning the ratio between the different harmonics in a controlled way.

TT 22.7 Mon 18:00 P1

Towards new precision measurements of the AC Josephson effect — ●SANDIP SAHA¹, OLIVER KIELER¹, RALF BEHR¹, JÖRN BEYER², JOHANNES KOHLMANN¹, and MARK BIELER¹ — ¹Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany — ²Physikalisch-Technische Bundesanstalt (PTB), Abbestraße 2-12, 10587 Berlin, Germany

The AC Josephson effect is used today to realise the unit volt since it

establishes a perfect relationship between voltage and frequency just based upon the magnetic flux quantum $\phi_0 = \frac{h}{2e}$. Around four decades ago, the universality of the Josephson effect was studied and experimentally verified with an uncertainty of 3 parts in 10^{19} [1]. Considering the recent progress in superconducting quantum technology and metrology, we believe that re-evaluating this uncertainty could shed new light on the precision of the AC Josephson effect. We plan to use two independent Josephson junction arrays comprising several thousand Josephson junctions, being driven by a microwave generator to synthesize DC voltages. To detect small voltage differences between these two arrays, which will be connected in a superconducting loop, a state-of-the-art DC SQUID will be inductively coupled and used as an extremely sensitive null detector. At the conference, we will explain the principle behind our experimental setup, provide a detailed introduction of the involved quantum devices, which will be fabricated using the established Nb thin film technology at PTB, and present a roadmap for the upcoming measurements.

[1] <https://doi.org/10.1103/PhysRevLett.58.1165>

TT 22.8 Mon 18:00 P1

Coulomb blockade in ultrasmall step-edge junctions made of granular aluminum — ●SERGEY LOTKHOV and LUKAS GRÜNHaupt — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

We developed a fabrication routine and implemented a Coulomb blockade transistor with two step-edge junctions made of granular aluminum (grAl) superconductive film. Our process neither involves widely-used shadow-evaporated overlaps, nor the surface oxidation of aluminum for creating the tunnel barriers. This technique enables multijunction single-charge circuitry free of stray replicas. At low temperatures, the transistor exhibited a typical periodic structure of Coulomb diamonds adjacent to the superconducting voltage gap of grAl, both varying under experimental conditions. The gap was found to depend weakly on the transversal magnetic field up to at least 2 Tesla, which we explain by the microstructure of the superconductive grAl film. Furthermore, the charging effects persisted unaffected across the superconducting transition of grAl, thus supporting a simple, single-electron tunneling picture of the Coulomb effects observed.

TT 22.9 Mon 18:00 P1

Towards next-generation Josephson arbitrary waveform synthesizers — ●NISHITA CHAUDHRY, OLIVER KIELER, ABDULRAHMAN WIDAA, MICHAEL HAAS, OMAR M. ALADDIN, and JOHANNES KOHLMANN — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

With the rapid emergence of new quantum technologies, there is a crucial need for cryogenic microwave generation and detection systems that eliminate additional noise and improve signal quality. We put forward the Josephson Arbitrary Waveform synthesizer (JAWS) as a drive-signal source for these quantum devices for ultrabroadband operation at cryogenic temperatures. The JAWS consists of a pulse-driven series array of Niobium-based SNS Josephson junctions. JAWS delivers ultra-precise, quantum-accurate quantized arbitrary waveforms with exceptional spectral purity of up to -125 dBc and extremely low noise or voltage drift. In this conference presentation, we will introduce the current effort at PTB in which we are extending the operation of previously established JAWS circuits to temperatures as low as 1 K by exploring different substrate options and optimizing parameters of the Josephson junctions. The JAWS chips will be able to provide four different signal channels from DC to GHz and can also be placed close to the quantum chips at cryogenic temperatures.

TT 22.10 Mon 18:00 P1

Impedance-matched Josephson Parametric Amplifiers — ●AMITESH GUPTA — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Frequency-multiplexed microwave readout of superconducting qubits is greatly benefited by low-noise and wide-band amplification. Over the past decade, Josephson junction based amplifiers, like the impedance-matched Josephson parametric amplifiers (JPAs), have become one of the solutions, offering quantum-limited noise performance along with bandwidth of a few hundreds of MHz. We present a streamlined way to design a matching network for JPAs using quarter-wave and half-wave transmission lines. It relies on eliminating the complex part of the impedance of the JPA's dc-SQUID, and matching the input to the negative resistance arising from pumping the JPA. We present harmonic balance simulations of our designs, and show first experimental

results of the devices fabricated using Nb-trilayer technology.

TT 22.11 Mon 18:00 P1

Charge Sensitive Superconducting Transmon Qubits for Infrared Radiation Detection — ●JONATHAN HUSCHLE¹, MARKUS GRIEDEL^{1,2}, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruhe Institute of Technology — ²Institute for Quantum Materials and Technologies (IQMT), Karlsruhe Institute of Technology

In superconductors, the absorption of photons with energies exceeding the energy gap breaks Cooper pairs. This increases the population of quasiparticles, enhances noise, and introduces additional dissipation at microwave frequencies. The coherence of superconducting qubits is particularly sensitive to these effects and can thus serve as probes of quasiparticle dynamics. To enhance the sensitivity, we use a charge susceptible transmon qubit to investigate charge noise. In combination with a controllable infrared radiation source, we study the impact on both the charge noise and the coherence time of the modified transmon qubit. We present the qubit design and report on our measurement results at millikelvin temperatures.

TT 22.12 Mon 18:00 P1

Tuneup Protocol for Superconducting Qubits — ●PAUL KUGLER¹, NICOLAS GOSLING¹, MASUM UDDIN², ASEN GEORGIEV³, LI-WEI CHANG³, SHROYA VAIDYA², HIRESH JADOENATHMISSIER⁴, MAHMUT ÇETIN⁴, PHILIPP LENHARD¹, NICOLAS ZAPATA¹, LUKAS SCHELLER⁵, ROBERT GARTMANN⁵, WANG N. WONG², MANOGNYA ACHARYA², TOBIAS LINDSTRÖM⁵, MARK BIELER³, SEBASTIAN DE GRAAF², LUKAS GRÜNHaupt³, and IOAN POP^{1,6,7} — ¹IQMT, KIT, Karlsruhe — ²NPL, Teddington, United Kingdom — ³PTB, Braunschweig — ⁴Orange Quantum Systems, Delft, The Netherlands — ⁵IPE, KIT, Karlsruhe — ⁶PHI, KIT, Karlsruhe — ⁷PI1, Stuttgart University, Stuttgart

We present a standardized, control-platform-agnostic procedure for tuning up superconducting qubits, developed to ensure consistency and reproducibility across laboratories and to enable metrological studies of qubit performance. A central component of the protocol is the calibration of a high-fidelity QND readout, which forms the foundation for all subsequent qubit measurements. Building on this, we establish the control pulses required for reliable qubit manipulation, including calibrated π and $\pi/2$ pulses. After completing the pulse-calibration workflow, we validate the tuneup through randomized benchmarking and readout-induced leakage benchmarking, providing quantitative checks of both gate performance and measurement backaction. This unified procedure supports transparent comparison of results across different control stacks and contributes to building a consistent metrological framework for superconducting-qubit experiments.

TT 22.13 Mon 18:00 P1

Investigation of Parasitic Two-Level Systems in Merged-Element Transmon Qubits — ●ÉTIENNE DAUM, BENEDIKT BERLITZ, ALEXEY V. USTINOV, and JÜRGEN LISENFELD — Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Straße 1, Karlsruhe, 76131, Baden-Württemberg, Germany

In conventional transmon qubits, decoherence is dominated by a large number of parasitic two-level systems (TLS) residing at the edges of its large area coplanar shunt capacitor and junction leads. Avoiding these defects by improvements in design, fabrication and materials proved to be a significant challenge that so far led to limited progress. The merged-element transmon qubit ("mergemon"), a recently proposed paradigm shift in transmon design, attempts to address these issues by engineering the Josephson junction to act as its own shunt capacitor. With its energy mostly confined within the junctions, efforts required to improve qubit coherence can be concentrated on the junction barrier, a potentially easier to control interface compared to exposed circuit areas. Incorporating an additional aluminium deposition and oxidation into the *in-situ* bandaged Niemeyer-Dolan technique, we were able to fabricate flux-tunable mergemon qubits achieving mean T_1 relaxation times of up to $130\mu\text{s}$ ($Q \approx 3.3 \times 10^6$). TLS spectroscopy under applied strain and electric fields, together with systematic design variations, revealed that even for mergemon qubits - despite their significantly reduced footprint and increased junction barrier volume - careful design considerations are still essential to avoid coherence limitations due to surface loss.

TT 22.14 Mon 18:00 P1

Superconducting quarton qubits with stacked Joseph-

son junctions — ●ALEX KREUZER¹, HOSSAM TOHAMY¹, THILO KRUMREY¹, JÜRGEN LISENFELD¹, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruher Institut für Technologie (KIT) — ²Institut für Quantenmaterialien und -technologien (IQMT), Karlsruher Institut für Technologie (KIT)

Realizing compact, low-loss inductive elements is a key challenge for scalable superconducting qubits. Although planar Josephson junction arrays offer large inductances, they also have a substantial footprint, which causes additional surface loss and increases the stray capacitance. We implement quarton flux qubits with a large positive anharmonicity using vertically stacked Josephson junctions, which offer compact inductance, low stray capacitance, and reduced surface participation.

We present DC transport characteristics of stacked junctions and microwave-loss measurements of quarton qubits. Qubit spectroscopy reveals numerous avoided crossings induced by two-level systems (TLS), suggesting the TLS in the array junctions as the dominant loss channel. We discuss how qubit coherence and the TLS density are influenced by stack geometry.

TT 22.15 Mon 18:00 P1

Building a Quantum Wheatstone Bridge — ●THILO KRUMREY¹, ALEX KREUZER¹, HOSSAM TOHAMY¹, ALAN C. SANTOS³, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut, Karlsruher Institut für Technologie, Karlsruhe, Germany — ²IQMT, Karlsruher Institut für Technologie, Karlsruhe, Germany — ³Instituto de Física Fundamental (IFF), Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain

Today's qubits, while still quite noisy, are sufficiently coherent for non-computing applications. We are exploring the possibility of using an arrangement of superconducting qubits to study the quantum version of the Wheatstone resistance bridge[1]. It would allow for comparative measurements of coupling energies using the interference of an excitation gradient across strongly coupled qubits. We propose an implementation of a quantum Wheatstone bridge using superconducting quantum circuits with quarton flux qubits. Here, the large positive anharmonicity and the tunability [2] of the operating frequency are beneficial for our application. We will discuss the current status on the qubits and resonators designs, simulation and fabrication results.

[1] K. Poulsen *et al.*, PRL **128**, 240401 (2022)

[2] F. Yan *et al.*, arXiv:2006.04130v1

TT 22.16 Mon 18:00 P1

Designing a W-band Josephson parametric amplifier. — ●JONAS N. KÄMMERER¹, URS STROBEL¹, JAKOB LENSCHEN¹, KARAPET HAMBARDZUMYAN¹, SERGEI MASIS¹, JÜRGEN LISENFELD¹, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany — ²Institut für QuantenMaterialien und Technologien (IQMT), Karlsruher Institut für Technologie, 76344 Eggenstein-Leopoldshafen, Germany

Superconducting quantum circuits operating in the millimeter-wave regime are expected to offer several advantages that could impact the scalability of future quantum computing systems. These advantages include a reduced footprint, faster qubit manipulation, increased thermal resilience, and higher operating temperatures.

The realization of superconducting qubits in the millimeter-wave regime presents several challenges, one of which is an efficient readout chain. It should include a Josephson parametric amplifier (JPA), which is a nonlinear device that amplifies microwave signals with added noise approaching the quantum limit.

Here, we propose a tunable JPA design operating in the W-band at a frequency of about 100 GHz. Our approach employs a frequency-tunable DC-SQUID made using niobium-based Josephson junction technology. We present numerical simulations conducted to determine the optimal design and operating parameters for three- and four-wave mixing and also address the challenges to overcome in practical devices, such as pumping and coupling schemes.

TT 22.17 Mon 18:00 P1

Immersion Cooling of Transmon Qubits — ●VASILII SEVRIUK¹, AMBER CARRECK¹, DANIEL DOLING¹, ZAKARIA MOHAMED¹, RAIS SHAIKHAI DAROV¹, LEV LEVITIN¹, PETRI HEIKKINEN¹, TOBIAS LINDSTROM², ALEXANDER TZALENCHUK^{1,2}, SEBASTIAN DE GRAAF², ANDREW CASEY¹, and JOHN SAUNDERS¹ — ¹Royal Holloway University of London, UK — ²National Physical Laboratory, UK

Superconducting qubits have become a standard platform both for developing new engineering approaches in quantum computation and for exploring fundamental questions in solid-state physics and quantum mechanics [1]. Despite this progress, achieving efficient thermalization of qubits remains an important challenge [2]. In this work, we present experimental results obtained by immersing a transmon qubit device into liquid helium and studying the temperature dependence of its key parameters. Our approach extends prior studies on immersion cooling of superconducting resonators [3].

[1] M. Devoret *et al.*, arXiv:cond-mat/0411174

[2] D. Lvov *et al.*, arXiv:2409.02784

[3] M. Lucas *et al.*, Nat. Commun. **14**, 3522 (2023)

TT 22.18 Mon 18:00 P1

Dual-tone spectroscopy of atomic tunneling systems in amorphous solids — ●ANTON JARECKA, JAN BLICKBERNDT, MORITZ MAUR, ANDREAS FLEISCHMANN, ANDREAS REISER, and CHRISTIAN ENSS — Kirchhoff Institute for Physics, Heidelberg University

The performance of state-of-the-art superconducting quantum devices is limited by noise and decoherence effects, which are known to originate from atomic tunneling systems (TSs) residing in interfaces and dielectric layers. With the goal of further understanding the dielectric properties of such TSs, we investigate their non-equilibrium response by performing radio-frequency dual-tone spectroscopy using a probe and a pump field. For that purpose, we have developed a superconducting microstructured LC-resonator consisting of four identical interdigital capacitors (IDCs) arranged in a Wheatstone bridge setup and two meander inductances, giving rise to two resonance branches. A bulk glass serves as the IDC's dielectric, providing an ensemble of TSs. We use the setup to probe a dielectric volume shared by the two resonances. Therefore, the resonances address the same ensemble of TSs. By tuning the TS-pump field interaction so that the dominant TS Rabi frequencies match the frequency difference of the resonant branches, we can precisely control the dielectric loss of our sample. The measurements are qualitatively described within a framework based on the dressing of tunneling states induced by strong pump fields. Probing these dressed state transitions provides insights into the non-equilibrium dynamics and, consequently, the dielectric response of atomic TSs.

TT 22.19 Mon 18:00 P1

Landau-Zener transitions in ultra-cold glasses — ●JAN BLICKBERNDT, CHRISTIAN STÄNDER, ANTON JARECKA, ANDREAS FLEISCHMANN, ANDREAS REISER, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University, Germany

Atomic tunneling systems (TSs) are inherent to disordered structures and therefore appear not only in amorphous solids, but also in oxide layers, tunneling barriers and interfaces of superconducting micro-structured devices, deteriorating their performance by introducing noise and decoherence. Understanding their nature is thus crucial to mitigate the adverse effects of TSs on quantum devices. In this work we investigate the non-equilibrium dynamics of a resonantly driven TS ensemble, which is influenced by slowly varying electric or mechanical bias fields by tuning the TSs energy splitting. To directly probe the TSs dielectric response, we developed a superconducting lumped element resonator microfabricated onto a bulk glass substrate, enabling controlled excitation and readout of the underlying TS population. By varying the sweep rate of the applied bias, we demonstrate rate-dependent control over the dielectric loss of the sample. Furthermore, when applying sufficiently large bias amplitudes we observe a dispersive red shift of the resonator frequency due to an excess saturation of low-energy TSs. Introducing noise bias fields leads to a measurable reduction of effective TS coherence times, demonstrating their sensitivity to spectral fluctuations in their environment. To complement our experiments, we developed a GPU-accelerated Monte Carlo simulation of the tunneling dynamics to validate and extend our findings.

TT 22.20 Mon 18:00 P1

Optimization of cross-type dc-SQUIDs for the readout of MMCs — ALEXANDER STOLL, ●LUKAS MÜNCH, DANIEL HENGSTLER, ANDREAS REIFENBERGER, ANDREAS FLEISCHMANN, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University, Germany

Readout chains of ultra-low-temperature detector systems often limit the achievable energy resolution. Even superconducting quantum interference devices (SQUIDs), the state-of-the-art sensors for cryogenic detectors such as metallic magnetic calorimeters (MMCs), typically dominate the white-noise regime. The energy sensitivity of a dc-

SQUID $\epsilon \sim T\sqrt{LC}$ is mainly set by the inductance, intrinsic Josephson junction capacitance, and temperature. While the inductance is fixed for practical reasons, the capacitance can be reduced by moving from a window-type to a cross-type junction geometry. Furthermore, the operation temperature of the SQUIDs which typically decouples from the much lower mixing chamber temperature due to heat dissipation in the shunt resistors, can be lowered. Following an idea from Stephen Boyd and coworkers (to be published), we divide the cooling fins into multiple sectors across the shunt resistor to improve electronic heat dissipation. We describe the fabrication of cross-type dc-SQUIDs for MMC readout, emphasizing the role of CMP-based processing in achieving high wafer-scale yield and uniformity on three-inch wafers. Finally, we present their characterization and compare the noise performance to earlier dc-SQUID generations.

TT 22.21 Mon 18:00 P1

AuTi Magnetic Penetration Depth Thermometers for low temperature microcalorimeters — ●NAEMI GRUN, CHRISTIAN ENSS, ANDREAS FLEISCHMANN, LOREDANA GASTALDO, DANIEL HENGSTLER, FLORIAN KAISER, LUKAS MÜNCH, ANDREAS REIFENBERGER, and MARTIN SCHWENDELE — Kirchhoff Institute for Physics, University Heidelberg

Low temperature microcalorimeters reach high energy resolution in a wide energy range thanks to very sensitive thermometers. Magnetic penetration depth thermometers (MPTs) would represent a very interesting alternative with respect to commonly used metallic magnetic calorimeters (MMCs) and transition edge sensors (TESs). The working principle of MPTs is based on the Meissner-Ochsenfeld effect and the temperature dependence of the magnetic penetration depth. A temperature increase due to energy deposition in the absorber material translates into an increase in the magnetic penetration depth of the MPT, which can be read out by highly sensitive SQUID magnetometers. We are investigating AuTi bilayers as a possible MPT sensor material and are targeting a transition temperature below 100 mK. To avoid hysteretic effects, the sensor does not have a bulk geometry, but is deposited onto the readout coil in the geometry of separate stripes or dots. We discuss the properties of the AuTi bilayers and the results obtained with MPT prototypes based on different geometries.

TT 22.22 Mon 18:00 P1

Identification of Noise Sources in Superconducting Microstructures — ●KRISHNAM MIMANI, DANIEL HENGSTLER, MATTHEW HERBST, DAVID MAZIBRADA, LUKAS MÜNCH, ANDREAS REIFENBERGER, MARKUS RINGER, CHRISTIAN STÄNDER, RUI YANG, ANDREAS FLEISCHMANN, LOREDANA GASTALDO, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University

Improving the performance of superconducting devices often means identifying and eliminating noise sources. Many noise sources are transferable across different device categories such as qubits, SQUIDs, and superconducting detectors due to the intrinsic nature of the micro-fabricated thin film materials. Our stand-alone device can analyze the specific noise contributions of these micro-fabricated thin films. The device consists of a Wheatstone-like bridge of four micro-fabricated superconducting inductors, two of which are filled with a sample material, and a pair of two-stage dc-SQUID read-out chains. We can use the method of cross-correlation, to suppress the noise of the read-out chains and derive the total noise contribution of our device, or drive the Wheatstone bridge with an ac-current to measure the complex susceptibility of the sample material. Our experiments are performed at temperatures between $T = 20$ mK and $T = 800$ mK in the frequency range from $f = 100$ mHz to $f = 500$ kHz. We present the results of multiple measurements on thin films of SiO₂, AuPd, Ag:Er, as well as Au:Er and perform a detailed comparison. We discuss our efforts to increase the frequency bandwidth for both our measurement modes, measuring towards noise levels of below $\sqrt{S_{\Phi}} = 10 \text{ n}\Phi_0/\sqrt{\text{Hz}}$.

TT 22.23 Mon 18:00 P1

Superconducting Resonators from Ultrathin NbN Films — ●HRISHIKESH BORAH, MEENAKSHI SHARMA, HAOLIN JIN, YEJIN LEE, and URI VOOL — Max Planck Institute for Chemical Physics of Solids

We explore the transport and microwave response of ultrathin Niobium Nitride (NbN) of 3 nm thickness. Transport measurements confirm the 2D behavior of our system, consistent with the Berezinskii-Kosterlitz-Thouless transition. In such ultrathin limit, the inertia of the Cooper pairs defined as kinetic inductance becomes dominant. Our films exhibit a high kinetic inductance of 300 pH/sq, which significantly impacts the response of superconducting microwave resonators patterned

from the films. Moreover, temperature dependence measurements of the microwave response reveal that in low temperature regime, the superfluid density follows a power-law rather than the BCS prediction. Energy losses at low temperature are dominated by two-level system (TLS) defects while at higher temperatures, losses are caused by the breaking of Cooper pairs. This work investigates the ultrathin NbN regime for compact, high-impedance devices ideal for quantum circuits and sensitive detectors.

TT 22.24 Mon 18:00 P1

Chaotic Behavior of Josephson Diodes — ●VJEKO DIMIĆ¹, SIMON FEYER¹, ALEXANDER KIRCHNER¹, DANIEL CRAWFORD², DAVIDE CURCIO³, GIORGIO BIASIOL³, TERO HEIKKILÄ², CHRISTOPH STRUNK¹, and LEANDRO TOSI^{1,4} — ¹Institute of Experimental and Applied Physics, University of Regensburg, Germany — ²Department of Physics and Nanoscience Center, University of Jyväskylä — ³CNR-Istituto Officina dei Materiali Laboratorio TASC, Italy — ⁴Centro Atomico Bariloche, Comision Nacional de Energia Atomica, Argentina

The behavior of nonlinear resonators is well described by the Duffing oscillator model. For sufficiently high driving powers, the response of the system has three solutions, two metastable, and one unstable, i.e., the system enters bifurcation regime. This also applies for nonlinear superconducting resonators where the nonlinearity stems from the nonlinear behavior of Josephson junctions. If instead we have a junction exhibiting the Josephson diode effect, the Duffing model acquires an additional term which results in reemergence of stable solutions for certain parameters. Here we present the design and measurement of two tunable $\lambda/4$ resonators fabricated out of a hybrid Al/InAs heterostructure. One resonator is terminated with a single Josephson junction, while the other is terminated with a SQUID. We perform microwave measurements of the resonators and observe the onset of the bifurcation regime in both devices, while the reemergence of stable solutions is observed in the SQUID device. We have also explored the dependence with in-plane magnetic field, in particular the range where superconducting diode effect has been observed.

TT 22.25 Mon 18:00 P1

Planar Broadband Superconducting Waveguide for Coherent Control of Rare-Earth Spin Ensembles — ●ARJUN BHASKER^{1,2}, GEORG MAIR^{2,1}, LÉA RICHARD^{2,1}, MICHAEL STANGER¹, ANDREAS ERB^{2,1}, HANS HUEBL^{2,1,3}, and NADEZHDA KUKHARCHYK^{2,1,3} — ¹School of Natural Sciences, Technische Universität München, 85748 Garching, Germany — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology, 80799 München, Germany

Solid-state quantum memories based on rare-earth ions require highly homogeneous microwave fields to enable coherent control of large spin ensembles. While coplanar waveguides can be used for this purpose, they inherently produce non-uniform field distribution: The microwave field peaks at the center conductor, and the field direction varies substantially within the gaps, which leads to a variety of Rabi frequencies. To overcome this limitation, we introduce a new planar superconducting broadband transmission-line architecture implemented via a technique such as flip-chip bonding, designed to generate a highly uniform microwave field across the active region. In this approach, a CaWO₄ crystal doped with erbium ions has to be thinned producing a flat and uniform membrane to ensure proper impedance matching and optimal coupling to the microwave field. Such a design provides a promising platform for implementing rare-earth-based quantum memories with microwave superconducting quantum technologies.

TT 22.26 Mon 18:00 P1

High-quality superconducting broadband microwave structures for broadband electron spin resonance experiments — ●ROBERT PANT^{1,2}, GEORG MAIR^{1,2}, ARJUN BHASKER^{1,2}, SEBASTIAN DOMINGUEZ-CALDERON^{1,2}, HANS HUEBL^{1,2,3}, and NADEZHDA KUKHARCHYK^{1,2,3} — ¹Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ²School of Natural Sciences, Technische Universität München, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology, 80799 München, Germany

Electron spin resonance (ESR) spectroscopy is a powerful tool when it comes to studying the internal structure of materials and characterizing spins of unpaired electrons within. Superconducting microwave resonators are widely employed for such studies allowing to achieve strong coupling to spin systems. However, a generally narrow fre-

quency range of their operation limits the amount of simultaneously coupled spin states. Over-coupled resonating structures can provide a substantially broader spectrum of microwave frequencies for resonance absorptions, thus improving the measurement efficiency. In the following work, several promising configurations of superconducting coplanar waveguide resonators in the over-coupled regime are developed, including a $\lambda/2$ transmission-line resonator with implemented interdigital capacitors that ensure an increased coupling rate to spin ensembles in the low frequency range of 0–4 GHz.

TT 22.27 Mon 18:00 P1

Metallic-Magnetic Calorimeters for Efficient High Resolution X-ray Spectroscopy for Energies up to 150 keV — •DANIEL KREUZBERGER, ANDREAS ABELN, HENDRIK HADENFELDT, DANIEL HENGSTLER, ANDREAS REIFENBERGER, DANIEL UNGER, ANDREAS FLEISCHMANN, LOREDANA GASTALDO, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University, Germany

Metallic Magnetic Calorimeters are cryogenic detectors for broadband x-ray spectroscopy with high energy resolution and small, well understood non-linearity. They consist of a metallic particle absorber, typically made of gold and a paramagnetic temperature sensor made of an erbium doped noble metal host material. If a photon is absorbed, its energy is converted to heat, leading to a temperature change of the sensor material. This temperature rise changes the magnetization of the sensor material, which is read out by a sensitive SQUID magnetometer.

Experiments on highly charged ions and light muonic atoms have brought up the necessity to build densely packed arrays of MMCs with a high stopping power for photon energies up to 150 keV. This can be achieved with the presented new microfabrication-process for 120 μm thick absorbers made of electroplated gold. We also present fabrication results for the fast thermalization of the MMCs using the backside of the silicon substrate, which can be achieved by using DRIE processes, and filling these TSVs with copper. Finally we present characterization results for two different MMC arrays fabricated with those newly developed processes and results from most-recent beamtimes.

TT 22.28 Mon 18:00 P1

MMC-based photon and phonon detector for scintillating crystals at mK temperatures — •IOANA-ALEXANDRA NITU, CHRISTIAN ENSS, ANDREAS FLEISCHMANN, CLARA MARIE GÜNTHER, DANIEL HENGSTLER, SEBASTIAN HILSCHER, ASHISH JADHAV, CAGLA MAHANOGLU, ANDREAS REIFENBERGER, and LOREDANA GASTALDO — Kirchhoff Institute for Physics, Heidelberg University

Scintillating bolometers operated at mK temperatures provide a means to probe for neutrinoless double beta decay ($0\nu\beta\beta$) and Dark Matter. The ratio of light to heat signals permits discrimination between heavy particles, for instance α particles, and lighter ones, like β or γ particles. The AMoRE collaboration uses separate photon and phonon detectors based on metallic magnetic calorimeter (MMC) technology to search for $0\nu\beta\beta$ in ^{100}Mo using LiMoO_4 crystals.

We present an integrated photon-phonon (P2) detector concept, where both detectors are microfabricated on the same 3-inch silicon substrate and thermally separated by etched trenches. Presently, the optimization of the photon and phonon detectors is done separately. The development of the photon detector has been completed and preliminary results validate fabrication procedures. A phonon detector prototype was designed and microfabricated using the same steps as the pre-existing photon detector. We present the fabrication steps to obtain the target mechanical and thermal properties and discuss preliminary results in comparison to the expected performance.

TT 22.29 Mon 18:00 P1

Time response of an MMC-based large-area photon detector operated at mK — •SEBASTIAN HILSCHER, CHRISTIAN ENSS, ANDREAS FLEISCHMANN, CLARA MARIE GÜNTHER, DANIEL HENGSTLER, ASHISH JADHAV, CAGLA MAHANOGLU, IOANA-ALEXANDRA NITU, ANDREAS REIFENBERGER, CHRISTIAN RITTER, DANIEL UNGER, and LOREDANA GASTALDO — Kirchhoff Institute for Physics, Heidelberg, Germany

We present a large-area photon detector based on low temperature metallic magnetic calorimeters (MMCs), for which the silicon substrate acts as absorber. The detector is designed for measuring light emission in scintillating crystals, for instance in the AMoRE experiment. The visible photons emitted in the scintillating crystal are absorbed on a central silicon area isolated by through-silicon trenches from the rest of the substrate. Prototype devices have been produced and character-

ized at mK temperatures with focus on the time profile of temperature pulses. Very important for the optimization of the detector is modeling this time profile. Here, we present simulations of the phonon propagation and scattering inside the silicon absorber, with either specular or diffusive reflections at the surfaces. These simulations provide a time dependence of the fraction of energy reaching the MMC sensor. We compare the results obtained from measurement and simulation and discuss the implications of the photon detector for the AMoRE experiment.

TT 22.30 Mon 18:00 P1

Towards large-area 256-pixel MMC arrays for high resolution X-ray spectroscopy — •ANDREAS ABELN, DANIEL HENGSTLER, LUCAS HERBSTTRITT, DANIEL KREUZBERGER, ANDREAS REIFENBERGER, ANDREAS FLEISCHMANN, LOREDANA GASTALDO, and CHRISTIAN ENSS — Kirchhoff Institute for Physics, Heidelberg University

Metallic Magnetic Calorimeters (MMCs) are energy-dispersive cryogenic particle detectors. Operated at temperatures below 50 mK, they provide very good energy resolution, high quantum efficiency as well as high linearity over a large energy range. In many precision experiments in X-ray spectroscopy the photon flux is small, thus a large active detection area is desirable. Therefore, we develop arrays with increasing number of pixels.

In this contribution we present a detector setup featuring a novel dense-packed 16×16 pixel MMC array. The pixels provide a total active area of $4 \text{ mm} \times 4 \text{ mm}$ and are equipped with $5 \mu\text{m}$ thick absorbers made of gold. This ensures a stopping power of at least 50 % for photon energies up to 20 keV. The expected energy resolution is 1.4 eV (FWHM) at an operating temperature of 20 mK. For the cost-effective read-out of the 128 detector channels we envisage the flux-ramp multiplexing technique. We present first results of the detector characterization obtained utilizing parallel 2-stage dc-SQUID read-out chains. We discuss the detector performance, focusing on the thermal behavior within the detector as well as to the thermal bath.

TT 22.31 Mon 18:00 P1

MOCCA: A molecule camera for the position and energy resolved detection of neutral molecule fragments — •N. FIEDLER¹, A. FLEISCHMANN¹, C. A. JAKOB², D. KREUZBERGER¹, A. ÖZKARA¹, D. HENGSTLER¹, A. REIFENBERGER¹, L. GASTALDO¹, P. MARTINI³, S. ROSÉN³, H. ZETTERGREN³, O. NOVOTNÝ², H. T. SCHMIDT³, and C. ENSS¹ — ¹Kirchhoff Institute for Physics, Heidelberg University — ²Max Planck Institute for Nuclear Physics, Heidelberg — ³Department of Physics, Stockholm University

The MOCCA detector is a high-resolution camera for neutral molecule fragments with kinetic energies in the keV range. It features several thousand pixels based on metallic magnetic calorimeters and is read out using SQUIDS. To reconstruct the kinematics of electron-ion and ion-ion reactions, MOCCA measures both the energy and the impact position of molecular fragments incident on the detector, even with multiple particles hitting the detector simultaneously. The latest fabricated version is currently being deployed at the Cryogenic Storage Ring (CSR) at the Max Planck Institute for Nuclear Physics in Heidelberg, where molecular ions are stored and prepared in their rotational and vibrational ground states, allowing detailed studies of electron-ion interactions. We present plans for integrating the 11.5k-pixel MOCCA-Quattro detector system into the Double ElectroStatic Ion Ring Experiment (DESIREE) at Stockholm University, which enables mutual neutralization of ions at extremely small relative velocities. This will significantly enhance studies of neutralization processes in complex molecules prepared in their quantum ground state.

TT 22.32 Mon 18:00 P1

Towards reproducible Transition Edge Sensors for rare event searches — •KILIAN HEIM¹, GODEHARD ANGLÖHER¹, LACI ANDRICEK², MUKUND BHARADWAJ¹, DIETER HAUFF³, BERND LIEBIG², GERHARD LIEMANN², JELENA NINKOVIC², KAROLINE SCHÄFFNER^{1,3}, KUMRIE SHERA¹, RAIMUND STRAUSS³, PHILIPP WASSER³, and LUTZ ZIEGELE¹ — ¹Max-Planck-Institut für Physik — ²Max-Planck Halbleiterlabor — ³Technische Universität München

One approach to the search for dark matter is the use of scintillating crystals, such as sodium iodide (NaI), operated at cryogenic temperatures, as implemented by the COSINUS experiment. The readout of the signal, generated upon a nuclear recoil in a NaI crystal, relies on tungsten based transition edge sensors (TESs). These sensors consist of thin ($\sim 200 \text{ nm}$) tungsten films that are operated in the transition between the normal and superconducting state.

The transition temperature of such thin tungsten films depends on a multitude of factors, including grain size, stress level, and film impurities. However, for COSINUS, and next-generation rare event searches, the ability to mass-produce sensors with a consistent transition temperature of ~ 15 mK is crucial. Achieving this necessitates a solid understanding of the factors influencing the transition temperature as well as a precise control of these parameters during the fabrication process.

This contribution presents the first steps taken towards the establishment of a reproducible TES fabrication process as well as future measures to achieve consistent transition temperatures.

TT 22.33 Mon 18:00 P1

In-situ thermometry of Holmium in LiYF_4 crystals with Erbium as a probe — ●JULIA LATOUR^{1,2,3}, CESARE MATTIROLI², MATTHIAS ALTHAMMER^{3,1}, NADEZHDA KUKHARCHYK^{3,1,4}, and HENRIK M. RØNNOW² — ¹Technische Universität München — ²École Polytechnique Fédérale de Lausanne — ³Walther-Meißner-Institut für Tieftemperaturforschung — ⁴Munich Center for Quantum Science and Technology

Measurements of sample temperatures in cryogenic environments are, in most cases, performed using resistance thermometers. Such measurements, however, do not allow for determining the actual temperature inside optical crystals, such as LiYF_4 , due to thermal boundary resistance and thermal-conductivity mismatches between the sample, mounting plate, and sensor. These limitations can be overcome by employing an in-situ spin-temperature measurement technique based on the analysis of changes in the hyperfine energy-level populations of fast-thermalizing, highly coherent electron spin systems. In this work, we investigate mixed ensembles of Holmium and Erbium ions diluted in a LiYF_4 host for in-situ spin thermometry. To this end, we monitored the relative changes in the absorption spectra of LiYF_4 with 0.1% and 1% Ho doping and 0.005% Er co-doping in the magnetic fields of 0–5 T over the temperature range of 0.1–1 K. We compare the thermometry results for the lower- and higher-doped samples to estimate the impact of ion-ion interactions. Samples doped with only Holmium and Erbium are similarly probed to serve as temperature references.

TT 22.34 Mon 18:00 P1

Fast calibration and performance verification of RuO_2 chip thermometers down to 20 mK utilizing adiabatic demagnetization refrigeration in the PPMS. — ●JORGINHO VILLAR GUERRERO, PHILIPP GEGENWART, CHRISTIAN HEIL, and TIM TREU — University Augsburg

Access to temperatures in the millikelvin (mK) range is essential for the research and development of quantum technologies. Calibrated low-temperature sensors are expensive and only available with long lead times. We focus on the fast calibration of cheap Ruthenium Oxide (RuO_2) thick-film resistor chips that are widely used in the automotive industry and are therefore readily available. Upon cooling to below 4 K, they show a pronounced rise of the resistance, which follows variable-range hopping and can be used for low-temperature thermometry down to 20 mK [1]. The thermometers feature a low mass and consequently a low specific heat. Their small size allows mounting them on small contact surfaces. For calibration and performance tests down to mK temperatures, we utilize adiabatic demagnetization of frustrated oxide quantum magnets in the Quantum Design Physical Property Measurement System [2]. We present a miniaturized thermometer calibration setup with reduced response time and minimal self-heating for use down to 20 mK. We report measurements against secondary thermometers with traceable calibration as well as verification with superconducting transitions of Rh-Ir alloy.

[1] R. W. Willekers et al., *Cryogenics* 30, Issue 4, 1990

[2] T. Treu et al., *J. Phys. Condens. Matter* 37, 013001 (2025)

TT 22.35 Mon 18:00 P1

Optimizing the Energy Resolution of Calorimetric Low Temperature Detectors (CLTDs) by Reducing Mechanical Vibrations of the Cryogenic Setup — ●ELIAS EISENSCHMIDT^{1,3}, HARDY WEISWEILER¹, ANDRÉ SCHIRMEISEN^{2,3}, JACK-ANDRÉ SCHMIDT^{2,3}, and SASKIA KRAFT-BERMUTH¹ — ¹Technische Hochschule Mittel-

hessen, D-35390 Giessen, Germany — ²Justus-Liebig-Universität Giessen, D-35392 Giessen, Germany — ³TransMIT GmbH, D-35392 Giessen, Germany

A CLTD consists of an absorber whose temperature can be measured with a thermometer. Due to the careful consideration of absorber's heat capacity and thermal coupling, the temperature increase of the absorber due to the impact of a particle can be directly related to the energy of said particle [1],

One limit to the energy resolution is electronic noise which is partly due to vibrations. In this study, the required low temperature is reached using a Pulse Tube Cooler (PTC) for precooling and a pumped ^4He pot on a second stage. The CLTD's energy resolution is noticeably influenced by mechanical vibrations. In this work, measurements and FEM simulations of vibrations at different cold finger designs are correlated to the energy resolution of heavy ion CLTDs obtained from alpha particles.

[1] P. Egelhof and S. Kraft-Bermuth, *Prog. Part. Nucl. Phys.* 132, 104031 (2023)

DOI:10.1016/j.pnpnp.2023.104031.

TT 22.36 Mon 18:00 P1

Optimization of a Single-Stage GM-Type Cooler for Large Thermal Masses — MIRIAM REIF³, ●JAN OLE SONNENBERGER^{1,2}, BERND SCHMIDT^{2,3}, JACK-ANDRÉ SCHMIDT², and ANDRÉ SCHIRMEISEN^{2,3} — ¹Technische Hochschule Mittelhessen, Friedberg, Germany — ²TransMIT GmbH, Giessen, Germany — ³Institute of Applied Physics, Justus-Liebig University, Giessen, Germany

The demands placed on cooling systems are constantly increasing, which is why they are becoming larger resulting in more overall mass, yet are still expected to cool as quickly as existing systems. Therefore, the systems must be optimized to cool larger masses.[1] A single-stage cooler is ideal for pre-cooling, which is why a single-stage GM-type PTS power cooler was tested as part of the investigation. The performance data of the system was recorded and analyzed under various operating conditions. Based on these measurements, a cooling curve was measured and optimized varying the operating frequency to determine the optimal operating point of the system.

Another another test was then carried out with an attached thermal load in the form of 42 kg of copper to investigate the cooling behavior under increased mass. Once the mass had cooled down without optimization, the cooling time was reduced by around 25% based on the data gained from the previous experiments. These tests provide deeper insight into the performance and optimization of the single-stage GM-type power cooler.

[1] Snodgrass et al., *Nat Commun* 15, 3386 (2024)

TT 22.37 Mon 18:00 P1

Purification of liquid Helium with a heat flush purifier in a dry cryostat — ●FRANZISKA HÖMKE and FOR THE DELIGHT COLLABORATION — Kirchhoff-Institute for Physics, 69120 Heidelberg, INF 227, Germany

The Direct search Experiment for Light dark matter (DELIGHT) aims to search for dark matter by probing elastic scattering interactions of light dark matter particles with helium atoms in liquid helium. The helium is cooled to low millikelvin temperatures within a $^3\text{He}/^4\text{He}$ dilution refrigerator. At these temperatures ^4He is in its superfluid phase, enabling a long mean free path for the phonons and rotons produced in the scattering events. However, ^3He impurities drastically limit the mean free path and hinder the ballistic propagation of the phonons and rotons. To achieve a sufficiently large mean free path, the ^3He concentration in the helium must be reduced by at least three orders of magnitude from the natural concentration.

A heat flush purifier makes use of the unique properties of superfluid ^4He to remove ^3He and other impurities via a temperature gradient. It can be operated in continuous flow and will be integrated into the helium filling circuit of the cell. In wet cryostats, these devices were able to achieve the desired ^3He concentration in ^4He within a single cycle, but no implementations in dry cryostats have yet been described.

This contribution presents the ongoing developments in the design and optimization of a heat flush purifier for the DELIGHT cell.

TT 23: Correlated Electrons – Poster I

Time: Monday 18:00–20:00

Location: P1

TT 23.1 Mon 18:00 P1

High-field magnetization of clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ — •DAVID RÖLL¹, LEONIE STÖDTER², CAROLIN KASTNER¹, SVEN LUTHER³, RALF FEYERHERM⁴, DIRK MENZEL¹, ANJA U. B. WOLTER⁵, KIRRILY RULE⁶, and STEFAN SÜLOW¹ — ¹IPKM, TU Braunschweig — ²FZ Jülich, JCMS at MLZ, Garching, Germany — ³HLD-EMFL, HZDR, Dresden-Rossendorf, Germany — ⁴HZB, Berlin, Germany — ⁵Leibniz IFW Dresden, Dresden, Germany — ⁶ANSTO, Lucas Heights, Australia

The mineral clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ is closely related to the Kagome material herbertsmithite $\text{ZnCu}_3\text{Cl}_2(\text{OH})_6$ and has been discussed as a geometrically frustrated magnet. Its Kagome structure of Cu^{2+} ions features antiferromagnetic in-plane coupling and weaker ferromagnetic interlayer exchange, giving rise to exotic quantum states at low temperatures and in applied magnetic fields. In recent years, we have extensively characterized the magnetic phase diagram up to 14 T, revealing multiple distinct magnetic phases.

Here, we present high-field magnetization measurements on a single-crystalline sample up to 52 T. The magnetization at 2.2 K increases with field but begins to saturate at about 15 T, reaching only a fraction of full magnetization and indicating that the system is not fully magnetized. This stands in clear contrast to previously published results, where the mineral is reported to be fully magnetized at around 35 T. Consequently, we expect the magnetization to rise again at fields beyond our current range, implying the possible presence of a magnetization plateau.

TT 23.2 Mon 18:00 P1

Anisotropic spin models on frustrated lattices: from spin liquids to supersolids — •MARTIN ULAGA¹, JURE KOKALJ^{2,3}, TAKAMI TOHYAMA⁴, and PETER PRELOVŠEK³ — ¹MPIPKS, Dresden, Germany — ²University of Ljubljana, Faculty of civic and geotedic engineering, Ljubljana, Slovenia — ³Institute "Jožef Stefan", Ljubljana, Slovenia — ⁴Science university of Tokyo, Tokyo, Japan

Recent experiments on novel materials, best described by easy-axis spin models on a triangular lattice, stimulated renewed theoretical interest in basic properties of anisotropic spin models on frustrated planar lattices. While the thermodynamic properties of the model on the Kagome lattices are consistent with the spin-liquid scenario in the whole range of anisotropies, the case of the triangular lattice is more complex. Several numerical studies indicate that anisotropic systems should follow the supersolid scenario with broken translation symmetry in the ground state, as well as the transverse magnetic order, implying a gapless Goldstone mode. Confirming this scenario at finite magnetic fields, we find numerically that at zero field, the available evidence points instead to a solid with a finite gap.

TT 23.3 Mon 18:00 P1

Observation of spin-glass behavior in Nd — •LORENZ PECH¹, LUKAS BAUER¹, JIRÍ POSPÍŠIL⁴, CHRISTOPH FRANZ¹, LEO MAXIMOV¹, ANDREAS BAUER^{1,3}, MARC A. WILDE^{1,3}, and CHRISTIAN PFLEIDERER^{1,2,3} — ¹Technical University of Munich (TUM) — ²MCQST, Munich — ³TUM Center for Quantum Engineering — ⁴Charles University, Prague

Frustration and effective disorder in Nd are expected to produce frozen, disordered spins with slow, history-dependent dynamics [1]. We investigate the low-temperature magnetic and electronic properties of single-crystal neodymium to map its complex phase behavior and search for a spin-glass like state. To identify such phases, we combine temperature and field sweeps with ac magnetization (frequency-resolved), dc magnetization (ZFC/FC), and relaxation measurements. From anomalies in $\chi'(T)$, $\chi''(T)$, $M(H)$, and dM/dH along principal crystallographic directions, we construct a T - B phase diagram. Established spin glass freezing criterias are the presence of a ZFC/FC bifurcation, a frequency-dependent shift of the χ' and χ'' peak, and slow non-exponential relaxation [2]. These benchmarks, together with more recent perspectives on complex low-temperature phases in correlated systems, provide the framework for interpreting our Nd data and distinguishing glassy behavior from conventional long-range magnetic order.

[1] Kamber, Umut et al. Science 368, eaay6757 (2020).

[2] K. Binder and A. P. Young, Rev. Mod. Phys. 58, 801 (1986).

TT 23.4 Mon 18:00 P1

Exploring Quantum Phases of Magnetic Skyrmions — •MARC CURRLE, SOPHEAK SORN, and MARKUS GARST — Karlsruhe Institute of Technology, Karlsruhe, Germany

The topological skyrmion density in the continuum theory of two-dimensional magnets obeys both a dipole conservation law and the Girvin-MacDonald-Platzman algebra, suggesting a close correspondence with the quantum Hall problem [1]. Motivated by this observation, we explore quantum phases of skyrmions using analogies with integer and fractional quantum Hall states. Employing an effective description in terms of collective coordinates for skyrmions, we demonstrate that quantum states of the skyrmion many-body system can be represented as holomorphic wavefunctions similar to the states within the lowest Landau level. We highlight the consequences of this correspondence, in particular, the possibility of systematically applying methods from quantum Hall physics to identify skyrmion liquid states. [1] S. Sorn, J. Schmalian, M. Garst, Phys. Rev. X 15, 041037 (2025)

TT 23.5 Mon 18:00 P1

Quantum Phase Transitions of Kitaev's Toric Code on a Honeycomb lattice — •VIKTOR KOTT, MATTHIAS MÜHLHAUSER, JAN ALEXANDER KOZIOL, and KAI PHILLIP SCHMIDT — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

We investigate the robustness of the topological phase of Kitaev's toric code in a uniform magnetic field on the honeycomb (and triangular) lattice using perturbative linked-cluster expansions (LCEs) based on a hypergraph decomposition, together with quantum Monte Carlo (QMC) simulations. The LCE approach allows us to correctly account for the nontrivial mutual exchange statistics of elementary anyonic excitations. By extracting the ground-state energy and excitation energies of the topological phase, we determine the quantum phase transitions out of the topologically ordered state. In addition, we use QMC to explore the full quantum phase diagram. In contrast to the conventional toric code on the square lattice, the ground-state phase diagram depends on the sign of the magnetic field, which distinguishes between unfrustrated and frustrated parameter regimes. This leads to distinct quantum-critical properties and a richer phase diagram.

TT 23.6 Mon 18:00 P1

The XY Toric Code on the Kagome lattice — •CONSTANZE KÖBL, MAXIMILIAN VIEWEG, and KAI PHILLIP SCHMIDT — Department Physik, Staudtstraße 7, 91058 Erlangen

This theoretical work investigates the XY toric code on the Kagome lattice, constituting a generalisation of the 2024 introduced XY checkerboard toric code on the square lattice [1]. Main objectives are deriving ground state and low-excitation properties and further extracting the parameter-dependent quantum phase diagram of the model. Besides a four-spin z -flavour star operator, two kinds of plaquette operators are introduced, including both Pauli x and y interactions and realising a bipartition. Due to the geometry of the lattice, the plaquette operators connect three and six spins each. Star operators still act as symmetries of the Hamiltonian, whereas different plaquette operator types generally do not commute. The behaviour in the limit of isolated plaquettes is examined analytically using first-order perturbation theory, checking for topological order. Further intuition is gained from exact diagonalisation of the full Hamiltonian for a system comprising 24 spins. A duality mapping is performed, giving rise to a self-dual model built from four- and six-spin Ising interactions. Symmetries of the dual model are investigated, and high-order perturbation theory is performed. The general goal is to understand the influence of geometry on the physical properties of topological codes.

[1] M. Vieweg, K.P. Schmidt, Phys. Rev. Res., 7 (2025)

TT 23.7 Mon 18:00 P1

Stochastic series expansion quantum Monte Carlo for quantum lattice models beyond spin 1/2 — •MELANIE A. R. WOLF, ANJA LANGHELD, CALVIN KRÄMER, JAN ALEXANDER KOZIOL, and KAI PHILLIP SCHMIDT — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany

Stochastic series expansion quantum Monte Carlo is a well established

method for the quantitative investigation of quantum spin models with spin 1/2. Especially, the sampling of quantum Ising models with arbitrary interactions [1] without a sign problem, constitutes an important milestone in the development of the method. Therefore, it follows naturally to ask how to transfer this efficient sampling scheme to quantum systems with a larger local Hilbert space like spin-one or quantum Potts models. In our work we implement the stochastic series expansion quantum Monte Carlo scheme [2] and explore the quantum and thermal properties of quantum Potts models.

[1] A. Sandvik, Phys. Rev. E 68, 056701

[2] C. Ding et al., arXiv:1702.02675

TT 23.8 Mon 18:00 P1

Convergence behavior of non-perturbative linked-cluster expansions at criticality — •HARALD LEISER, MAX HÖRMANN, and KAI PHILIP SCHMIDT — Chair for Theoretical Physics V, FAU Erlangen-Nürnberg, Germany

Non-perturbative linked-cluster expansions (NLCE) provide a systematic framework for computing properties of quantum lattice models directly in the thermodynamic limit. For applying it to excited states, we use a transformation T that block-diagonalizes cluster Hamiltonians, like the Schrieffer-Wolff transformation, while satisfying cluster-additivity. In perturbative linked-cluster expansions up to order N , certain classes of transformations all yield identical and exact results at order N . However, in non-perturbative LCE this equivalence breaks down entirely, as the hierarchical structure of contributions is absent. As a result, the non-perturbative effects introduced by different transformations can produce different convergence behavior, also depending on the observable under study. Our goal is to understand how different choices of T influence the convergence behavior and what these differences reveal about the transformations themselves. Furthermore, we aim to understand the role of the transformation T in extracting quantum-critical behavior from NLCEs. For that, we analyze the energy gap of the transverse-field Ising chain at its quantum critical point, since its exact solution reduces the computational complexity to polynomial, enabling comparison up to large system sizes.

TT 23.9 Mon 18:00 P1

Optimized Crystal Synthesis and Anisotropic Magnetism of the 2D Layered Magnets MPSe_3 ($M = \text{Fe, Ni, Mn}$) — •MASOUMEH RAHIMKHANI¹, SAICHARAN ASWARTHAM², MARTIN KOSTKA¹, ASHWINI BALODHI¹, ANDREAS KREYSSIG¹, and ANNA E. BÖHMER¹ — ¹Experimental Physics IV, Ruhr-University Bochum, Bochum, Germany — ²International Centre for Interfacing Magnetism and Superconductivity with Topological Matter, Institute of Physics, Polish Academy of Sciences, Warszawa, Poland

Transition-metal phosphochalcogenides MPSe_3 ($M = \text{Fe, Ni, Mn}$) are important layered van der Waals materials with rich magnetic and electronic behavior. Among them, FePSe_3 is a much investigated layered antiferromagnet with strong potential for applications in two-dimensional spintronics and quantum devices.

Here, we use an additive-free chemical vapor transport technique for growth of single crystals of FePSe_3 . Single crystals reach up to 3 mm in length and show nearly ideal atomic ratio composition in energy-dispersive x-ray spectroscopy. Magnetic measurements reveal an antiferromagnetic transition around 120 K. We studied the effect of substitution at the Fe site on the anisotropic magnetism. We will discuss how substituted $\text{Fe}_{1-x}\text{M}_x\text{PSe}_3$ single crystals can be prepared and how substitution at the Fe site affects the anisotropic magnetism.

TT 23.10 Mon 18:00 P1

Electronic and Magnetic Properties of CaMn_2P_2 and SrMn_2P_2 Single Crystals — •JULE KIRSCHKE, JOSCHA GRUNWALD, T. R. THOMAS, N. S. SANGEETHA, ASHWINI BALODHI, ANDREAS KREYSSIG, and ANNA E. BÖHMER — Experimental Physics IV, Ruhr-University Bochum, Bochum, Germany

CaMn_2P_2 and SrMn_2P_2 are insulators that adopt the trigonal CaAl_2Si_2 -type structure containing corrugated Mn honeycomb layers. Here, we report a systematic study of single crystals grown from Sn flux, including attempts to synthesize $\text{Sr}_{1-x}\text{K}_x\text{Mn}_2\text{P}_2$, which revealed that K does not substitute in the SrMn_2P_2 structure. In contrast, CaMn_2P_2 exhibits an unexpected sensitivity to the Ca content used during growth. While powder x-ray diffraction confirms identical crystal structures for all batches, their transport properties differ drastically. Samples prepared with high Ca content during the growth anomalously show almost metallic temperature dependence of the resistivity, whereas others show the insulating behavior commonly re-

ported in the literature. The electronic and magnetic properties of different samples were studied by heat capacity and magnetization measurements.

We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG) under CRC/TRR 288.

TT 23.11 Mon 18:00 P1

Quantum effects in the magnon spectrum of 2D altermagnets on a square lattice and anisotropic honeycomb lattice via continuous similarity transformations. — •DAG-BJÖRN HERING¹, VANESSA SULAIMAN¹, RAYMOND WIEDMANN³, MATTHIAS R. WALTHER², GÖTZ S. UHRIG¹, and KAI P. SCHMIDT² — ¹Condensed Matter Theory, Technische Universität Dortmund, Otto-Hahn-Straße 4, 44221 Dortmund, Germany — ²Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany — ³Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569, Stuttgart, Germany

We investigate quantum effects on magnon excitations in a minimal spin-1/2 Heisenberg model for 2D altermagnets on the square lattice and for an anisotropic honeycomb lattice. For both, a continuous similarity transformation is applied in momentum space to derive an effective Hamiltonian that conserves the number of magnon excitations. This allows us to quantitatively calculate the one-magnon dispersion, the effects of magnon-magnon interactions, and the dynamic structure factor in a certain range of parameters. For the altermagnet, we focus on the altermagnetic spin splitting of the magnon bands and the size of the roton minimum. For the honeycomb, we additionally analyze the ground state energy and the staggered magnetization. We further analyze the stability of the assumed long-range order and the magnons by different generators.

TT 23.12 Mon 18:00 P1

Spectral densities for inelastic scattering in anisotropic Heisenberg models on mono- and bilayer square lattices and the honeycomb lattice via continuous similarity transformations — •VANESSA SULAIMAN¹, DAG-BJÖRN HERING¹, MATTHIAS R. WALTHER², KAI P. SCHMIDT², and GÖTZ S. UHRIG¹ — ¹Condensed Matter Theory, Technische Universität Dortmund, Otto-Hahn-Straße 4, 44221 Dortmund, Germany — ²Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany

We apply a continuous similarity transformation (CST) [1] with a magnon-conserving generator to the antiferromagnetic anisotropic XXZ model. For the square lattice, the resulting effective Hamiltonian has already been analyzed [2]. We extend the approach by applying the CST to observables as well. Using the continuous fraction representation, we calculate spectral densities for these observables on the square and honeycomb lattice, as well as the bilayer square lattice. These are compared to experimental data from RIXS measurements [3], for example with single-layered $\text{Ca}_2\text{CuO}_2\text{Cl}_2$ and bilayer $\text{Sr}_3\text{Ir}_2\text{O}_7$. [1] M. Powalski et al., Phys. Rev. Lett. **115**, 207202 (2015) and SciPost Phys. **4**, 001 (2018)

[2] M. R. Walther et al., Phys. Rev. Research **5**, 013132 (2023)

[3] K.-J. Zhou et al., J. Synchrotron Rad. **29**, 563 (2022)

TT 23.13 Mon 18:00 P1

Hall Response, Angular Magnetoresistance, and Field-Induced Metamagnetism in $\text{Sr}_4\text{Ru}_3\text{O}_{10}$ — •ILKE MASA¹, SIMONE SEIPEL¹, LARA PÄTZOLD¹, ZAHRA GHAZINEZHAD¹, AGUSTINUS AGUNG NUGROHO², MARKUS BRADEN¹, and THOMAS LORENZ¹ — ¹Institute of Physics II; University of Cologne, Germany — ²Bandung Institute of Technology, Indonesia

$\text{Sr}_4\text{Ru}_3\text{O}_{10}$ is a ferromagnetic metal with $T_C \approx 105$ K and exhibits an additional metamagnetic transition below 50 K, whose microscopic origin remains unclear. We investigate single crystals to characterize the anisotropy of magnetization and electrical transport. For in-plane currents, we measure both the normal and anomalous Hall effects, finding a non-monotonic temperature dependence and a low-temperature sign reversal of the anomalous Hall signal, similar to behavior known from SrRuO_3 and associated with Weyl points in its band structure. Due to the layered crystal structure, the out-of-plane resistivity is highly anisotropic ($\rho_c \gg \rho_{ab}$) and shows pronounced changes across the metamagnetic transition. From magnetoresistance data, we extract the field-induced metamagnetic transition at low temperatures and analyse the angular dependence of both the transition fields and the in-plane magnetoresistance. We also identify a clear angular magnetoresistance response in $\text{Sr}_4\text{Ru}_3\text{O}_{10}$. Possible low-temperature phases remain sub-

jects of ongoing research.

Funded by the DFG via CRC 1238 projects A02, B01 and B04.

TT 23.14 Mon 18:00 P1

Heat Transport and Thermodynamic Properties of the Quasi-Two-Dimensional Quantum Magnet $\text{Cu}_2(\text{OH})_3\text{Br}$ — •NAINISH TICKOO¹, ROHIT SHARMA¹, LUCAS BERGER¹, ZHIYING ZHAO², ZHE WANG³, and THOMAS LORENZ¹ — ¹Institute of Physics II, University of Cologne, D-50937 Cologne, Germany — ²State Key Laboratory of Structural Chemistry, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou, Fujian 350002, China — ³Department of Physics, TU Dortmund University, D-44227 Dortmund, Germany

$\text{Cu}_2(\text{OH})_3\text{Br}$ is a quasi-two-dimensional quantum magnet that can be seen as a system of coupled antiferromagnetic spin-1/2 chains. Specific heat, magnetisation and magnetostriction measurements have shown pronounced anomalies at $T_N = 9.3$ K. These measurements, along with Monte Carlo simulations, have shown that below the T_N , the system undergoes a field-induced transition from a 3D ordered state to a partially decoupled state when a magnetic field ($B_c = 16.3$ T) is applied transverse to the ordered spins. This transition is interpreted as a dimensional reduction arising from the distinct responses of the AFM chains to an external magnetic field [1]. This study examines the thermal conductivity κ (T, B) of $\text{Cu}_2(\text{OH})_3\text{Br}$ single crystals under magnetic fields applied along the crystallographic b axis. Strong anomalies in κ near T_N reveal a significant interplay between phonons and magnetic excitations in low-temperature heat transport

Funded by the DFG via CRC 1238 Projects A01, B01 and B04.

[1] A. Reinold et al., Phys. Rev. B 111, L100405 (2025)

TT 23.15 Mon 18:00 P1

Magnetic and Electronic Transport Behavior in Cr-Based Quantum Materials — •SHITAO QU, RAN TAO, MENG MENG LONG, MAD S FONGER HANSEN, and F. MALTE GROSCHKE — Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

Unconventional superconductivity among transition metal compounds is seen in Cu-, Fe- and most recently Ni-based materials. What about other transition metal systems? There are a surprising number of **chromium**-based superconductors, often in conjunction with applied pressure: CrAs , $\text{A}_2\text{Cr}_3\text{As}_3$ (with A an alkaline metal), ACr_3As_3 , and CsCr_3Sb_5 . Moreover, CrSb is one of the best-studied metallic altermagnets. These findings motivate a wider study of Cr-based correlated electron materials.

We initially investigate (i) CrP – an isostructural and isoelectronic relative to CrAs, (ii) CrSe – an altermagnet candidate, and (iii) the Kagome lattice systems CsCr_3Sb_5 and CsCr_6Sb_6 .

Single crystals are prepared via flux and vapour-transport techniques and characterised in standard X-ray, magnetometry and transport measurements. They enable studies of the electronic structure and magnetic/superconducting phase diagram, forming a promising basis for exploring correlated-electron behavior in Cr-based quantum systems more widely.

TT 23.16 Mon 18:00 P1

Correlated Electronic Structure of Layered Cathode Material LiMnO_2 — •OWEN COLIRE, FRANCESCO CASSOL, and SILKE BIERMANN — Centre de Physique Théorique (CPHT), Ecole Polytechnique, Institut Polytechnique de Paris, CNRS, Palaiseau, France

Electronic Coulomb correlations are ubiquitous in transition metal compounds. Our work focuses on layered LiMnO_2 , a cathode material used in Li-ion batteries, which crystallizes in a monoclinic structure with alternating Lithium and MnO₆ layers. The compound is a Mott insulator with a high-spin d₄ configuration undergoing a transition to an antiferromagnetically ordered state below the Néel temperature of 250 K. We investigate the electronic structure using Density Functional Theory calculations and combined Density Functional - Dynamical Mean Field Theory, with an emphasis on the interplay of the intra-atomic Hund's exchange coupling and crystal field splittings.

TT 23.17 Mon 18:00 P1

Non-equilibrium Charge Dynamics at the metal-insulator transition in κ -(BETS)₂Mn[N(CN)₂]₃ — •SANGEETA PANWAR¹, TIM THYZEL¹, JENS MÜLLER¹, MARK KARTSOVNIK², and NATALIA KUSHCH³ — ¹Institute of Physics, Goethe-Universität Frankfurt, Frankfurt (Main), Germany — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — ³private

Low-dimensional molecular conductors have been shown to host electronic ferroelectricity, where electronic degrees of freedom cause polar order, allowing for fast switching and phase control [1]. Using fluctuation spectroscopy, we recently investigated the nature of electronic ferroelectricity in the organic conductor κ -(BETS)₂Mn[N(CN)₂]₃ [2], representative of a broader class of quasi two-dimensional correlated electron systems. Here, we explore how these phenomena evolve when tuning the bandwidth by applying hydrostatic pressure. We will investigate the slow dynamics of polar nanoregions (PNR) and the evolution of drastic changes in the dynamics as the system is tuned from the insulating to the superconducting phase. By employing fluctuation spectroscopy under pressure, we aim to study how superconductivity emerges from the ferroelectric/multiferroic insulating state and to examine how PNR formation and glassy dipolar freezing evolve [3].

[1] Lang et al., J. Electronic Materials 54, 5087 (2025)

[2] Thomas et al., npj Spintronics 2, 24 (2024)

[3] Zverev et al. PRB 82, 155123 (2010)

TT 23.18 Mon 18:00 P1

Ru L-edge RIXS on the dimer compound $\text{Ba}_3\text{CeRu}_2\text{O}_9$: a cluster Mott insulator? — •LARA PÄTZOLD¹, FREDERIK PAECH¹, ENRICO BERGAMASCO¹, HENRIK SCHILLING², ANNA SANDBERG³, HLYNUR GRETARSSON⁴, PETRA BECKER-BOHATÝ², MARIA HERMANN³, and MARKUS GRÜNINGER¹ — ¹II. Physikalisches Institut, University of Cologne, Germany — ²Kristallographie, University of Cologne, Germany — ³KOMKO, University of Stockholm, Sweden — ⁴DESY, Hamburg, Germany

Cluster Mott insulators host charge carriers in quasi-molecular orbitals on, e.g., dimers or tetramers [1-2]. With strong spin-orbit coupling, this may yield unconventional quasi-molecular magnetic moments tunable via, e.g., intracluster hopping. Cluster Mott insulators emerge in 5d transition-metal compounds due to large hopping, whereas in 3d materials one expects conventional Mott behavior with carriers localized on individual sites. To clarify whether cluster Mott insulators are realized in 4d compounds, we address the electronic structure of $\text{Ba}_3\text{CeRu}_2\text{O}_9$ that hosts Ru_2O_9 dimers with 4 t_{2g} holes. Ru L-edge RIXS and exact diagonalization reveal a rich excitation spectrum on top of an intricate non-magnetic ground state in the intermediate regime. Compared to 5d cluster Mott insulators, $\text{Ba}_3\text{CeRu}_2\text{O}_9$ shows reduced intracluster hopping, smaller spin-orbit coupling, and larger electronic correlations, realizing an intriguing part of phase space.

[1] Revelli *et al.*, Sci. Adv. 5, eaav4020 (2019).

[2] Magnaterra *et al.*, PRL 133, 046501 (2024).

TT 23.19 Mon 18:00 P1

Sample-Based Quantum Diagonalization of Similarity-Transformed Hamiltonians for Strongly Correlated Systems — •EMANUELE RICCI^{1,2} and WERNER DOBRAUTZ^{1,2,3,4} — ¹Technical University Dresden, 01069 Dresden, Germany — ²Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 01069 Dresden, Germany — ³Center for Advanced Systems Understanding, 02826 Görlitz, Germany — ⁴Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

One of the central challenges in electronic structure theory is the accurate description of strongly correlated systems. We address this using a hybrid quantum-classical scheme, sample-based quantum diagonalization, in which a quantum computer acts as a dedicated sampler to identify a compact, problem-adapted subspace of important Slater determinants. The corresponding reduced Hamiltonian is then diagonalized classically to obtain the ground state. To mitigate quantum errors, we apply a classical post-processing step that projects samples onto the correct particle-number sector.

Before sampling, we perform a similarity transformation of the Hamiltonian that concentrates the ground-state weight into a smaller set of determinants, reducing the relevant subspace and improving accuracy at the cost of a non-Hermitian effective Hamiltonian. While non-Hermiticity would ordinarily hinder quantum algorithms, we demonstrate that it can still be exploited within a sampling-based framework using the UCJ (unitary cluster Jastrow) ansatz initialized with single and double amplitudes from the transformed Hamiltonian.

TT 23.20 Mon 18:00 P1

A Local-Wave Basis for the Hubbard Model — •LEON WASTL^{1,2} and WERNER DOBRAUTZ^{1,2,3,4} — ¹Center for Advanced Systems Understanding, 02826 Görlitz, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — ³Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 01069

Dresden, Germany — ⁴Technical University Dresden, 01069 Dresden, Germany

The Fermi-Hubbard model is the prototypical model for interacting electrons and can be employed to describe a wide variety of physical phenomena. Its 2D version is believed to contain the fundamental physics describing low-temperature superconductivity. We present a new basis for the two-dimensional Hubbard model which we call the local-wave basis as it is a hybrid between real space and momentum space. We numerically study the advantages of our newly found transformation using the density matrix renormalization group (DMRG). Since DMRG in its more recent form is a method that is inherently one-dimensional as it is built on top of the matrix product state (MPS) formalism, we combine our local-wave basis with a new way of ordering the sites in the MPS based on a modified version of simulated annealing (SA) using the two-site mutual information as its objective function. Combined with this approach to find the optimal ordering, we show that our method yields lower energies for the same maximal bond dimension than both the pure momentum space and the real space formulation in the low to intermediate U/t regime.

TT 23.21 Mon 18:00 P1

Calculating Moments for Many-Electrons Systems — ●ELAHEH ADIBI and ERIK KOCH — Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany

We describe an approach for computing the M^{th} moment of an N -electron system, defined as $\langle E^M \rangle = \text{Tr } H^M$. Since the Hamiltonian H consists of pairs of creation-annihilation operators and the calculation is performed in the basis of Slater determinants $\{|I\rangle\}$, the matrix element $\langle I|H^M|I\rangle$ contributes to the moment only when the orbital indices of the creation operators form a permutation of those of the annihilation operators. Writing the permutations in cycle notation, the simplest contributions arise from permutations creating a single cycle in which all orbitals are different. These permutations are classified by their number of descents. Permutations with the same number of descents contribute equally to $\sum_I \langle I|H^M|I\rangle$. Since the number of permutations with the same number of descents is given by the Eulerian numbers, it suffices to compute the trace for one permutation and multiply the result by this number. In this way the trace can be evaluated combinatorially, without explicitly constructing the many-body Hilbert space. We are able to calculate the all other permutations with respect to these permutations. Finally, we present a recursive formula for the moment that is computationally efficient.

TT 23.22 Mon 18:00 P1

Polynomial Neural Networks in Quantum Many-Body Physics — ●ASHISH YASHWANTH KANGEN^{1,2} and WERNER DOBRAUTZ^{1,2,3,4} — ¹Technical University Dresden, 01069 Dresden, Germany — ²Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 01069 Dresden, Germany — ³Center for Advanced Systems Understanding, 02826 Görlitz, Germany — ⁴Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Polynomial neural networks were originally derived by applying tensor decompositions to high-order weight tensors. This derivation yields a model architecture that is inherently non-linear through Hadamard products, effectively eliminating the need for standard, tensor-unfriendly activation functions like ReLU.

In this work, we investigate the utility of this architecture within the context of quantum many-body physics and chemistry. We demonstrate that the algebraic properties of these polynomial expansions allow them to serve as robust, activation-free representations of complex quantum correlations. We explore two specific applications: (1) as a standalone wave function ansatz, which can be optimised via both deterministic Density Matrix Renormalization Group sweeps and Variational Monte Carlo, and (2) as a Jastrow correlation factor within the Transcorrelated approach for Quantum Chemistry, trainable via standard gradient-based machine learning optimisation. This framework suggests that the tensor structure underlying polynomial networks offers a flexible and numerically stable bridge between classical deep learning and quantum simulation.

TT 23.23 Mon 18:00 P1

Quantics tensor trains: Quantifying entanglement across length scales — STEFAN ROHSHAP¹, JHENG-WEI ROHSHAP², ●ALENA LORENZ³, SERAP HASIL¹, KARSTEN HELD¹, ANNA KAUCH¹, and MARKUS WALLERBERGER¹ — ¹TU Wien — ²Univ. Grenoble Alpes — ³JMU Würzburg

Understanding entanglement remains one of the most intriguing problems in physics. In contrast to particle and site entanglement, length or energy scale entanglement, quantifying the information exchange between different length scales, has received far less attention. Here, we identify the quantics tensor train (QTT) technique, a matrix product state-inspired approach for overcoming computational bottlenecks in resource-intensive numerical calculations, as a renormalization group method by analytically expressing an exact cyclic reduction-based real-space renormalization scheme in QTT language. We precisely match the QTT bond dimension, a measure of length scale entanglement, to the number of rescaled couplings generated in each coarse-graining renormalization step and present our results for the one-dimensional tight-binding model with n -th-nearest-neighbor hopping. Furthermore, though analytically unfeasible, we numerically generate the bond-dimension of the two- and three-dimensional case of the interacting and non-interacting Green's function in momentum space and find, that for the interacting as well as for the one-dimensional non-interacting Green's function, the bond dimension saturates when lowering the temperature.

TT 23.24 Mon 18:00 P1

DMFT-Lanczos study of Alkali-Doped Fullerides: Superconductivity across the (U, J) plane — ●LARA BREMER, LORENZO CRIPPA, IGOR KRIVENKO, and TIM O. WEHLING — I. Institute of Theoretical Physics, University of Hamburg, Notkestraße 9-11, 22607 Hamburg

Alkali-doped fullerides (A_3C_{60}) provide a versatile platform for studying unconventional s -wave superconductivity in a strongly correlated setting, where superconducting phases emerge in close proximity to Mott insulating states. These molecular superconductors exhibit critical temperatures up to about 40 K. Theoretical descriptions of alkali-doped fullerides commonly employ a three-orbital Hubbard-Kanamori model whose defining feature is an effective negative Hund's coupling arising from the coupling of the electronic states to intramolecular Jahn-Teller phonon modes, thereby reversing the usual Hund's rules.

In this contribution we present calculations performed with the multi-orbital Lanczos impurity solver of the EDIPack library within a dynamical mean-field theory framework. We explore the (U, J) interaction space, focusing on the evolution from the regime of weak negative Hund's coupling to regimes with strongly negative Hund's coupling. We analyze how the interplay between the Mott insulating phase present for large Hubbard interaction U and the charge-disproportionated insulating phase present for large negative values of J influences the character of the superconducting states and changes critical temperatures.

TT 23.25 Mon 18:00 P1

Investigating Non-Hermitian Dynamics in Neural Quantum States — ●MOHAMMED BOKY^{1,2} and WERNER DOBRAUTZ^{1,2,3,4} — ¹Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 01069 Dresden, Germany — ²Technical University Dresden, 01069 Dresden, Germany — ³Center for Advanced Systems Understanding, 02826 Görlitz, Germany — ⁴Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Both the Neural Quantum States (NQS) and the Transcorrelated (TC) method have proven to be impactful approaches in Ab Initio quantum chemistry and quantum many-body settings. The potential of combining these methods remains largely unexplored. In this work, the application and impact of the combination of these methods are explored with a focus on the computational cost.

The application of the similarity transform in the TC method yields non-Hermitian Hamiltonians. The optimization and impact of this non-Hermiticity on NQS dynamics pose both a great challenge and a source of unexplored possibilities to navigate physics with correlations that differ in magnitude.

In order to investigate both the impact and challenges of these methods, a study is done on a variety of different systems. These systems range from Ab Initio quantum chemistry problems such as hydrogen chains, to lattice models such as the non-Hermitian Transverse Field Ising and the Hubbard model.

TT 23.26 Mon 18:00 P1

Non-equilibrium DMFT solved with the help of Tensor Cross Interpolation — ●BASTIAN SCHINDLER¹, EVA PAPROTZKI^{1,2}, and MARTIN ECKSTEIN^{1,2} — ¹I. Institute for Theoretical Physics, University of Hamburg, Notkestraße 9-11, 22607 Hamburg, Germany — ²The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

The non-perturbative solution of the quantum impurity problem provides the biggest computational challenge when DMFT is applied in non-equilibrium. Most applications of non-equilibrium DMFT are based on simplified perturbative solutions [1]. In diagrammatic approaches to the impurity model, the numerical integration of high-dimensional expressions poses the main computational bottleneck, limiting feasible expansion orders and the number of accessible time steps. Tensor Cross Interpolation (TCI) has recently emerged as a powerful technique to mitigate the exponential scaling of computational cost with dimensionality [2]. In this work, we apply TCI to diagrammatic expressions obtained from a pseudo-particle expansion of the hybridization around the atomic limit in the non-equilibrium steady state. We demonstrate that, with an appropriate parametrization and an FFT-based integration scheme [3], TCI yields a significant speed-up for higher-order contributions. Moreover, we employ TCI to efficiently evaluate the multidimensional integrals required for higher-order spectroscopy, in particular time-resolved resonant inelastic x-ray scattering. [1] Murakami et al., Rev. Mod. Phys. 97.3 (2025) [2] Núñez Fernández, et al., SciPost Physics 18.3 (2025) [3] Eckstein, arXiv:2410.19707 (2024)

TT 23.27 Mon 18:00 P1

Stochastic semiclassical electron-lattice dynamics with DMFT — •TOM KAHANA, FRANCESCO VALIERA, and MARTIN ECKSTEIN — I. Institute of Theoretical Physics, University of Hamburg, Hamburg, Germany

The interplay between lattice motion and strongly correlated electronic phases poses a major challenge in nonequilibrium condensed-matter systems, especially near phase transitions where ionic distortions strongly affect the electronic state. We address this problem by solving the coupled electron-lattice dynamics using a quasi-equilibrium (adiabatic) Dynamical Mean-Field Theory on an inhomogeneous lattice defined by the instantaneous phonon configuration. Conservative forces, friction, and stochastic contributions to the lattice dynamics are obtained from the electronic correlation functions. Because each lattice site must be treated as an impurity embedded in a self-consistent bath, this approach is computationally demanding. To make it feasible, we replace the DMFT impurity solver with a trained neural-network emulator that reproduces high-order impurity solutions. This NN-accelerated DMFT loop enables computationally efficient simulations of the coupled electron-lattice dynamics on inhomogeneous lattices. We present benchmarks for the Hubbard-Holstein model. The method provides a path toward simulations of photo-induced transitions in correlated materials, such as Mott and charge-ordered states.

TT 23.28 Mon 18:00 P1

Superradiance in Higher-Order Correlated Collective Emission — •DANIIL PLATONOV^{1,2}, XIN H. H. ZHANG^{1,2,3}, and PETER RABL^{1,2,3} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

We investigate supercorrelated decay of an initially inverted ensemble of two-level emitters, where cooperative emission is governed by higher powers of the collective decay operator beyond conventional Dicke superradiance. We develop a qualitative theoretical framework that captures the essential mechanism of generalized supercorrelated decay and predicts the corresponding scaling laws. This framework clarifies the physical distinctions between conventional superradiance and higher-order supercorrelated emission. We further analyze the phenomenon in a waveguide quantum electrodynamics setting, where guided modes mediate strong collective interactions. By deriving an effective semiclassical theory, we obtain a computationally efficient description that enables large-scale simulations of the dynamics.

TT 23.29 Mon 18:00 P1

Hierarchy of timescales in a disordered spin-1/2 XX ladder — •KADIR ÇEVEN, LUKAS PEINEMANN, and FABIAN HEIDRICH-MEISNER — Institut für Theoretische Physik, Georg-August-Universität Göttingen, Göttingen, Germany

Understanding the timescales associated with relaxation to equilibrium in closed quantum many-body systems is one of the central focuses in the study of their non-equilibrium dynamics. At late times, these relaxation processes exhibit universal behavior, emerging from the inherent randomness of chaotic Hamiltonians. In our work [1], we investigate a disordered spin-1/2 XX ladder – an experimentally realizable model

known for its diffusive dynamics – to explore the connection between transport properties and spectral measures derived solely from the system's energy levels via these relaxation timescales. We begin by analyzing the spectral form factor, which yields the time when the system begins to follow the random matrix theory (RMT) statistics, known as the RMT time. We then determine the Thouless times – the average times for a local excitation to diffuse across the entire finite system – through the linear-response theory for both spin and energy transport. Our numerical results confirm that the RMT time scales quadratically with system size and upper bounds the Thouless times. Interestingly, we also find that, unlike other non-integrable models, spin diffusion proceeds faster than energy diffusion.

Supported by the DFG via FOR 5522.

[1] K.Çeven, L. Peinemann, F. Heidrich-Meisner, arXiv:2509.20078(2025).

TT 23.30 Mon 18:00 P1

Charge carrier relaxation dynamics in the one-dimensional Kondo lattice model — •ARTURO PEREZ ROMERO, MICA SCHWARM, and FABIAN HEIDRICH-MEISNER — Institut für Theoretische Physik, Georg-August-Universität Göttingen, D-37077 Göttingen, Germany

A generic question in the field of ultrafast dynamics is concerned with the relaxation dynamics and the subsequent thermalization of optically excited charge carriers. Among several possible relaxation channels available in a solid-state system, we focus on the coupling to magnetic excitations. In this paper, we study the real-time dynamics of a paradigmatic model, the Kondo lattice model in one dimension. We conduct a comprehensive study of the relaxation processes by evaluating the spin polarization of the conduction electron, the local spin-spin correlation between localized and conduction electrons, and the electronic momentum distribution. While in the well-studied cases of one or two charge carriers in a ferromagnetic background, no thermalization occurs, we demonstrate that the stationary state is compatible with thermalization if either the electronic filling is finite or the magnetic background is in the singlet sector. Our real-time simulations using the time-dependent Lanczos method are corroborated by a direct comparison with finite-temperature expectation values and an analysis of the spectrum in terms of the gap ratio.

This work was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) via CRC 1073.

TT 23.31 Mon 18:00 P1

Collective dynamics in SmNiC₂ probed by time resolved spectroscopy — •PRIYANKA YOGI¹, CHANDRA V KOTYADA¹, BHAGEERATH SWARAJ¹, AMON. P LANZ¹, AMIR.A HAGHIGHIRAD², SOFIA. M SOULIOU², MATTHIEU LE TACON², and JURE DEMSAR¹ — ¹JGU Mainz — ²KIT

Rare-earth transition-metal carbides RNiC₂ are a unique class of intermetallic compounds that crystallize in a non-centrosymmetric orthorhombic CeNiC₂-type structure. Except for LaNiC₂ and CeNiC₂, where exotic superconductivity has been reported, most members of this family exhibit quasi-1D charge-density-wave (CDW) order and competing magnetic order at low temperature. SmNiC₂ is unique, where an incommensurate CDW order appearing below $T_{CDW} \approx 148$ K gets fully suppressed below a first-order transition into a ferromagnetic (FM) phase at $T_M \approx 18$ K.

Here, we employ optical pump-probe spectroscopy to investigate the interplay between the FM and CDW phases by probing single-particle and collective dynamics as a function of temperature. The FM phase is characterized by rather slow (10 ps) demagnetization dynamics, while in the CDW phase, we observe characteristic CDW collective modes. The dominant amplitude mode is found at 1.45 THz, showing pronounced softening towards T_{CDW} . Excitation density-dependent studies provide additional information on the strength of the two phases.

TT 23.32 Mon 18:00 P1

High precision physics in Anderson impurity models, from neutrino mass to axion production in the sun. — •VERA BUTZ and MAURITS W HAVERKORT — Universität Heidelberg, Institut für theoretische Physik, Philosophenweg 19, 69120 Heidelberg

High-precision comparisons between experimental measurements and numerical simulations not only test the accuracy of computational methods but also offer deeper insights into fundamental physics. In this work, we investigate how charged ions with multiple electrons interact with continuum states, such as photons, free electrons, or as-yet-unobserved particles. This is achieved by using a generalized Anderson impurity model, in which the interactions can be described via the

self-energy or hybridization function. The real part of the self-energy induces energy shifts in atomic multiplets, such as the Lamb shift, while the imaginary part results in finite lifetimes for excited states, leading to phenomena like fluorescence or Auger-Meitner decay. Using this method of high-precision calculations of decay rates, on highly charged heavy ions in laboratory or astrophysical settings, allows us to probe the Standard Model. Be that by measuring unknowns, like the neutrino mass [1] or discovering new potential particles like dark matter candidates [2].

[1] Nat. Phys. 20, 921 (2024)

[2] JCAP 09 (2021) 006

TT 23.33 Mon 18:00 P1

Critical dynamics at isostructural instabilities — ●NICK SANDER — Karlsruhe Institute of Technology

At an elastic structural instability at least one of the elastic moduli vanishes. An acoustic phonon only softens at such an instability if it is accompanied with a change of crystal symmetry. At isostructural transitions with vanishing bulk modulus, however, no softening occurs and all microscopic phonon modes remain non-critical [1]. Nevertheless, we demonstrate that there exist four macroscopic critical elastic modes that will determine the critical dynamics at such an instability. These modes represent conformal symmetry transformations and the displacement vector satisfy a corresponding Killing equation, whose exact form depends on the crystal symmetry. We discuss implications for instabilities in correlated materials like the Mott metal-insulator transition, and realizations with mechanical metamaterials.

[1] R. A. Cowley, Phys. Rev. B 13, 4877 (1976)

TT 23.34 Mon 18:00 P1

Quantum geometry in the context of many-body perturba-

tion theory — ●MARIO GEOFFROY and CORENTIN MORICE — Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS, Orsay, France

Quantum geometry gives rise to some of the most topical physical phenomena in the past decades, but our current understanding of it remains based on single-particle topological band theory, and fails in the presence of electronic correlations [1]. This is particularly problematic given the overwhelming usage of density functional theory for the diagnosis of topological states in materials [2]. Many-body generalizations of the Chern number and other invariants have been put forward, but many-body quantum geometry remains elusive. We study the influence of electronic interactions on the Berry curvature in tractable systems, in view of developing formalisms adapted to accurate predictions in real materials.

[1] J. Vidal et al., PRB 84, 041109(R) (2011)

[2] B. Bradlyn et al., Nature 547, 298 (2017)

TT 23.35 Mon 18:00 P1

Higher-harmonic generation in the driven Mott-Hubbard model — ●ABDELRAHMAN AZAB, FRIEDEMANN QUEISSER, and RALF SCHEUTZHOLD — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany

Motivated by recent experiments, we study the generation of higher harmonics in the Mott insulator state of the Fermi-Hubbard model under the influence of an oscillating external electromagnetic field, see also [1]. We find a strong dependence of the higher-harmonic intensity on the spin order (e.g., anti-ferromagnetic versus paramagnetic phase).

Funding by the DFG through the SFB 1242 is gratefully acknowledged.

[1] F. Queisser and R. Schützhold, Phys. Rev. B 109, 205110 (2024).

TT 24: Focus Session: Quantum Sensing with Solid State Spin defects I (joint session TT/MA)

The electron spins of defects in solid state materials show remarkable quantum coherence, making them excellent sensors. Recent advances in material engineering and measurement techniques lead to continuous improvements in the sensitivity and resolution of established single spin sensors such as the Nitrogen-Vacancy center in diamond, and the development of new defect sensors in materials such as Silicon Carbide and hexagonal Boron Nitride. In condensed matter physics, such sensors are often being used for exploring the structure of magnets, superconductors, topological phases, etc. This focus session will highlight most of the recent experimental and theoretical advances, current challenges, and emerging directions, focusing both on the improvements of the defects themselves, and their use for exploring novel phenomena in condensed matter physics.

Coordinators: Aparajita Singha (TU Dresden), Uri Vool (Max Planck Institute for Chemical Physics of Solids)

Time: Tuesday 9:30–12:45

Location: HSZ/0003

Topical Talk TT 24.1 Tue 9:30 HSZ/0003
Exploring nanoscale van der Waals magnetism using single spin microscopy — ●PATRICK MALETINSKY — Basel University, Departement of Physics, Klingelbergstrasse 82, 4056 Basel

Atomically thin van der Waals (vdW) magnets provide a unique platform to explore magnetism in the ultimate two-dimensional limit [1]. Their weak interlayer coupling, tunable anisotropy, and gate sensitivity enable engineering of magnetic order and spin textures at the atomic scale. However, their small magnetic moments, nanoscale domains, and complex coupling make them difficult to probe experimentally [2].

I will present recent progress in understanding vdW magnetism using single-spin magnetometry based on nitrogen-vacancy centers in diamond. This quantum-sensing technique enables nanoscale imaging of magnetic order, phase transitions in few-layer systems under ambient and cryogenic conditions. I will show how this approach reveals microscopic mechanisms of magnetism in layered materials and uncovers phenomena such as "lateral exchange bias" and spin-reorientation transitions in ultrathin magnets [3,4].

I will conclude with an outlook on how quantum sensors can advance the study of correlated and topological magnetism in vdW materials [5], and how combining them with strain, gating, or optical control may enable designer spintronic and magnonic systems.

[1] Science 363, 706; Nat. Nanotechnol. 14, 408 [2] Science 364, 973 [3] Nat. Commun. 15, 6005 [4] Nat. Commun. 16, 9725 [5] Nat. Rev. Phys. 6, 753

Topical Talk TT 24.2 Tue 10:00 HSZ/0003
Optically addressable spin defects in two-dimensional materials — ●VLADIMIR DYAKONOV — Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany

Two-dimensional (2D) materials have emerged as the new playground for quantum photonics devices. Among them, hexagonal boron nitride (hBN) is an interesting candidate, mainly because of its crystallographic compatibility with different 2D materials, but also because of its ability to harbour optically active defects generating single photons. The negatively charged boron vacancy was the first intrinsic, optically addressable spin defect in hBN that allows coherent control at room temperature, as reported in 2020. [1] Although other types of spin centers have been found in this material since then, this spin-1 color center remains the only one with a clearly elucidated structure. Practical applications of hBN spin centres as intrinsic magnetic field, temperature, etc. sensors in van der Waals heterostructures are hence envisioned. To further boost the quantum sensing applications of this spin defect in hBN, we investigated the dynamics of the intermediate

state, because it is likely to trap electrons for a certain time, which affects the subsequent sensing protocol when the pulsed magnetic resonance experiment is designed.[2] Finally, we found that spin defects exhibit a direct correlation between Raman features and PL intensity, which allowed us to develop an all-optical method for determining the absolute spin defect density in flakes. [3]

[1] A. Gottscholl et al., Nat. Mater. 19, 540 (2020)

[2] P. Konrad et al., arXiv:2503.22815 [quant-ph] (2025)

[3] A. Patra et al., Adv. Funct. Mater. e17851 (2025).

Topical Talk TT 24.3 Tue 10:30 HSZ/0003
Nitrogen vacancy centers in diamond as novel sensing and imaging tool for magnetic nanostructures, in life science and chemistry — SEBASTIAN WESTRICH¹, NIKHITA KHERA¹, EMMA RESMANN¹, EPHRAIM SPINDLER¹, KRISTIN KÜHL¹, ALENA ERLÉNACH¹, MATHIAS WEILER¹, GEORG VON FREYMAN¹, ARTUR WIDERA¹, MARIA WÄCHTLER², STEFANIE MÜLLER-SCHÜSSELE³, and •ELKE NEU-RUFFING¹ — ¹Department of Physics and Research Center Optimas, RPTU Kaiserslautern Landau, Erwin-Schrödinger-Straße 56 67663 Kaiserslautern — ²Institut für Physikalische Chemie, Christian-Albrechts-Universität zu Kiel — ³Department of Biology, RPTU Kaiserslautern Landau

Nitrogen vacancy centers (NV centers) locally probe magnetic fields, electric fields and temperature. Advantages of NV sensors include their sensitivity for fluctuating magnetic fields, which can be harnessed e.g. to detect free radicals. Additionally, near field based energy transfer serves as sensing resource to detect optically-active dipoles in close proximity. The talk will summarize our work on using scanning NV-based magnetometry to characterize magnetic nanostructures, including calibrating the scanning NV's position with respect to the sample. We highlight work on imaging frustrated magnetic systems (spin ice) as well as magnetic structures obtained via Direct Laser Writing. As another route towards broadening the field of applicability, we demonstrate for the first time near field energy transfer between NV centers and a naturally occurring fluorophore, namely chlorophyll. We furthermore explore routes to employ NV centers as sensor in photocatalysis.

15 min. break

Topical Talk TT 24.4 Tue 11:15 HSZ/0003
Electron spin, nuclear spin, and optical properties of transition-metal defects in silicon carbide with perspectives for quantum technologies — •GUIDO BURKARD — Department of Physics and IQST, University of Konstanz, 78457 Konstanz, Germany
 Transition-metal (TM) defects in silicon carbide (SiC) have emerged as a promising solid-state platform for quantum technologies, particularly because certain species, such as vanadium, provide optical emission in the telecom band and thus enable efficient spin-photon interfaces and quantum memories. In parallel, high-spin nuclei in solids are attracting growing interest for quantum information processing due to their long coherence times and intrinsically large Hilbert spaces, which support advanced protocols in quantum communication, measurement-based quantum computing, and quantum sensing, as well as explorations of fundamental quantum phenomena. A scalable route toward quantum networking relies on modular devices that combine an optically addressable electronic spin with one or more nuclear-spin qubits. We present a theoretical framework for TM defects in SiC. We model the spin and optical structure of a single active 3d electron, revealing how crystal fields and spin-orbit coupling modify selection rules, the g-tensor, and Rabi dynamics. We derive the effective hyperfine interaction within the spin-orbit-induced Kramers doublets and analyze nuclear-electron state transfer. Building on these insights, we propose a driven, dissipative protocol for robust nuclear-spin polarization and investigate how strain engineering can tailor electronic levels, optical Λ systems, and spin initialization pathways.

Topical Talk TT 24.5 Tue 11:45 HSZ/0003
Statics and dynamics of complex magnetic states in microstructures — •AURORE FINCO — Laboratoire Charles Coulomb,

CNRS and University of Montpellier, Montpellier, France

Scanning NV center microscopy is a versatile technique allowing both the mapping of static magnetic textures [1] and of microwave fields, which can be generated for example by spin waves. Here I will focus on the investigation of microstructures.

I will first show how we can use magnetoelectric coupling in the anti-ferromagnetic multiferroic bismuth ferrite to pattern a thin film using electric field and create whirling textures of both electric polarization and magnetization [2].

In a second part, I will discuss ferromagnetic microstructures, in the room-temperature van der Waals magnet Fe₅GeTe₂, demonstrating the stabilization of vortices [3], and in permalloy, which hosts either a S state or a vortex. In this material and when choosing the appropriate dimensions for the microstructures, spin wave modes with frequencies in the vicinity of 2.87 GHz are present and can therefore be probed and imaged. Through the handedness of the stray field that these spin wave mode produce, we can even discriminate between several modes with similar frequencies.

[1] Finco and Jacques, APL Materials 11, 100901 (2023)

[2] Chaudron et al, Nature Materials 23, 905 (2024)

[3] Sfeir et al, Physical Review Materials 9, 114003 (2025)

TT 24.6 Tue 12:15 HSZ/0003
Probing Vortex Dynamics in 2D Superconductors with Scanning Quantum Microscope — •MALIK LINGER¹, SREEHARI JAYARAM¹, LUCAS PUPIM², RUOMING PENG¹, MATHIAS SCHEURER², JURGEN SMET³, and JÖRG WRACHTRUP^{1,3} — ¹3rd Institute of Physics, University Stuttgart, Stuttgart, Germany — ²Institute for Theoretical Physics III, University Stuttgart, Stuttgart, Germany — ³Max Planck Institute for Solid State Research, Stuttgart, Germany

Magnetic dynamics at the nanoscale provide crucial insight into the behavior of superconductors. Using single-spin scanning quantum microscopy, we probe vortex dynamics in the two-dimensional superconductor NbSe₂. Our measurements reveal a disordered vortex glass phase that melts near the critical temperature and displays cooling-rate-dependent configurations. Surprisingly, magnetic noise persists well below T_c, with a strength that increases at lower temperatures - contrary to expectations. This behavior, detected via spin decoherence, points to an intrinsic origin driven by competition between supercurrent density and thermal fluctuations. Our results establish single-spin microscopy as a powerful platform for investigating fluctuations in 2D superconductors.

TT 24.7 Tue 12:30 HSZ/0003
Quantum sensing of a synthetic 3D spin texture — •R. J. PEÑA ROMÁN^{1,2,3}, S. MAITY^{1,2}, F. SAMAD^{4,5}, S. JOSEPHY⁶, A. MORALES⁶, S. CHATTOPADHYAY^{1,3}, A. KAKAY⁴, K. KERN^{2,7}, O. HELLWIG^{4,5}, and A. SINGHA^{1,2,3} — ¹IFMP, Dresden University of Technology — ²Max Planck Institute for Solid State Research — ³Wurzburg-Dresden Cluster of Excellence (ct.qmat) — ⁴Institute of Ion Beam Physics and Material Research, Helmholtz-Zentrum Dresden-Rossendorf — ⁵Institute of Physics, Chemnitz University of Technology — ⁶QZabre AG, Zurich — ⁷Institute de Physique, École Polytechnique Fédérale de Lausanne

Multilayered synthetic antiferromagnets (SAFs) are artificial three-dimensional (3D) architectures engineered to create novel, complex, and stable spin textures. Magnetic imaging of the spin texture is a crucial step for achieving tailored material performance and new functionalities. However, the deterministic detection of the magnetic textures and their quantitative characterization at the nanoscale remains challenging. Here, we use nitrogen-vacancy scanning probe microscopy under ambient conditions to perform quantitative vector-field magnetometry in a multilayered SAF. We demonstrate distinct fingerprints emerging from spin noise and constant stray fields, providing insights into the structure of domains and domain walls, as well as into magnetic noise associated with thermal spin waves. Combined with modern machine learning approaches, this work opens up new possibilities for quantitative magnetometry in materials with tailored and complex 3D spin textures.

TT 25: f-Electron Systems

Time: Tuesday 9:30–12:30

Location: HSZ/0101

TT 25.1 Tue 9:30 HSZ/0101

Strong correlations in rare earth intermetallic compounds — ●PAYEL SHEE¹, CHIA JUNG YANG², TANAYA HALDER¹, NAINISH TICKOO¹, SHISHIR KUMAR PANDEY³, ASHIS KUMAR NANDY¹, RUTA KULKARNI⁴, ARUMUGAM THAMIZHAVEL⁴, MANFRED FIEBIG², ANAMITRA MUKHERJEE¹, and SHOYON PAL¹ — ¹National Institute of Science Education and Research, Bhubaneswar, India — ²ETH Zurich, Zurich, Switzerland — ³Artificial Intelligence for Science Institute, Beijing, China — ⁴Tata Institute of Fundamental Research, Mumbai, India

In rare-earth intermetallic compounds, the strong correlations between magnetic ordering and the crystal electric field (CEF) are essential to understand their many-body ground states. The CEF excitations at a low energy scale becomes crucial to study as it leaves its fingerprints on the exotic magnetic behaviour in rare-earth intermetallics. Using THz time-domain spectroscopy, we have directly probed the underlying CEF states in two distinct material system: a prototype Kondo lattice system (CeAg₂Ge₂) and a metallic ferromagnet (PrSi). In CeAg₂Ge₂, we elucidate the low lying CEF state to strongly couple with the Ruderman-Kittel-Kasuya-Yosida (RKKY) interaction, evidenced by a distinct blueshift in the transition frequency [1]. However, in PrSi, we identify a prominent increase in the population of the higher CEF state at the curie temperature, showcasing an intricate interplay between CEF and magnetic ordering in these strongly correlated systems[2].

[1] P. Shee et al., Phys. Rev. B 109, 075133 (2024)

[2] P. Shee et al. manuscript submitted to Advanced Science.

TT 25.2 Tue 9:45 HSZ/0101

Rare-earth nitrides: nitrogen stoichiometry, 4f valence, and the role of the rare-earth 5d states in SmN — ANNA MELÉNDEZ-SANS¹, VANDA M. PEREIRA¹, CHUN-FU CHANG¹, CHANG-YANG KUO^{1,2,3}, CHIEN-TE CHEN², LIU HAO TJENG¹, and ●SIMONE G. ALTENDORF¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²National Synchrotron Radiation Research Center, Hsinchu, Taiwan — ³Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

We report on the influence of nitrogen stoichiometry on the electronic structure of epitaxial rare-earth nitride (REN) thin films grown by molecular beam epitaxy under ultra-high vacuum base conditions using moderate growth conditions, i.e., slow deposition rates, and moderate temperatures and pressures. The systematic variation of the growth parameters enables precise control of the nitrogen content and the preparation of near-stoichiometric, well-ordered REN thin films [1,2]. Using samarium nitride as a critical model system, we present a combined x-ray photoelectron spectroscopy and x-ray absorption spectroscopy study that reveals the dependence of the rare-earth valence and electronic structure on the nitrogen content. Our findings suggest that the RE 5d states may play a crucial role in the nitrogen-deficient samples, as the empty states can stabilize the RE 4f valence by hosting the extra electrons.

[1] V. M. Pereira et al., Phys. Rev. Mater. 7, 124405 (2023)

[2] A. Meléndez-Sans et al., Phys. Rev. B 110, 045120 (2024)

TT 25.3 Tue 10:00 HSZ/0101

Terahertz Signatures of Coupled Topological and Heavy-Fermion States in SmB₆ — ●ZEKAI CHEN, DEBANKIT PRIYADARSHI, ERIK W. DE VOS, and MANFRED FIEBIG — Department of Materials, ETH Zurich, Zurich, Switzerland.

We present a THz time-domain spectroscopy study that resonantly probes the conducting surface state of the topological Kondo insulator samarium hexaboride (SmB₆). Previous work on Kondo insulators has shown that the Kondo quasiparticles disintegrate near a quantum critical point (QCP) following THz radiation, leading to a delayed echo-pulse-like signal in the time domain [1]. In contrast to these materials, SmB₆ exhibits an additional in-gap state that is hypothesized to be related to its topological surface conductivity. In the presented experiment, this in-gap state is resonantly probed with THz radiation. Our results show the aforementioned echo-like signal at 3 ps, which matches the theoretical surface Kondo temperature [2]. The link between the topological surface state and the Kondo effect is corroborated by the observation of a transition towards negative optical conductivity of the instantaneous THz reflection, which emerges on the same temperature

scale as the echo-response. Our results provide insight into the emergence of a coupling between the in-gap surface state and the underlying correlated Kondo physics in SmB₆.

[1] Nature Physics 14, 1103 (2018)

[2] Physical Review Letters, 114, 177202 (2015)

TT 25.4 Tue 10:15 HSZ/0101

Observation of 5f valence fluctuations in UPd₂Cd₂₀ by high-resolution XAS — ●JINDŘICH KOLOREŇ — Institute of Physics (FZU), Czech Academy of Sciences, Prague, Czech Republic

The regime of valence fluctuations, known from anomalous rare-earth systems, has not yet been identified by microscopic techniques in any uranium compound. It was only suggested in a few of them on the basis of thermodynamic measurements (such as the magnetic susceptibility) and their similarity to the behavior of rare-earth valence fluctuators. Such arguments, however, are hardly unequivocal. We present uranium *L*₃ and *M*₄ x-ray absorption spectra taken on UPd₂Cd₂₀, which is a heavy-fermion *antiferromagnet*. Although it has only one type of uranium site in its primitive cell, the spectra obtained in the high-energy-resolution fluorescence-detection mode display two edges, each associated with a different valence state, 5f² and 5f³. Moreover, the shape of the *M*₄ spectrum is well approximated by a combination of UCl₃ (5f³) and UCl₄ (5f²) spectra. This suggests 5f² ↔ 5f³ fluctuations on a timescale longer than the characteristic time of the spectroscopy technique. Unlike 4f systems, in which such fluctuations typically lead to a *destruction of magnetism* due to one of the involved 4fⁿ configurations being non-magnetic, the 5f² and 5f³ states are both magnetic, allowing for a magnetic ordering in the fluctuating state.

This contribution is a result of a collaboration between Niigata University, Japan Atomic Energy Agency, Kyushu University, Japan Synchrotron Radiation Research Institute, Helmholtz-Zentrum Dresden-Rossendorf, ESRF in Grenoble, and Charles University in Prague.

TT 25.5 Tue 10:30 HSZ/0101

Stoichiometry control of the magnetic structure and crystalline electric field effects in the Kondo lattice CeAlGe — ●SOOHYEON SHIN and YIXI SU — Juelich Center for Neutron Science at MLZ, Lichtenbergstrasse 1, Garching 85748, Germany

CeAlGe crystallizes in the LaAlSi-type tetragonal structure, where spatial inversion symmetry is broken. This system is expected to host Weyl fermions near a Fermi surface that becomes more stable when time-reversal symmetry is broken. The magnetic ground state and associated topological properties of CeAlGe are known to depend sensitively on chemical stoichiometry. For instance, crystals grown by the flux method typically contain 5-15% excess Al on the Ge site and exhibit commensurate antiferromagnetic order below T=5.1 K. In contrast, crystals prepared by the floating-zone method under 30 bar of Ar gas yield stoichiometric compositions and display incommensurate order below T=4.4 K, where topological Hall effects are induced by external magnetic fields.

In this presentation, we report recent neutron-scattering experiments. Small-angle scattering reveals the emergence of additional incommensurate magnetic ordering associated with Al substitution. Furthermore, time-of-flight measurements suggest the presence of a magnetoelastic bound state between the first excited crystal-field level and an optical phonon mode near 17 meV. We will discuss the implications of this magnetoelastic bound state for the magnetic structures in CeAlGe.

TT 25.6 Tue 10:45 HSZ/0101

Acoustic signatures of field-induced electronic topological transitions in YbNi₄P₂ — ●JÉRÉMY SOURD¹, E.O. ELJAOUHARI², B.V. SCHWARZE¹, K. KLIEMT³, C. KRELLNER³, F. HUSTEDT^{1,4}, J. WOSNITZA^{1,4}, S. ZHERLITSYN¹, and G. ZWICKNAGL^{2,5} —

¹Dresden High Magnetic Field Laboratory (HLDEMFL), HZDR, Germany — ²Institut für Mathematische Physik, TU Braunschweig —

³Physikalisches Institut, Johann Wolfgang Goethe-Universität, Frankfurt am Main — ⁴Institut für Festkörper- und Materialphysik, TU Dresden — ⁵Max Planck Institute for Chemical Physics of Solids, Dresden

The Fermi surface is a central concept to elaborate the physical properties of correlated electron systems. While resulting from the pre-

cise chemistry of a given material through its crystal and electronic structures, the Fermi-surface shape and topology can evolve drastically upon varying a control parameter leading to an electronic-topological transition (ETT). In heavy-fermion systems the strong electronic correlations generate renormalized flat bands close to the Fermi level, leading to effective Fermi energies of the order of 10 T. Thus, in these systems the Zeeman energy from moderate magnetic field is enough to induce an ETT, as observed for example in YbNi_4P_2 . We used acoustic waves in order to probe the sequence of ETT in YbNi_4P_2 , by performing ultrasound experiments at low temperature. By comparing the observed anomalies of the sound velocity for different acoustic modes, we show how ultrasound permits to better explore the reciprocal space structure of the ETTs in YbNi_4P_2 .

15 min. break

TT 25.7 Tue 11:15 HSZ/0101

Tuning quadrupolar order in YbRu_2Ge_2 using uniaxial stress — ●ARINDAM GHARA¹, CAITLIN I. O'NEIL¹, ELENA GATI^{1,2}, YOUSHENG LI³, NUBIA CAROCA-CANALES¹, CHRISTOPH GEIBEL¹, HILARY NOAD¹, and MICHAEL NICKLAS¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²Goethe University Frankfurt, Germany — ³National Taiwan University, Taiwan

Multipolar order has gained renewed attention due to its close connection with nematicity, altermagnetism, and quantum criticality. YbRu_2Ge_2 exhibits a ferroquadrupolar transition at $T_Q = 10.2\text{ K}$ accompanied by a tetragonal-to-orthorhombic structural distortion [1,2]. Experimental studies [2] have proposed a B_{1g} order parameter for the ferroquadrupolar ground state. According to theoretical work [3], a transverse field, such as a magnetic field along the c axis or a B_{2g} stress, can drive YbRu_2Ge_2 towards a quantum critical point. This makes YbRu_2Ge_2 a model system for studying quadrupolar fluctuations under symmetry-resolved tuning parameters.

We used these tuning parameters to map the phase diagram of YbRu_2Ge_2 via resistance and Young's modulus measurements. While the data under c -axis magnetic field behave as expected for a transverse field, the response to B_{2g} stress is unexpected: the resistivity anomaly broadens, whereas the Young's modulus anomaly stays sharp. This behaviour challenges the assumption that B_{2g} stress acts purely as a transverse field.

[1] Jeevan *et al.*, *Phys. Rev. B* **73**, 020407 (2006)

[2] Rosenberg *et al.*, *PNAS* **116**, 7232 (2019)

[3] Maharaj *et al.*, *PNAS* **114**, 13430 (2017)

TT 25.8 Tue 11:30 HSZ/0101

$\text{Yb}_5\text{Rh}_6\text{Sn}_{18}$: a valence fluctuating system with ultra-low thermal conductivity — ●OLEKSANDR BOLIELYI¹, VOLODYMYR LEVYTSKYI¹, KRISTINA O. KVASHNINA², ANDREAS LEITHE-JASPER³, and ROMAN GUMENIUK¹ — ¹Institut für Experimentelle Physik, TU Bergakademie Freiberg, 09596 Freiberg, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf (HZDR), 01314 Dresden, Germany — ³Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany

$\text{Yb}_5\text{Rh}_6\text{Sn}_{18}$ obtained by high-frequency melting of elemental metals crystallizes with an unique structural configuration closely related to the $\text{Yb}_3\text{Rh}_4\text{Sn}_{13}$ Remeika prototype. An important feature of this structure is that the small Sn1-atoms reside within enlarged Frank-Kasper polyhedra thus, possessing potential for a "rattling" motion. X-ray absorption spectra of $\text{Yb}_5\text{Rh}_6\text{Sn}_{18}$ indicate Yb-ions to be in the intermediate valence state (IVS), i.e. switching between the $4f^{13}$ (Yb^{3+}) and $4f^{14}$ (Yb^{2+}) configurations. In agreement with this finding temperature dependence of magnetic susceptibility reveals a well pronounced maximum. Both Hall and Seebeck coefficients indicate the change of charge carrier type from electrons to holes between 120 and 220 K. Together with electrical resistivity and theoretical DFT calculations these effects confirm $\text{Yb}_5\text{Rh}_6\text{Sn}_{18}$ to be a metal, which disobeys the free electron gas theory. The ultra-low thermal conductivity is attributed to the appearance of phonon resonance as well as to the "rattling" motion of Sn1 atoms in the studied structure.

TT 25.9 Tue 11:45 HSZ/0101

Antiferromagnetic order and spin excitations in HoInCu_4 — ●O. STOCKERT¹, X. BORALEY², J. LASS², R. SIBILLE², Ø. S. FJELLVÅG^{2,3}, S. MOODY², A. M. LÄUCHLI^{2,4}, V. FRITSCH⁵, and D. G. MAZZONE² — ¹Max-Planck-Institut CPFS, Dresden — ²Paul-

Scherrer-Institut, Villigen, Switzerland — ³Institute for Energy Technology, Kjeller, Norway — ⁴École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland — ⁵Universität Augsburg, Augsburg

Magnetic frustration quite often leads to novel quantum phases in condensed matter physics. Here, we focus on the intermetallic compound HoInCu_4 with a face-centered cubic structure being prone to frustration.

We performed extensive elastic and inelastic neutron scattering on HoInCu_4 to unravel the magnetic structure and to study the underlying exchange interactions [1,2]. Below 0.76 K HoInCu_4 orders in a type-III AF structure with a reduced ordered moment and partially disordered Ho spins. Enhanced spin fluctuations due to frustration are detected as a diffuse signal, even well inside the ordered state. In the magnetic field polarized state the spin excitations and the magnetic diffuse scattering can be well modeled using linear spin-wave theory yielding a consistent set of nearest and next-nearest neighbor interactions. In contrast, in zero magnetic field spin-wave theory fully fails to describe the overdamped spin excitations in the AF ordered state. All these findings emphasize the importance of frustration in HoInCu_4 .

[1] O. Stockert *et al.*, *Phys. Rev. Res.* **2**, 013183 (2020).

[2] X. Boraley *et al.*, *Phys. Rev. Lett.* **135**, 046702 (2025).

TT 25.10 Tue 12:00 HSZ/0101

Single crystal growth and characterization of EuMn_2Si_2 and EuMn_2Ge_2 — ●JANINA STRAHL¹, TOM GERNTKE^{1,2}, KRISTIN KLIENT¹, KURT KUMMER², and CORNELIUS KRELLNER¹ — ¹Institute of Physics, Goethe-University, Frankfurt (Main), Germany — ²European Synchrotron Radiation Facility (ESRF), F-38043 Grenoble Cedex, France

EuMn_2Si_2 exhibits a thermally driven valence transition of the europium ions from Eu^{3+} at low temperatures to $\text{Eu}^{2.5+}$ at high temperatures [1]. The isoelectronic and isostructural substitution of silicon with germanium leads to a stabilization of the divalent state of Eu in EuMn_2Ge_2 with reported ferromagnetic Eu ordering below 13 K [2]. Both rare earth intermetallic 122 compounds crystallize in the tetragonal ThCr_2Si_2 structure type and show antiferromagnetic ordering of the manganese sublattices above room temperature. In literature [1,2], additional Mn spin-reorientation transitions in polycrystalline EuMn_2Si_2 samples at low temperatures were observed. In this contribution, we present the single crystal growth and physical properties of both compounds. We found antiferromagnetic ordering of the Eu ions in single crystalline EuMn_2Ge_2 below 10.4 K. Furthermore, there is evidence that previously reported Mn reorientation transitions are absent in pure EuMn_2Si_2 single crystals, and a valence crossover occurs between 350-530 K.

[1] M. Hofmann *et al.*, *Phys. Rev. B* **69**, 174432 (2004)

[2] I. Nowik *et al.*, *Phys. Rev. B* **55**, 3033 (1997)

TT 25.11 Tue 12:15 HSZ/0101

Polaronic quasiparticles in the valence-transition compound

$\text{TmSe}_{1-x}\text{Te}_x$ — ●CHUL-HEE MIN^{1,2}, SIMON MÜLLER³, LENART DUDY⁴, MICHAEL HEBER⁵, WOOJAE CHOI⁶, JONATHAN DENLIGNER⁷, CHANG JONG KANG⁸, MATTHIAS KALLÄNE², NILS WIND⁵, MARKUS SCHOLZ⁵, CHRISTOPH SCHLUETER⁵, ANDREI GLOSKOVSKII⁵, EMILE RIENKS⁸, VLADIMIR HINKOV³, HENDRIK BENTMANN¹, YONG SEUNG KWON⁶, FRIEDRICH REINERT³, HYEONG DO KIM⁹, and KAI ROSSNAGEL^{2,5} — ¹FYI, NTNU, Norway — ²IEAP, CAU Kiel, Germany — ³Uni. Würzburg, Germany — ⁴SOLEIL, France — ⁵DESY, Germany — ⁶DGIST, South Korea — ⁷ALS, USA — ⁸BESSY II, Germany — ⁹PAL, South Korea

Exotic quasiparticle states have been proposed in mixed-valent compounds exhibiting valence transitions. However, clear spectroscopic evidence identifying these states has remained elusive. Using synchrotron-based photoemission spectroscopy, we have probed the Tm $3d$ and $4f$ emissions in $\text{TmSe}_{1-x}\text{Te}_x$, where a semimetal-insulator transition occurs. Our photoemission results reveal a novel quasiparticle excitation in the semimetallic phase: a Holstein polaron. This local lattice distortion, induced by $4f$ photohole, is surprising in a metallic system where efficient screening is expected. We interpret this observation as evidence that, in heavy fermion systems, the conduction electrons' screening response is slower than the characteristic atomic distortion. Our finding underscores the critical role of electron-phonon coupling, which necessitates an extension of the standard Periodic Anderson Model.

[1] *Phys. Rev. Lett.* **135**, 186501 (2025)

TT 26: Correlated Magnetism – Frustrated Systems

Time: Tuesday 9:30–12:15

Location: HSZ/0103

TT 26.1 Tue 9:30 HSZ/0103

Finite-temperature Lanczos approach to frustrated quantum spin systems — ●ANDREAS HONECKER¹, MALO ROUXEL¹, and KATARÍNA KARL'OVÁ² — ¹Laboratoire de Physique Théorique et Modélisation, CNRS, CY Cergy Paris Université, France — ²Department of Theoretical Physics and Astrophysics, P.J. Šafárik University, Košice, Slovakia

The finite-temperature Lanczos method or its quantum typicality variants are a method of choice for computing thermodynamic properties of frustrated quantum spin systems, in particular in two dimensions. Here we show that quasi-exact results can be obtained with moderate numerical effort for systems with $N \leq 40$ spins $1/2$, even if the method involves Monte Carlo sampling. We illustrate the approach on the diamond-decorated square and honeycomb lattices. These models not only distinguish themselves by the presence of local conservation laws, but also offer a rich phase diagram, including phases with macroscopic ground-state degeneracy. We comment in particular on the resulting enhanced magnetocaloric effect [1].

[1] K. Karl'ová, A. Honecker, N. Çaçi, S. Wessel, J. Strečka, T. Verkholyak, Phys. Rev. B **110**, 214429 (2024).

TT 26.2 Tue 9:45 HSZ/0103

Quantum annealing for lattice models with long-range interactions — ●JAN ALEXANDER KOZIOL and KAI PHILLIP SCHMIDT — Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), D-91058 Erlangen, Germany

We use superconducting qubit quantum annealing devices to determine the ground state in the thermodynamic limit of Ising models with algebraically decaying long-range interactions. This is enabled by a unit-cell-based optimization scheme, in which the finite optimizations on each unit cell are performed using commercial quantum annealing hardware. To demonstrate the capabilities of the approach, we choose three exemplary problems relevant for other quantum simulation platforms and material science: (i) the calculation of devil's staircases of magnetization plateaus of the long-range Ising model in a longitudinal field on the triangular lattice, motivated by atomic and molecular quantum simulators; (ii) the evaluation of the ground state of the same model on the Kagomé lattice in the absence of a field, motivated by artificial spin ice; (iii) the study of models with modified few-nearest-neighbor interactions relevant for Ising compounds with potential long-range interactions. The approach discussed in this work provides a useful and realistic application of existing quantum annealing technology, applicable across many research areas in which lattice problems with resummable long-range interactions are relevant.

TT 26.3 Tue 10:00 HSZ/0103

Nature of intersite exchange interactions in Ce triangular-lattice delafossites — ●LEONID POUROVSKII — CPHT, CNRS, Ecole polytechnique, IP Paris, 91120 Palaiseau, France — Collège de France, Université PSL, 75005 Paris, France

Anisotropic intersite exchange interactions (IEI) in frustrated rare-earth magnets are difficult to assess both theoretically and experimentally. We propose an ab initio force-theorem framework combining the quasi-atomic Hubbard-I approach to $4f$ correlations with a static mean-field treatment of the on-site intershell Coulomb interaction between rare-earth $4f$ and $5d$ states to simultaneously capture both $4f$ superexchange and $5d$ -mediated indirect exchange. Applying it to a set of Ce delafossites – the selenide CsCeSe_2 , sulfide KCeS_2 , and oxide RbCeO_2 – we find a remarkable qualitative evolution of IEI. While the superexchange is found to dominate over the indirect exchange in the oxide, the situation is reversed in the selenide. Both coupling mechanisms are found to contribute comparably in the sulfide. The calculated IEI place CsCeSe_2 and KCeS_2 in the yz -stripe region of the published spin- $1/2$ triangular-lattice model phase diagram, in agreement with experiment, while those for RbCeO_2 correspond to the 120° antiferromagnetic order. The magnetic excitation spectra of CsCeSe_2 and KCeS_2 evaluated from the calculated spin Hamiltonians are in good qualitative and quantitative agreement with experimental data.

TT 26.4 Tue 10:15 HSZ/0103

Quantum Monte Carlo study of the Su-Schrieffer-Heeger model on a triangular lattice — ●DISHA HOU¹, ANIKA GÖTZ¹,

JADSON SILVA², NATANAEL COSTA², and FAKHER ASSAAD¹ — ¹Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Würzburg, Germany — ²Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

We study the half-filled bond Su-Schrieffer-Heeger (SSH) model on the triangular lattice using sign-problem-free auxiliary-field quantum Monte Carlo methods. By varying the hopping matrix element, we interpolate between the assisted hopping limit — characterized by an emergent local \mathbb{Z}_2 symmetry and phases in which the hopping is weakly modulated by phonons. In addition to a s-wave superconducting state and a staggered valence-bond solid state, we observe an emergent flux phase which, in the absence of fluctuations, would exhibit a Dirac dispersion. We find that this phase is gapped and does not appear to break any ultraviolet symmetries of the model, leading us to tentatively identify it as a gapped \mathbb{Z}_2 quantum spin liquid phase.

TT 26.5 Tue 10:30 HSZ/0103

Exact nematic and mixed magnetic phases driven by competing orders on the pyrochlore lattice — ●NICCOLÒ FRANCINI, LUKAS SCHMIDT, LUKAS JANSSEN, and DANIEL LOZANO-GÓMEZ — Institut für Theoretische Physik und Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, 01062 Dresden, Germany

Pyrochlore magnets are a paradigmatic example of three-dimensional frustrated systems and provide an excellent platform for studying a variety of exotic many-body phenomena. In recent years, increasing attention has been devoted to bilinear spin models on this lattice, where multiple magnetic phases can be degenerate in energy, often stabilizing unconventional magnetic states. In this work, we focus on one such model, parametrized by the interaction coupling $J_{z\pm}$, which defines a line in parameter space corresponding to the phase boundary between three distinct magnetic phases. Using a combination of analytical and numerical methods, we show that this model exhibits an order-by-disorder mechanism at low temperatures, giving rise to a *mixed* magnetic phase. This represents the first realization of a $\mathbf{q} = 0$ long-range-ordered phase in a pyrochlore magnet characterized by two distinct order parameters, which we denote as the $A_2 \oplus \psi_2$ phase. Furthermore, at $J_{z\pm} = 1/\sqrt{2}$, the model acquires a subextensive number of discrete symmetries, which preclude the stabilization of conventional long-range order and instead lead to the emergence of a novel nematic phase. We characterize this nematic phase, describe how its ground-state configurations are constructed, and analyze its stability at higher temperatures and under small deviations from $J_{z\pm} = 1/\sqrt{2}$.

TT 26.6 Tue 10:45 HSZ/0103

From Open-Shell Nanographenes to Quantum Spin Chains: Controllable Spins in Carbon Ladders — ●ANDONI AGIRRE^{1,2}, THOMAS FREDERIKSEN^{1,3}, GÉZA GIEDKE^{1,3}, and TOBIAS GRASS^{1,3} — ¹Donostia International Physics Center (DIPC), Manuel Lardizabal Pasealekua 4, 20018 Donostia, Basque Country — ²Department of PMAS: Physics, Chemistry and Technology, University of the Basque Country (UPV/EHU), Manuel Lardizabal Pasealekua 3, 20018 Donostia, Basque Country — ³IKERBASQUE, Basque Foundation for Science, Euskadi Plaza 5, 48009 Bilbao, Basque Country

The low-energy electronic structure of nanographenes with open-shell configurations can be faithfully represented by effective quantum spin models, providing a promising route toward carbon-based quantum simulators. Here we demonstrate this correspondence for an oligo-indenodene molecule, composed of alternating pentagon-hexagon rings and theoretically mapped to a frustrated Fermi-Hubbard ladder. We show that a spin- $1/2$ Heisenberg chain consisting of only one spin per pentagon and featuring nearest- and next-nearest-neighbor couplings, quantitatively reproduces the molecular excitation spectrum and entanglement structure obtained from matrix-product-state calculations. By systematically identifying the effective spins with delocalized fermionic modes across the molecular backbone, we achieve near-quantitative agreement in both static and dynamical magnetic properties. Our results establish them as experimentally realizable platforms for exploring frustrated magnetism and correlated spin dynamics in purely carbon-based materials.

15 min. break

TT 26.7 Tue 11:15 HSZ/0103

Single crystal growth and study of the spin gap system Cu_3WO_6 — ●ANNAROSE JOSE PALLIYAN^{1,2}, NAZMUL ISLAM², CINTLI AGUILAR-MALDONADO², RALF FEYERHERM², ANDREY MALYUK³, SABINE WURMEHL³, and BELLA LAKE^{2,1} — ¹Technische Universität Berlin, Germany — ²Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — ³Leibniz Institute for Solid State and Materials Research Dresden, Germany

Frustration in magnetic materials is an important phenomena leading to exotic quantum states due to the presence of the competing interactions in those materials. From this point of view, cuprates are interesting because of the possibility of having multiple correlations and interactions resulting in unusual correlated phases[1]. Copper tungstate, Cu_3WO_6 , is one such compound where Cu^{2+} ($S=1/2$) occupies the triangular bipyramidal sites. This cubic system (Pa-3) hosts a unique magnetic lattice consisting of coupled hexagons and equilateral triangles of Cu^{2+} giving rise to multiple exchange interactions. In order to study the magnetic behavior and solve the magnetic Hamiltonian of this material, we have grown the first single crystals of Cu_3WO_6 by several different growth techniques and the high crystalline quality of these crystals has been confirmed. We have also studied the thermodynamic properties on these crystals down to low temperatures and our results confirm the reported singlet ground state with a spin gap of about 130K which suggests a dominant hexagonal interaction[2].

[1] Y. Fudamoto et al., *Phys. Rev B* 65, 174428 (2002)

[2] M. Hase et al., *Phys. B: Condens. Matter* 215, 325 (1995)

TT 26.8 Tue 11:30 HSZ/0103

Magnetic frustration and field-induced transitions in the octahedral lattice iridate Ho_3IrO_6 — ●ABANOUB HANNA¹, CINTLI AGUILAR MALDONADO¹, RALF FEYERHERM¹, A.T. M. NAZMUL ISLAM¹, and BELLA LAKE^{1,2} — ¹Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Hahn-Meitner Platz 1, D-14109 Berlin, Germany — ²Institut für Festkörperphysik, Technische Universität Berlin, Germany

Ho_3IrO_6 is a new octahedral lattice compound in which holmium ions form a distorted network of corner sharing octahedra, providing a clean platform to study frustration in rare earth iridates. X ray and neutron powder diffraction confirm a single phase cubic Ia-3 structure with ordered Ho and Ir sites and no detectable impurities, so the magnetic behaviour can be interpreted without structural complications. Low temperature magnetometry shows a sharp transition near 1 kelvin with strong field dependence, and Curie Weiss analysis indicates antiferromagnetic interactions and a large frustration parameter, pointing to competing exchanges on the octahedral lattice. AC susceptibility, nonlinear magnetization curves and field dependent anomalies reveal

a genuine thermodynamic transition and metamagnetic steps, while heat capacity data are consistent with a low lying triplet ground state and an additional Schottky like feature around 5 K.

TT 26.9 Tue 11:45 HSZ/0103

Crystal growth, electronic and magnetic Properties of $\text{Mn}_3\text{Al}_9\text{Si}$ — ●ASHIWINI BALODHI¹, MIN GYU KIM², ANDREAS KREYSSIG¹, and ANNA E. BÖHMER¹ — ¹Experimental Physics IV, Ruhr-University Bochum, Bochum, Germany — ²University of Wisconsin-Milwaukee, Milwaukee, USA

The Mn-based intermetallic compound $\text{Mn}_3\text{Al}_9\text{Si}$ crystallizes in a hexagonal structure in which the Mn ions form a well-separated triangular network, giving rise to unusual transport and thermodynamic behavior. We have synthesized high-quality single crystals of $\text{Mn}_3\text{Al}_9\text{Si}$ and performed magnetic, transport and heat-capacity measurements. The magnetic susceptibility exhibits isotropic behavior with no evidence of long-range magnetic ordering down to 1.8 K. Low-temperature resistivity measurements reveal a negative magnetoresistance. We further present the critical scaling behavior in applied magnetic fields, in both magnetization and heat-capacity.

We acknowledge funding from the European Research Council through Project 101040811, Distort-to-Grasp.

TT 26.10 Tue 12:00 HSZ/0103

Synthesis and characterization of $\text{Mn}_3\text{Al}_2\text{Si}_3\text{O}_{12}$ single crystal — ●MARWA ABOUELELA^{1,2}, ATM NAZMUL ISLAM², RALF FEYERHERM², and BELLA LAKE^{1,2} — ¹Institut für Festkörperphysik, Technische Universität, Berlin, Germany — ²Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

Geometric magnetic frustration, typically found in materials with triangular and tetrahedral motifs, has attracted significant interest in recent research [1]. The garnet $\text{Mn}_3\text{Al}_2\text{Si}_3\text{O}_{12}$ exhibits geometrical frustration, where magnetic Mn^{2+} ($3d^5$) ions that have spin-5/2 form hyper-Kagome structure which is three-dimensional network of corner-sharing triangles [2]. In this study, we synthesized the first single crystals of $\text{Mn}_3\text{Al}_2\text{Si}_3\text{O}_{12}$ grown by the optical floating-zone technique. X-ray and neutron diffraction confirmed the garnet space group $Ia\bar{3}d$. Temperature-dependent magnetic susceptibility measurements reveal antiferromagnetic ordering of the Mn^{2+} ions below $T_N = 6.5$ K, along with an effective moment of $5.85 \mu_B$ and a Curie-Weiss temperature of $T_{CW} = -24.48$ K, giving a frustration index of $f = |\theta_{CW}/T_N| = 3.8$. Investigation of the magnetic structure below T_N and the short-range order above T_N is ongoing.

[1] Islam, Manisha et al., *Crystals* 13 (2023)397

[2] Lau et al., *Phys. Rev. B* 80 (2009) 214414

TT 27: Focus Session: Tunable Correlations in van der Waals Quantum Materials II (joint session TT/DS/HL)

Time: Tuesday 9:30–10:45

Location: HSZ/0105

Invited Talk

TT 27.1 Tue 9:30 HSZ/0105

Simulating high-temperature superconductivity in a triangular moiré lattice — ●KIN FAI MAK — Luruper Chaussee 149 Bldg. 900 (MPSD), 22761 Hamburg, Germany

Moiré materials built on transition metal dichalcogenide semiconductors have emerged as a tunable platform for simulating the Hubbard model on a triangular lattice. A natural question arises: Can the platform be tuned to yield a phase diagram similar to that in high-temperature cuprate superconductors? In this talk, I will discuss the emergence of high-temperature superconductivity near the Mott transition in a triangular moiré lattice with intermediate coupling strength. The emergent doping-temperature phase diagram looks remarkably similar to that in cuprate superconductors. I will also discuss the evolution of the phase diagram by tuning the band structure of the material by gating. The results could provide a new angle for understanding the phenomenon of high-temperature superconductivity in strongly correlated materials.

TT 27.2 Tue 10:00 HSZ/0105

Engineering Hubbard models with gated two-dimensional moiré systems — ●YIQI YANG¹, YUBO YANG², MIGUEL MORALES³, and SHIWEI ZHANG³ — ¹Lund University, Lund, Sweden — ²Hofstra

University, New York, USA — ³Flatiron Institute, New York, USA

Lattice models are powerful tools for studying strongly correlated quantum many-body systems, but their general lack of exact solutions motivates efforts to simulate them in tunable platforms. Recently, a promising new candidate has emerged for such platforms from two-dimensional materials. A subset of moiré systems can be effectively described as a two-dimensional electron gas (2D EG) subject to a moiré potential, with electron-electron interactions screened by nearby metallic gates. In this talk, we present the realization of lattice models in such systems [1]. We show that, by controlling the gate separation, a 2D EG in a square moiré potential can be systematically tuned into a system whose ground state exhibits orders analogous to those of the square lattice Hubbard model, including the stripe phase. Furthermore, we study how variations in gate separation and moiré potential depth affect the ground-state orders. A number of antiferromagnetic phases, as well as a ferromagnetic phase and a paramagnetic phase, are identified. We then apply our quantitative downfolding approach to triangular moiré systems closer to current experimental conditions, compare them with the square lattice parameters studied, and outline routes for experimental realization of the phases.

[1] arXiv:2508.13314

TT 27.3 Tue 10:15 HSZ/0105

Dirac quantum criticality in twisted double bilayer transition metal dichalcogenides — ●JAN BIEDERMANN and LUKAS JANSSEN

— Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

We investigate the phase diagram of twisted double bilayer transition metal dichalcogenides with ABBA stacking as a function of twist angle and pressure. At a filling of 2 holes per moiré unit cell, the noninteracting system hosts a Dirac semimetal with graphene-like low-energy bands. At small twist angles however, interactions dominate the low-temperature physics, stabilizing an antiferromagnetic insulating ground state that is characterized by spin density modulations at the moiré scale. The twist-tuned semimetal-to-antiferromagnet transition is shown to be continuous and belongs to the Gross-Neveu-Heisenberg universality class. We propose that this transition may also be realized by applying uniaxial pressure to a sample, raising the intriguing possibility of experimentally measuring the associated critical exponents for the first time.

TT 27.4 Tue 10:30 HSZ/0105

Chemically Tunable Correlation Strength in Breathing Mode Kagome van der Waals Materials $\text{Nb}_3(\text{F}, \text{Cl}, \text{Br}, \text{I})_8$ — ●JOOST

ARETZ¹, SERGI GRYTSIUK¹, XIAOJING LIU², GIOVANNA FERACO², CHRYSTALLA KNEKNA^{2,3}, MUHAMMAD WASEEM², ZHIYING DAN², MARCO BIANCHI⁴, PHILIP HOFMANN⁴, MAZHAR ALI⁵, MIKHAIL KATSNELSON^{1,6}, ANTONIJA GRUBIŠIĆ-ČABO², HUGO STRAND⁷, ERIK VAN LOON⁸, and MALTE RÖSNER^{1,9} — ¹Radboud University, Nijmegen, Netherlands — ²University of Groningen, Netherlands — ³University of Amsterdam, Netherlands — ⁴Aarhus University, Denmark — ⁵Delft University of Technology, Netherlands — ⁶Constructor University, Bremen, Germany — ⁷Örebro University, Sweden — ⁸Lund University, Sweden — ⁹Bielefeld University, Germany

Finding tunable correlated electron systems in nature is highly desirable for studying strongly correlated materials. Our recent work demonstrates that the Nb_3X_8 -family offers such a platform for tuning correlation effects in van der Waals systems. By using ab initio downfolding and cluster dynamical mean-field theory we show how correlation effects evolve across the halide series. In these materials an intriguing interplay between in-plane trimerization and out-of-plane dimerization leads to correlated insulating behavior, where the strength of correlations can be tuned by switching the halide or by changing the layer number. The predicted trends are supported by ARPES measurements. The correlated electron physics in this system is robust, tunable and layered, which allows studying the role of correlations in devices such as the $\text{NbSe}_2/\text{Nb}_3\text{Br}_8$ Josephson diode.

TT 28: Superconducting Electronics: SQUIDS and other Josephson Circuits and Components

Time: Tuesday 9:30–12:45

Location: CHE/0089

TT 28.1 Tue 9:30 CHE/0089

Gate-controlled switching in non-centrosymmetric superconducting devices - Large output voltage — ●JENNIFER KOCH¹,LEON RUP¹, ANGELO DI BERNARDO^{1,2}, and ELKE SCHEER¹ — ¹Universität Konstanz, Konstanz, Germany — ²Università degli Studi di Salerno, Fisciano (SA), Italy

Gate-controlled supercurrent (GCS) devices have become of great interest as a superconducting equivalent to complementary metal-oxide-semiconductor (CMOS) logic. The underlying concept is based on the observation that supercurrent can be controlled electrically through the application of a gate voltage [1,2].

We investigate GCS devices made of the non-centrosymmetric superconductor $\text{Nb}_{0.18}\text{Re}_{0.82}$. By combining geometric adjustments with the material's high normal-state resistivity, we achieve a significant increase of the output voltage. The resulting voltage is high enough to drive CMOS transistors, demonstrating the potential of GCS devices to interface directly with conventional semiconductor electronics. This finding represents an important step towards hybrid computing architectures.

[1] De Simoni et al., Nature Nanotech 13, 802 (2018)

[2] Paolucci et al., Nano Letters 18, 4195 (2018)

TT 28.2 Tue 9:45 CHE/0089

Chemical-mechanical polishing process for the fabrication of cross-type Nb/Al-AlO_x/Nb Josephson tunnel junctions — ●ALEXANDER STOLL, LUKAS MÜNCH, DANIEL HENGSTLER, ANDREAS REIFENBERGER, ANDREAS FLEISCHMANN, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University, Germany

The core elements at the frontier of superconducting electronic devices, such as qubits or superconducting quantum interference devices (SQUIDS), are the Josephson tunnel junctions (JJs). To enable scaling in production of these devices, good parameter control is required, including a uniform quality and reproducibility. We use a cross-type geometry for our JJs so that our junction area is not limited by alignment inaccuracies and, at the same time, parasitic capacitances and thus parasitic LC resonances can be avoided. A sputtered SiO_2 layer used for the insulation of the structured Nb/Al-AlO_x/Nb trilayer including its sidewalls usually requires a time-consuming lift-off and leaves behind undesired wings that can compromise the quality of subsequent layers. To mitigate these challenges, we introduced a chemical-mechanical polishing (CMP) step. We present our optimized fabrication process which achieves a well-embedded, smooth, and uniform post-CMP surface and substantially improves the reliability and yield of our JJs on 3 inch wafer-scale. A variety of tests to characterize the JJs based on their *IV*-characteristics and their Fraunhofer Patterns as well as the electrical properties of the superconducting Nb

are discussed.

TT 28.3 Tue 10:00 CHE/0089

Towards the next generation of dc SQUID sensors — ●MAURO ESATTORE¹, OLIVER KIELER¹, MICHAEL PAULSEN², RAINER KÖRBER², PATRYK KRZYSZCZKO², MARK BIELER¹, and JÖRN BEYER² — ¹Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — ²Physikalisch-Technische Bundesanstalt, Abbestraße 2-10, 10587 Berlin, Germany

This is an update on our path towards next-generation SQUID devices, featuring “fine-pitch” input coils and window-type Nb/Al-AlO_x/Nb Josephson junctions (JJs), both realized with sub-micrometer dimensions. The circuit elements are fabricated using electron beam lithography and are integrated into existing sensor designs which are currently fabricated using UV lithography, which limits the minimal dimensions. For current sensor SQUIDS, it is crucial to maximize the inductive coupling k between the signal input coil and the SQUID loop to minimize the coupled energy sensitivity $\varepsilon_c = \varepsilon/k^2$ - with ε being the intrinsic energy sensitivity. The SQUID energy sensitivity $\varepsilon \approx \sqrt{C_{JJ}}$ can also be lowered by reducing the JJ capacitance C_{JJ} . Our aim is to achieve high sensor compactness as well as reduced coupling losses, without further modifying the sensors design. To that end, we fabricated fine-pitch coils with lateral width down to 0.3 μm - almost an order of magnitude smaller than coils fabricated with UV lithography - with inductance values ranging from 400 nH to 14 μH , depending on the number of coil windings. Details concerning design aspects of both circuit elements, their fabrication and characterization results are provided.

are discussed.

TT 28.4 Tue 10:15 CHE/0089

Tapping-mode SQUID-on-tip Microscopy with Proximity Josephson Junctions — ●MATTHIJS ROG¹, TYCHO J. BLOM¹, DAAN B. BOLTJE^{1,2}, MILAN P. ALLAN^{1,2,3}, and KAVEH LAHABI^{1,2} — ¹Institute of Physics, Leiden University, Leiden, The Netherlands — ²QuantaMap B.V., Leiden, The Netherlands — ³Faculty of Physics, Ludwig-Maximilians-University Munich, Munich, Germany

Understanding nanoscale dynamics in strongly correlated systems and quantum materials requires investigating the interplay between dissipation, magnetism and electronic transport. The local mapping of transport properties, such as current flow, and their relation to geometry and magnetism still remains a major challenge. Here, we introduce tapping-mode SQUID-on-tip, which combines atomic force microscopy (AFM) with nanoSQUID sensing. This microscope is able to simultaneously image magnetic flux, electrical currents, local heating and sample topography. Our probes minimize nanoSQUID-sample distance, provide in-plane magnetic sensitivity, and operate even on

highly corrugated nanostructures and devices. Our fully electronic readout removes the need for optical elements and external radiation. By using proximity-junction nanoSQUIDS with large voltage output, we resolve nanoscale currents down to 100 nA using a simple four-probe electronic readout. In addition to demonstrating the technique, we will show the first applications to strongly correlated electron systems, where our microscope offers immediate new insights into the underlying physics.

[1] M. Rog et al., arXiv:2508.21575

TT 28.5 Tue 10:30 CHE/0089

Nanoscale SQUID on a wireframe tip cantilever by corner lithography — •THIJS ROSKAMP¹, TIM HORSTINK², MELISSA GOODWIN¹, ERWIN BERENSCHOT¹, ROELAND HUIJINK², EDIN SARAJILIC², NIELS TAS¹, and HANS HILGENKAMP¹ — ¹MESA+ Institute, University of Twente, Enschede, The Netherlands — ²Bruker Nederland B.V., Bruker Corporation, Leiderdorp, The Netherlands

Superconducting quantum interference devices (SQUIDS) are the most sensitive magnetic flux sensors and are used in scanning SQUID microscopy (SSM) to spatially resolve and map magnetism. Conventional SSM probes make use of planar silicon substrates which limit their spatial resolution to several micrometers due to an increased sample-pickup area spacing.

Employing ideas from other scanning probe techniques like atomic force microscopy, moving the SQUID to the apex of tip on a scanning probe can significantly increase the spatial resolution.

We have used the principles of corner lithography and molding in silicon wafers to create freestanding superconducting wireframe tips on cantilevers on the wafer scale. With a focused ion beam we pattern superconducting weak links at the apex of the fabricated wireframe tips to create SQUIDS with sizes from sub-100 nm to several micrometers. By integrating the wireframe probe on a silicon nitride cantilever with pre-defined contact pads, leads, and resistive strain gauges, we create a SQUID on cantilever probe which will enable simultaneous magnetic and topographic imaging.

TT 28.6 Tue 10:45 CHE/0089

Low noise amplification using Nb trilayer Dimer Josephson Junction Array Amplifiers — •BHOOMIKA R BHAT, ASEN L GEORGIEV, FABIAN KAAP, VICTOR GAYDAMACHENKO, CHRISTOPH KISSLING, JUDITH FELGNER, MARK BIELER, and LUKAS GRÜNHaupt — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Minimizing added noise in amplification is crucial for quantum-based devices requiring microwave readout signals in the femtowatt range. For example, in superconducting qubits, it significantly improves readout fidelity. Extensive efforts over the last decade have been made in the development of parametric amplifiers to address this challenge. We develop a Dimer Josephson Junction Array Amplifier (DJJAA) [1], in which parametric amplification in the degenerate four-wave-mixing regime is facilitated by pairs of resonant modes, referred to as dimers. We design it to feature multiple flux-tunable dimers within the 2 to 8 GHz range, each of which could be utilized for parametric amplification. Our DJJAAs have 900 to 3000 dc-SQUIDS, and we fabricate them using Nb/Al-AlO_x/Nb trilayer technology. We present the fabrication flow of our devices and provide an overview of the corresponding experimental results. Our devices show gain on the order of 20 dB with bandwidths in the range of 5 to 10 MHz and the typical input saturation powers are on the order of -110 dBm.

[1] P. Winkel et al., Phys. Rev. Applied 13, 024015 (2020).

15 min. break

TT 28.7 Tue 11:15 CHE/0089

Controlling three- and four-wave mixing processes in JTWPAs — •DANIIL BAZULIN^{1,2}, JOHANNES SCHIRK^{1,2}, NIKLAS BRUCKMOSER^{1,2}, LEON KOCH³, YONGJIE YUAN⁴, MICHAEL HAIDER^{4,5}, STEFAN FILIPP^{1,2,6}, and KIRILL G. FEDOROV^{1,2,6} — ¹Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ²Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ³Peak Quantum GmbH, 85748 Garching, Germany — ⁴TUM School of Computation Information and Technology, Technical University of Munich, 85748 Garching, Germany — ⁵Universität der Bundeswehr München, 85579 Neubiberg, Germany — ⁶Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

Josephson travelling-wave parametric amplifiers (JTWPAs) are essential for scalable quantum computing with superconducting circuits. Their typical bandwidths of several gigahertz, in combination with quantum-limited noise performance, enable high-fidelity multiplexed readout of qubits. In JTWPAs, amplification occurs due to the interaction between the pump and signal modes in a nonlinear medium provided by superconducting nonlinear asymmetric inductive elements (SNAILs). Here, we experimentally investigate a robust JTWPA design based on SNAILs that is capable of operating in both three- and four-wave-mixing regimes. Our results show that we can fully suppress the three-wave mixing process while observing over 10 dB gain from the four-wave pumping over the bandwidth of 4 GHz.

TT 28.8 Tue 11:30 CHE/0089

Demonstration of natively phase-matched parametric amplification in a left-handed transmission line — •CHRISTOPH KISSLING¹, VICTOR GAYDAMACHENKO¹, FABIAN KAAP¹, MELANIE ZIEGLER², HANNES TOEPFER², and LUKAS GRÜNHaupt¹ — ¹Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — ²Technische Universität Ilmenau, Ehrenbergstraße 29, 98693 Ilmenau

Wideband amplification of weak microwave signals is a key ingredient for cutting-edge experiments ranging from quantum information processing to the search for dark matter. A class of devices that achieves this is the traveling-wave parametric amplifier (TWPA). So far, all TWPA implementations are based on right-handed transmission lines, which exhibit a positive refractive index. Recently, an alternative approach has been proposed that utilizes left-handed transmission lines, which have a negative refractive index [1]. This property allows for self-phase-matched parametric amplification in the four-wave-mixing regime, eliminating the need for any engineering of nonlinearity or dispersion for phase matching. Here, we present our implementation of this concept, which employs a left-handed transmission line with nonlinear inductors made from a granular aluminum thin film. First results show a signal power gain exceeding 10 dB, dynamically tunable across multiple GHz. With only one lithography step, and an order-of-magnitude reduction in circuit length, the concept is promising to significantly reduce the complexity of designing and fabricating a TWPA.

[1] C. Kow et al., Phys. Rev. Applied 24, 024026 (2025)

TT 28.9 Tue 11:45 CHE/0089

Towards 1 V Josephson Arbitrary Waveform Synthesizer — •OMAR M. ALADDIN¹, OLIVER KIELER¹, ABDULRAHMAN WIDAA¹, HANNES PREISSLER¹, ERASMUS WOLF², MARCO SCHUBERT², JUDITH FELGNER¹, ROLF-WERNER GERDAU¹, JOHANNES KOHLMANN¹, and MARK BIELER¹ — ¹Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — ²Supracon AG, An der Lehmgrube 11, 07751 Jena, Germany

The Josephson Arbitrary Waveform Synthesizer (JAWS) provides quantum-accurate AC voltage waveforms with high spectral purity, low noise, and inherent long-term stability. Based on pulse-driven Josephson junction (JJ) arrays, JAWS is established as the primary AC voltage standard. Recent JAWS developments at PTB include increasing the output voltage per chip, targeting 1 V RMS to advance its use in high-accuracy metrological applications [1]. Current efforts focus on enhancing the JAWS fabrication process to enable larger array sizes using 5-stacked JJ arrays. The stacked junction technology is combined with improved on-chip Wilkinson power dividers, allowing the incorporation of more than two JJ arrays on one chip [2]. The power dividers have been successfully demonstrated with 3-stacked JJ arrays achieving 600 mV RMS per JAWS chip with a total of 36,000 junctions. In this contribution, we present the recent results of 5-stacked JJ arrays and Wilkinson power dividers with up to 60,000 JJs per JAWS chip.

[1] DOI: 10.1016/B978-0-323-90800-9.000001-9

[2] DOI: 10.1109/TASC.2021.3055161

TT 28.10 Tue 12:00 CHE/0089

Study on the feedthrough error in quantum-based superconducting RF waveform generators — •MICHAEL HAAS, ABDULRAHMAN WIDAA, OLIVER KIELER, MARCO KRAUS, RALF BEHR, JOHANNES KOHLMANN, and MARK BIELER — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Quantum-based signal generators are of great interest for a variety of applications such as electrical metrology or quantum computing. The Josephson Arbitrary Waveform Synthesizer (JAWS) consisting of an

array of Josephson junctions is one of such devices. It allows the generation of arbitrary, low-noise waveforms with high spectral purity by utilizing the Josephson effect. This approach is well established for signal frequencies in the kHz to low MHz range. However, modern applications typically demand increasing signal frequencies, reaching the microwave range. To satisfy the need for higher JAWS output frequencies, modified circuit designs and bias schemes are necessary. This is mainly because of the so-called feedthrough error, which denotes an input signal being fed through to the output. We will present recent developments of GHz-JAWS at PTB, comprising detailed investigations on the feedthrough error and methods for its reduction.

TT 28.11 Tue 12:15 CHE/0089

Nonequilibrium plasmon fluid in a Josephson junction chain — ANTON V. BUBIS¹, ●LUCIA VIGLIOTTI¹, MAKSYM SERBYN¹, and ANDREW P. HIGGINBOTHAM² — ¹Institute of Science and Technology Austria, Am Campus 1, Klosterneuburg, 3400, Austria — ²James Franck Institute and Department of Physics, University of Chicago, 929 E 57th St, Chicago, Illinois 60637, USA

With the recent push towards the development of quantum technologies, multimode quantum systems, such as superconducting resonators, have drawn considerable attention. These systems can be generally described as weakly nonlinear bosonic modes coupled to a thermal bath and subject to coherent driving. As the number of modes grows and extrinsic decoherence is reduced, understanding the mode-to-mode interaction becomes increasingly relevant, especially far from equilibrium. We consider the interacting plasmonic modes emerging in a long chain of Josephson junctions (JJs), probed via multitone microwave spectroscopy. We investigate the nonequilibrium kinetics of the resulting one-dimensional quantum fluid both theoretically and experimentally, focusing on four-wave-mixing processes. Under two coherent drives, we observe cascaded coupling between plasmonic modes, reproduced using

input-output theory applied to nonlinear mode multiplets. Under incoherent broadband drive, we explore the kinetics of weakly populated modes and numerically implement a kinetic equation that predicts the non-equilibrium steady state and captures the excess linewidth of non-driven modes. Our work establishes the key role of four-wave-mixing nonlinearities in the non-equilibrium response of JJ chains.

TT 28.12 Tue 12:30 CHE/0089

Superconducting non-volatile memory device based on charge trapping in Al₂O₃. — ●LEON RUF¹, JENNIFER KOCH¹, ANGELO DI BERNARDO^{1,2}, and ELKE SCHEER¹ — ¹Department of Physics, University of Konstanz, 78464 Konstanz, Germany — ²Department of Physics, University of Salerno, 84084 Salerno, Italy

Gate-controlled supercurrent (GCS) is a debated research topic. Experiments on three-terminal devices have shown that applying a gate voltage can modulate the supercurrent [1]. The authors interpret their findings as a direct electric-field effect, suggesting potential for CMOS-compatible superconducting transistors.

In contrast, other studies suggest that the observed modulation stems from a small leakage current flowing within the substrate [2,3], which can be as small as a few fA causing nonequilibrium phonons and/or electrons suppressing the supercurrent. A leakage current flowing through the substrate is typically undesirable for applications.

Here, instead, we show that the charge-trapping properties of the Al₂O₃ substrate can be harnessed to realize a non-volatile superconducting memory device based on the GCS effect [4]. We outline the device concept and operating principle and provide an outlook on future avenues for device optimization.

[1] De Simoni et al., Nat. Nanotechnol. 13, 802 (2018).

[2] Ritter et al., Nat. Electron. 5, 71 (2022).

[3] Basset et al., Phys. Rev. Research 3, 043169 (2021).

[4] Ruf et al., arXiv:2503.17241 (2025).

TT 29: Unconventional Superconductors

Time: Tuesday 9:30–12:45

Location: CHE/0091

TT 29.1 Tue 9:30 CHE/0091

Investigation of the field-dependent phase diagram of UTe₂ — ●F. HUSTEDT^{1,2}, M. KIMATA³, S. NADUVILE THADATHIL^{1,2}, M. KÖNIG⁵, G. LAPERTOT⁴, J.-P. BRISON⁴, G. KNEBEL⁴, J. WOSNITZA^{1,2}, and T. HELM¹ — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL) and Würzburg-Dresden Cluster of Excellence ctd.qmat, HZDR, Germany — ²Institut für Festkörper- und Materialphysik, TU Dresden, Germany — ³Institute for Materials Research, Tohoku University, Japan — ⁴Centre CEA de Grenoble, France — ⁵Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

While the general shape of the UTe₂ superconducting (SC) phase diagram is already known, there are still investigations ongoing regarding the details of the SC states. This includes, for example, the shape and nature of the high-field reentrant SC phase near the crystallographic *b* axis as well as multiple superconducting phases at lower fields. Especially interesting is the case for field applied parallel to the *b* axis. The phase diagram proposed by Rosuel *et al.* [1] contains two second-order phase transition lines meeting, which is thermodynamically forbidden [2]. This problem could be resolved by a fourth line emerging from this point. The first indication of such a line was proposed by Sakai *et al.* [3]. We performed transport studies on a microfabricated sample to get deeper insight in the phase diagram for both the *a* axis and *b* axis as well as the angle-dependent behavior of the emergent phases.

[1] Rosuel *et al.*, PRX 13, 011022 (2023)

[2] Yip *et al.*, PRB 43, 2742 (1991)

[3] Sakai *et al.*, PRL 130, 196002 (2023)

TT 29.2 Tue 9:45 CHE/0091

Determining the superconducting order parameter of UPT₃ using scanning tunneling microscopy — ●REBECCA BISSET¹, LUKE C. RHODES¹, HUGO DECITRE¹, MATTHEW NEAT¹, ANA MALDONADO¹, ANDREW HUXLEY², CAROLINA A. MARQUES¹, and PETER WAHL^{1,3} — ¹SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, United Kingdom — ²SUPA, School of Physics and Astronomy, University of Edinburgh, Kings Buildings, Edinburgh, EH9 3FD, United Kingdom — ³Physikalisches Institut, Universität Bonn, Nussallee 12, 53115

Bonn, Germany

The hunt for spin-triplet superconductors has excited researchers for decades, with new candidates regularly being proposed as others are ruled out. This pairing of electrons into a Cooper pair state with total spin of one is allowed theoretically but has yet to be confirmed in a material. A system with these characteristics would have profound fundamental and technological implications. Here, we use ultra-low temperature scanning tunneling microscopy to measure the superconducting gap of UPT₃, which reveals a zero-bias Andreev bound state in the surface perpendicular to the *c*-axis. The superconducting origin of the gap is confirmed via observation of a vortex lattice, as well as by suppression of the gap above the expected critical field and temperature. For triplet pairing, such an Andreev state is fragile against Rashba spin-splitting, whereas for singlet pairing it remains robust, strongly suggesting that UPT₃ is a spin-singlet superconductor.

TT 29.3 Tue 10:00 CHE/0091

Study of tri-layer Bismuth-based Cuprates through ARPES measurement — ●ELISA AUFRAY^{1,2}, LENART DUDY², and SIHAM BENHABIB¹ — ¹Laboratoire de Physique des Solides, CNRS, Orsay, France — ²Synchrotron Soleil, CEA, CNRS, St Aubin, France

It is now well established that three-layer cuprates exhibit the highest critical temperature within each family, making them particularly interesting systems for studying superconductivity. Due to the presence of an underdoped inner CuO₂ plane, the magnetic environment is expected to differ from that of two-layer cuprates, a feature that has indeed been demonstrated by nuclear magnetic resonance measurements. This doping imbalance has also been revealed by ARPES measurements on the three-layer compound Bi2223. The bismuth-based three-layer cuprate is one of the most accessible in terms of synthesis and experimental investigation, and together with Hg1223 it belongs to the cuprates with the highest critical temperatures across the entire family. This makes it an excellent candidate for understanding three-layer physics, as highlighted by the number of recent publications devoted to it. Among these ARPES studies, only a few focus on the antinodal region where superconductivity truly emerges, so systematic comparisons between nodal and antinodal behavior are still lacking. In

this presentation, we report our ARPES measurements on Bi2223. We present the momentum dependence of the 70 meV kink, which has previously been studied in the nodal region in superconducting state, as well as a comparison between the normal and superconducting phases.

TT 29.4 Tue 10:15 CHE/0091

Boundary critical temperature in unconventional superconductors and effects of impurities — ●DAVID HAINK^{1,2} and BENEDIKT FAUSEWEH^{1,2} — ¹High-performance Computing, Institute of Software Technology, German Aerospace Center (DLR), 51147 Cologne, Germany — ²Condensed Matter Theory, TU Dortmund University, Otto-Hahn-Straße 4, 44227 Dortmund, Germany

In BCS theory, s-wave superconductors have a higher critical temperature at their boundaries than in their bulk [PRB 101, 134512 (2020)]. We show that this boundary behavior does not hold for p-wave, but for d-wave superconductors and for coexisting phases. We further investigate the effects of randomly distributed impurities in the chemical potential on the critical temperature of the edge.

TT 29.5 Tue 10:30 CHE/0091

Weak competition between magnetism and superconductivity in the heavy-fermion compound CeRh₂As₂ — ●PAVLO KHANENKO^{1,2}, JAVIER F. LANDAETA², SIMON RUET², THOMAS LÜHMANN², KONSTANTIN SEMENIUK^{2,3,6}, MAX PELLY⁴, ANDREAS W. ROST⁴, GRZEGORZ CHAJEWSKI⁵, DARIUSZ KACZOROWSKI⁵, CHRISTOPH GEIBEL², SEUNGHYUN KHM², ELENA HASSINGER^{3,6}, and MANUEL BRANDO² — ¹Helmholtz Zentrum Dresden Rossendorf, Germany — ²MPI CPfS, Germany — ³TUD, Germany — ⁴University of St. Andrews, United Kingdom — ⁵Institute of Low Temperature and Structure Research, Poland — ⁶KIT Karlsruhe, Germany

The heavy-fermion superconductor CeRh₂As₂ shows superconductivity at $T_c = 0.35$ K, which is preceded by another phase (phase I) at $T_0 = 0.54$ K. Recent μ SR studies detected an internal magnetic field within phase I and suggested its coexistence with superconductivity. When a magnetic field is applied parallel to the c axis of its tetragonal unit cell, a second superconducting (SC) phase is observed at $\mu_0 H^* \approx 4$ T. An earlier study has shown that phase I persists up to $\mu_0 H_0 \approx 6$ T, larger than H^* . However, the phase transition disappeared upon entering the SC dome, contradicting thermodynamic considerations. Here, we report magnetic field-dependent ac-susceptibility and magnetostriction measurements on high-quality single crystals. We observed clear evidence of the singularity at H_0 in fields up to 7 T and inside the SC dome. Analysis of the phase boundaries in terms of the Ginzburg-Landau theory of coupled order parameters shows a weak competition between phase I and superconductivity.

TT 29.6 Tue 10:45 CHE/0091

Entropy-rich superconductivity and unconventional vortex dynamics in CeRh₂As₂ — ●SHUAI ZHANG, XINYANG LIU, ENKE LIU, and PEIJIE SUN — Institute of Physics and Beijing National Laboratory for Condensed Matter Physics, Chinese Academy of Sciences, Beijing 100190, China

We investigate the multiple superconducting (SC) phases SC1 and SC2 of CeRh₂As₂ using high-resolution magnetocaloric-effect (MCE) measurements. Pronounced temperature hysteresis observed during quasiadiabatic field sweeps provides direct thermodynamic evidence that both the SC1-normal (NS) and SC2-NS transitions are first order. In contrast, a continuous yet asymmetric entropy evolution across the SC1-SC2 boundary reveals a change in the superconducting order parameter, consistent with a second-order transition. The observed temperature dips in field-sweep traces identify SC2 as a higher-entropy phase compared with SC1 and NS. Furthermore, the two-step resistive transitions and enhanced ΔT near the SC2-NS boundary highlight the unconventional and current-sensitive nature of SC2. These results establish a comprehensive thermodynamic phase diagram for CeRh₂As₂ and demonstrate that MCE is a powerful probe of entropy discontinuities and symmetry reconstruction in locally noncentrosymmetric superconductors.

TT 29.7 Tue 11:00 CHE/0091

Chiral topological superconductivity in hole-doped Sn/Si(111) — ●MATTHEW BUNNEY^{1,2}, LUCCA MARCHETTI¹, DOMENICO DI SANTE³, CARSTEN HONERKAMP², and STEPHAN RACHEL¹ — ¹School of Physics, University of Melbourne, Australia — ²Institute for Theoretical Solid State Physics, RWTH Aachen University, Germany — ³Department of Physics and Astronomy, University of Bologna, Italy

A third monolayer of tin atoms on the semiconductor substrate Si(111) has been shown to become superconducting upon six to ten percent hole doping. Experiments have reported promising results hinting at a superconducting chiral d -wave order parameter. Here we examine Sn/Si(111) by combining most recent ab initio results, quasi-particle interference calculations, state-of-the-art truncated-unity functional renormalization group simulations and Bogoliubov-de Gennes analysis. We show remarkable agreement between experimental and theoretical quasi-particle interference data both in the metallic and superconducting regimes. The interacting phase diagram reveals that the superconductivity is indeed chiral d -wave with Chern number $C = 4$. Surprisingly, magnetically ordered phases are absent, instead we find charge density wave order, as observed in related compounds, as a competing phase. Our results substantiate further that Sn/Si(111) is a promising candidate material for chiral topological superconductivity.

15 min. break

TT 29.8 Tue 11:30 CHE/0091

Point-contact spectroscopy of atomic contacts from the non-centrosymmetric superconductor Nb₁₈Re₈₂ — ●TIARK TIWARY, ELIAS HADZIC, MARCEL STROHMEIER, and ELKE SCHEER — University of Konstanz, 78457 Konstanz, Germany

Revealing various properties of unconventional superconductivity, the non-centrosymmetric superconductor Nb₁₈Re₈₂ (Nb-Re) has become of great interest in the recent years. A key feature is the absence of inversion symmetry which is causing a Rashba-type spin-orbit coupling. Theoretically, this lack of symmetry allows for an admixture of spin-singlet and spin-triplet states. While previous measurements [1] on point contacts with Nb-Re single crystals stated the existence of two distinct BCS-like superconducting energy gaps, measurements on Nb-Re thin films [2] are showing a single s-wave gap. To address these inconsistencies, we utilised the mechanically controlled break junction technique to characterise Nb-Re atomic contacts. We observe the typical features of Andreev reflections for atomic contacts with high transmission as well as tunneling spectra for contacts with low transmission. As a result the two distinct gaps observed in [1] can be reproduced. While the temperature dependencies of both gaps follow an BCS-like behaviour, the magnetic field dependent measurements shows a non-BCS-like behaviour.

[1] Cirillo et al., Phys. Rev. B, **91**, 134508 (2015)

[2] Cirillo et al., Phys. Rev. B, **94**, 104512 (2016)

TT 29.9 Tue 11:45 CHE/0091

Unconventional superconductivity in monolayer transition metal dichalcogenides — ●SUBHOJIT ROY¹, ANDREAS KREISEL², BRIAN ANDERSEN³, and SHANTANU MUKHERJEE⁴ — ¹University of Regensburg, Regensburg, Germany — ²Niels Bohr Institute, University of Copenhagen, Denmark — ³Niels Bohr Institute, University of Copenhagen, Denmark — ⁴Indian Institute of Technology Madras, Chennai, India

The observation of a Leggett mode, nodal superconducting gaps in STM measurements, unusually large in-plane upper critical fields far exceeding the Pauli limit, and a two-fold gap anisotropy in magnetoresistance experiments all point toward an unconventional pairing mechanism. Ab-initio calculations have further revealed a strongly anisotropic Eliashberg electron-phonon spectral function in monolayer NbSe₂, with a significant contribution arising from same-spin K - K' scattering. In this work [1], we consider the interplay of electron-electron and electron-phonon interactions. Starting from the ab-initio phonon spectrum, we compute the effective phonon-mediated interaction and incorporate it into an RPA-based description of the screened Coulomb interaction. Our framework captures the full lattice structure, the multi-orbital character of the relevant d-band states, and phonon retardation effects within a unified microscopic model. Using this model, we address key magnetic-field-dependent phenomena in Ising superconductors, including the enhanced Pauli limit and the two-fold magnetoresistance anisotropy.

[1] S. Roy et al., arXiv:2509.03907 (2025).

TT 29.10 Tue 12:00 CHE/0091

Effects of YIG exchange field on TMDC superconductor NbSe₂ — ●ALFREDO SPURI¹, MARCIN FAITSCH¹, CHRISTIAN WIEDEMANN¹, WOLFGANG BELZIG¹, ELKE SCHEER¹, and ANGELO DI BERNARDO^{1,2} — ¹Universität Konstanz, Konstanz, Germany — ²Univeristà degli studi di Salerno, Fisciano, Italy

Yttrium iron garnet (YIG) [1] is a heavily investigated material for application in spintronic devices as a ferromagnet with high critical temperature ($T_C \sim 560$ °C), insulating properties due to a large bandgap of ~ 2.85 eV, and a strong local in-plane exchange field ($H_{ex} \sim 10^2$ T). Coupling YIG with a natural 2D Ising superconductor like NbSe₂, with a very high in-plane critical field ($H_C \sim 40$ T in the monolayer limit) [2], offers the possibility of novel unconventional superconducting states.

We have assembled YIG/NbSe₂ heterostructures and investigated their superconducting properties. NbSe₂ with a YIG flake on top reveals features in the $T_C(B)$ curve that are not found on bare NbSe₂. We tentatively attribute the features in the heterostructures to scattering between two different energy bands in NbSe₂, enhanced by the strong exchange field of the YIG.

[1] R. Hartmann et al., APL Mater. 12, 031121 (2024).

[2] X. Xi et al., Nature Phys. 12, 139 (2016).

TT 29.11 Tue 12:15 CHE/0091

Effects of disorder on the superconducting properties of YFe₂Ge₂ — ●MADS HANSEN¹, HAN ZONG¹, JIASHENG CHEN¹, ROMIAN GRASSET², SIHAM BENHABIB³, and MALTE GROSCHKE¹ — ¹University of Cambridge, Cambridge, United Kingdom — ²Laboratoire des Solides Irradiés, École Polytechnique, CNRS, Institut Polytechnique de Paris, Palaiseau, France — ³Laboratoire de Physique des Solides, Orsay, France

YFe₂Ge₂ has been reported as an unconventional superconductor [1–3]. The non-Fermi liquid behavior observed in the normal state, as well as enhanced magnetic fluctuations [4,5] evidence the strongly correlated nature of the electron system. The pairing mechanism remains unknown, however, theoretical proposals hypothesize two different scenarios: an $s^{+/-}$ [6] or a triplet pairing wavefunction [7]. We have grown high quality crystals and induced point-like defects at various concentrations, using the electron irradiation facility SIRIUS. Here, we present a study on the effect of disorder on the Sommerfeld coefficient and the transport properties of YFe₂Ge₂ to address the outstanding

question of the pairing mechanism.

[1] Y. Zou et al., Phys. Status Solidi RRL 8, 928 (2014)

[2] J. Chen et al., Phys. Rev. Lett. 116, 127001 (2016)

[3] J. Chen et al., Phys. Rev. Lett. 125, 237002 (2020)

[4] N. Sirica et al., Phys. Rev. B 91, 121102 (2015)

[5] H. Wo et al., Phys. Rev. Lett. 122, 217003 (2019)

[6] A. Subedi, Phys. Rev. 89, 024504 (2014)

[7] D. J. Singh, Phys. Rev. B 89, 024505 (2014)

TT 29.12 Tue 12:30 CHE/0091

Inverse proximity effect and unconventional superconductivity in the Pb/CrTe hybrid thin films — ●LICHEN JI^{1,2}, WEI CHEN², XINYU ZHOU², XUSHENG WANG², YI HU², XIAOPENG HU², QINGHUA ZHANG³, DING ZHANG², QI-KUN XUE², and SHUAI-HUA JI² — ¹Max Planck Institute for Chemical Physics of Solids, Dresden 01187, Germany — ²State Key Laboratory of Low-Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084, China — ³Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

Two-dimensional (2D) heterostructures provide an important platform for exploring unconventional quantum states. Here, we investigate molecular-beam-epitaxial 2D vertical superconductor (S)/ferromagnet (F) hybrids composed of superconducting Pb and ferromagnetic CrTe using in situ scanning tunneling microscopy and ex situ transport measurements. We observe an unconventional superconducting gap structure accompanied by a pronounced inverse proximity effect. Transport data further show strong suppression of both the critical temperature and upper critical field. Importantly, the critical temperature exhibits an oscillatory dependence on the CrTe thickness, and re-entrant superconductivity emerges within a finite magnetic-field window. These results offer new insights into the unconventional superconducting properties of Pb/CrTe hybrids, underscoring the crucial role of interfacial effect and inverse proximity effect.

TT 30: Caloric Effects in Ferromagnetic Materials (joint session MA/TT)

Time: Tuesday 9:30–11:30

Location: POT/0151

Invited Talk

TT 30.1 Tue 9:30 POT/0151

Magnetic Cooling: From applications at room temperature to hydrogen liquefaction — ●T. GOTTSCHALL¹, E. BYKOV¹, M. STRASSHEIM¹, T. PLATTE², C. FUJITA², D. BENKE², M. FRIES², W. LIU³, A. DÖRING³, K. SKOKOV³, O. GUTFLEISCH³, and J. WOSNITZA¹ — ¹Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — ²MAGNOTHERM Solutions GmbH, Darmstadt, Germany — ³Technical University of Darmstadt, Darmstadt, Germany

Magnetic cooling can be utilized to construct environmentally friendly cooling devices, air conditioners, and heat pumps. Recently, low temperatures became the focus of attention as an area of application for magnetocaloric cooling, namely for hydrogen liquefaction. The conventional liquefaction process uses up to 40 % of the lower heating value of the gas we are compressing, just to liquefy it! Magnetocaloric materials enable an alternative and more efficient approach. A large number of compounds are already known that show magnetocaloric effects in the desired temperature range and new candidates are constantly being added. In this work, we would like to discuss our current progress for the creation of a materials library for cryogenic applications. The basis for this is our characterization infrastructure for materials research at TU Darmstadt and the Dresden High Magnetic Field Laboratory in static and pulsed magnetic fields. Furthermore, we also provide an overview of the recent results in the demonstrator development of a magnetic hydrogen liquefier within the framework of the European project HyLICAL.

TT 30.2 Tue 10:00 POT/0151

Hydrogen tunned transition temperature of GdFeSi for magnetocaloric hydrogen liquefaction application — ●ALLAN DÖRING¹, WEI LIU¹, MARC STRASSHEIM², TINO GOTTSCHALL², KONSTANTIN SKOKOV¹, and OLIVER GUTFLEISCH¹ — ¹Institute of Materials Science, Functional Materials, Technical University of Darmstadt, Darmstadt, Germany — ²Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany

Hydrogen can play an important role in the future carbon-neutral society. Among several alternatives to store this energy carrier, the liquid H₂ (LH₂) stands out for its higher volume-to-energy ratio. However, the actual method of H₂ liquefaction sums up to 34% of the costs of LH₂. The magnetocaloric cooling could be one alternative to improve the efficiency of the process. Thus, it is essential to conduct research on materials exhibiting a strong magnetocaloric effect (MCE) within the temperature range of 20 K to 77 K. The peak of the MCE is at transition temperatures, such as the Curie temperature (TC). The magnetocaloric effect peak of GdFeSi is at 125 K. In this study, the TC of GdFeSi was shifted to lower temperatures by hydrogenation process, achieving a shift of over 90 K. By the anisotropic crystal expansion, GdFeSiH exhibited and higher magnetocaloric effect than the pristine alloy, not only by the isothermal entropy change, but also directly measured adiabatic temperature change. We acknowledge the HyLICAL project for the funding of this research through grant 101101461, and Deutsche Forschungsgemeinschaft (DFG) within the CRC/TRR 270 (Project-ID 405553726).

TT 30.3 Tue 10:15 POT/0151

First-principles investigation of chemical substitution and interstitial doping in La(Fe,Si)₁₃ — ●ANITA YADAV and MARKUS E. GRUNER — University of Duisburg-Essen, 47057 Duisburg, Germany

La(Fe_xSi_{1-x})₁₃ is a prominent magnetocaloric material, characterized by a sharp first-order phase transition and a large associated entropy change. Its behavior arises from an intricate coupling among the magnetic, electronic, and lattice degrees of freedom, which makes the material highly responsive to external factors and enables targeted tuning of its magnetocaloric response [1,2]. The operating range can be modified through substitution and interstitial loading, which can alter the local atomic environment and reshape the coupling between structural and magnetic subsystems. In this work, we employ first-principles calculations in the framework of density functional theory (DFT) to systematically screen the impact of chemical substitution and loading of light elements on interstitial sites with respect to structural stability, lat-

tice expansion, magnetic interactions, and thermodynamic behavior. Furthermore, we explore the benefits of machine-learning force-fields based on our DFT results for an efficient modeling of the thermodynamic properties of $\text{La}(\text{Fe}_x\text{Si}_{1-x})_{13}$ -based compounds. Funding by the DFG via TRR270 (B06) is gratefully acknowledged.

[1] M. E. Gruner *et al.*, Phys. Rev. Lett. **114**, 057202 (2015)

[2] K. P. Skokov *et al.*, Appl. Phys. Rev. **10**, 031408 (2023)

TT 30.4 Tue 10:30 POT/0151

Magnetocaloric Laves phases based on light rare earths: Addressing Criticality — ●M. STRASSHEIM^{1,2}, L. BEYER^{3,4}, J. WOSNITZA^{1,2}, and T. GOTTSCHALL¹ — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — ²Institut für Festkörper- und Materialphysik, TU Dresden, Germany — ³Leibniz Institute for Solid State and Materials Research Dresden, Germany — ⁴TU Bergakademie Freiberg, Germany

Laves-phase intermetallic compounds based on heavy rare-earth elements have long been recognized for their excellent magnetocaloric performance at low temperatures, making them promising candidates for cryogenic cooling applications. However, the reliance on heavy rare earths poses challenges in terms of cost, availability, and sustainability. In this work, we explore the magnetocaloric properties of the light rare-earth-based Laves phase CeFe_2 . By the substitution of Al, its unstable ferromagnetism can be disturbed enough to establish an antiferromagnetic phase below 80 K. Using a combination of structural, magnetic, and direct adiabatic temperature change measurements at the Dresden High Field Laboratory, we investigate the potential of this antiferromagnetic state for its potential in magnetocaloric hydrogen liquefaction.

TT 30.5 Tue 10:45 POT/0151

Pressure effect on the magnetocaloric response of RCo_2 Laves Phases — ●CATALINA SALAZAR-MEJIA¹, E. BYKOV¹, W. LIU², K. SKOKOV², O. GUTFLEISCH², J. WOSNITZA^{1,3}, and T. GOTTSCHALL¹ — ¹High Magnetic Field Laboratory (HLD-EMFL), Helmholtz-Zentrum Dresden-Rossendorf, Germany — ²Institut für Materialwissenschaft, TU Darmstadt, Germany — ³Institut für Festkörper- und Materialphysik, TU Dresden, Germany

Rare-earth Laves phases are potential candidates for magnetic refrigeration at cryogenic temperatures. They exhibit large magnetocaloric effects and their transition temperatures can be tuned through elemental substitutions. In this work, we investigate the effect of hydrostatic pressure on the magnetism and magnetocaloric effect of RCo_2 Laves phases with rare-earth elements $R = \text{Tb}$, Dy , Ho , and Er . In general, we observe that the Curie temperature, T_C , decreases with applied pressure in all alloys. T_C is most sensitive to pressure in TbCo_2 , with $dT_C/dp \approx -22 \text{ K/GPa}$, and this value decreases systematically along the series, reaching $dT_C/dp \approx -7.7 \text{ K/GPa}$ in ErCo_2 . More interestingly, hydrostatic pressure has an almost negligible effect on the magnetocaloric response - specifically on the isothermal entropy change, ΔS_T , with the exception of HoCo_2 , where ΔS_T increases by about 26% under an applied pressure of approximately 1 GPa and for a magnetic field change of 5 T.

TT 30.6 Tue 11:00 POT/0151

Manipulating Magnetocaloric Properties Through Magnetic Exchange at $\text{Mn}_{3-x}\text{GaC}/\text{Fe}$ Interfaces — ●IVAN TARASOV and ULF WIEDWALD — Faculty of Physics and Center for Nanointegration (CENIDE), University of Duisburg-Essen, 47057 Duisburg, Germany

Magnetocaloric materials enable solid-state cooling by exploiting temperature changes under magnetic-field variation. Manganese-based antiperovskites (APVs, Mn_3AX) are promising materials due to their sharp, tunable first-order magnetostructural transition (FOMST). A key challenge is to control the working temperature window and enhance the magnetocaloric response within a given material system. Tailoring magnetic exchange interactions offers a new strategy.

Here, we investigate APV/Fe bilayers, focusing on interface-driven exchange effects. Uncoupled $\text{Mn}_2\text{GaC}_{1.1}$ films show a sharp FOMST at 189 K with a strong $\partial M/\partial T$ peak. A 5 nm Fe cap lowers the transition to 175 K, broadens hysteresis, and suppresses the $\partial M/\partial T$ peak above 1 T. The bare APV exhibits $\Delta S_m \approx 10 \text{ J kg}^{-1} \text{ K}^{-1}$ at $B = 6 \text{ T}$, whereas coupling reduces this to $\sim 1 \text{ J kg}^{-1} \text{ K}^{-1}$ at $B = 5 \text{ T}$. In multi-domain bilayers, $\partial M/\partial T$ increases by 15% (AFM-FM) and 46% (FM-PM) for a Fe film thickness of $t = 2.6 \text{ nm}$, but disappears for $t = 21 \text{ nm}$, accompanied by an anomaly near 50 K linked to interfacial AFM ordering.

Funding by the Deutsche Forschungsgemeinschaft (DFG) within CRC/TRR 270, project B02 (Project-ID 405553726) is gratefully acknowledged.

TT 30.7 Tue 11:15 POT/0151

Frustration and Antiferromagnetic Ordering in Low-Temperature Materials for Adiabatic Demagnetization — ●ANTON JESCHE, TIM TREU, MARVIN KLINGER, JORGINHO VILLAR GUERRERO, and PHILIPP GEGENWART — EP VI, Institute of Physics, University of Augsburg, Germany

The development of improved materials for adiabatic demagnetization refrigeration (ADR) has been driven increasingly by research on magnetically frustrated systems, where competing interactions can suppress magnetic ordering to very low temperatures [1]. Such behavior is particularly attractive for low-temperature cooling and has led to several promising rare-earth-based compounds. Notable examples include $\text{KBaYb}(\text{BO}_3)_2$, which reaches temperatures near 20 mK [2], and NaGdP_2O_7 , which demonstrates extended hold times below 2 K in standard cryogenic environments [3].

This contribution will highlight selected Yb- and Gd-based materials and discuss the influence of frustration and antiferromagnetic (AFM) ordering on their cooling performance. Using NaGdP_2O_7 as a representative case, we examine how magnetic entropy near AFM transitions affects ADR behavior under varying magnetic fields and temperatures. We further show that high-resolution thermodynamic information, such as heat capacity, can be extracted directly from ADR curves.

[1] M. E. Zhitomirsky, Phys. Rev. B, 2003, 67, 104421, [2] Y. Tokiwa, Commun. Mater. 2021, 2, 42, [3] P. Telang, Phys. Rev. B, 2025, 111, 064434

TT 31: Frustrated Magnets I (joint session MA/TT)

Time: Tuesday 9:30–12:30

Location: POT/0361

TT 31.1 Tue 9:30 POT/0361

Spontaneous symmetry breaking in the Heisenberg antiferromagnet on a triangular lattice — ●BASTIAN PRADENAS^{1,2}, GRIGOR ADAMYAN^{1,3}, and OLEG TCHERNYSHYOV¹ — ¹William H. Miller III Department of Physics and Astronomy, Johns Hopkins University, Baltimore, USA — ²Leibniz Institute for Solid State and Materials Research, IFW, Dresden, Germany — ³Department of Physics, Massachusetts Institute of Technology, Cambridge, USA

We present a detailed investigation of an overlooked symmetry structure in non-collinear antiferromagnets that gives rise to an emergent quantum number for magnons. Focusing on the triangular-lattice Heisenberg antiferromagnet, we show that its spin order parameter transforms under an enlarged symmetry group, $\text{SO}(3)_L \times \text{SO}(2)_R$, rather than the conventional spin-rotation group $\text{SO}(3)$. Although this larger symmetry is spontaneously broken by the ground state, a residual subgroup survives, leading to conserved Noether charges

that, upon quantization, endow magnons with an additional quantum number—*isospin*—beyond their energy and momentum. Our results provide a comprehensive framework for understanding symmetry, degeneracy, and quantum numbers in non-collinear magnetic systems, and bridge an unexpected connection between the paradigms of symmetry breaking in non-collinear antiferromagnets and chiral symmetry breaking in particle physics.

TT 31.2 Tue 9:45 POT/0361

Antiferro octupolar order in the $5d^1$ double perovskite $\text{Sr}_2\text{MgReO}_6$ and its spectroscopic signatures — ●DARIO FIORE MOSCA¹ and LEONID POUROVSKI^{2,3} — ¹University of Vienna, Faculty of Physics and Center for Computational Materials Science, Vienna, Austria — ²CPHT, CNRS, Ecole polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ³College de France, Université PSL, 11 place Marcelin Berthelot, 75005 Paris, France

Hidden-order phases governed by high-rank multipolar order param-

ters have recently been identified in several cubic 5d double perovskites. Because experimental probes often couple weakly to high-rank moments, multipolar orders can remain elusive or be misinterpreted as lower-rank phases. A notable example is the 5d¹ double perovskite Sr₂MgReO₆, originally proposed as a spin glass and later reclassified as a conventional dipolar antiferromagnet.

In this work, we show instead that Sr₂MgReO₆ hosts a hidden antiferroic order of magnetic octupoles. The dominant tetragonal crystal field isolates a doublet carrying octupolar degrees of freedom, while weak dipolar moments arise only through admixture of the excited $j = 1/2$ spin-orbit multiplet. This octupolar order produces characteristic quasigapless magnetic excitations and superstructural neutron-diffraction intensities that peak at large scattering momenta.

This results highlights the tunability of multipolar interactions in spin-orbit entangled materials and places Sr₂MgReO₆ with unconventional octupolar phases.

TT 31.3 Tue 10:00 POT/0361

Field-dependent CEF excitations in Ce₂Bi — ●NIKOLAI PAVLOVSKII¹, ALEXANDER SUKHANOV², ANTON KULBAKOV¹, MICHAEL SMIDMAN³, FEDERICO MAZZA⁴, DARREN PEETS¹, KAUSHICK PARUI¹, ROSS STEWART⁵, ROSS PILTZ⁶, and DMYTRO INOSOV¹ — ¹TU Dresden, Germany — ²University of Augsburg, Germany — ³Zhejiang University, China — ⁴TU Vienna, Austria — ⁵ISIS, UK — ⁶ANSTO, Australia

Ce₂Bi is a cerium-based intermetallic compound where crystal-field (CEF) splitting and anisotropic magnetic interactions occur on comparable energy scales. To identify the relevant low-energy degrees of freedom, we investigate the field dependence of CEF-related excitations in single-crystalline Ce₂Bi using neutron-scattering techniques. Single-crystal diffraction establishes the crystallographic symmetry at the Ce site, providing the structural framework required for interpreting the magnetic excitations. The excitation spectrum shows a clear magnetic mode within the $J = 5/2$ manifold whose energy and intensity vary strongly with applied field. Crucially, the mode displays clear dispersion, demonstrating the presence of exchange interactions; as a result, what was previously interpreted as a localized CEF level is revealed to be a dispersive magnetic exciton. The field-induced evolution of this exciton constrains the mixing within the CEF manifold and the anisotropy of the ground-state Kramers doublet.

TT 31.4 Tue 10:15 POT/0361

High-field magnetic excitations in a kagome antiferromagnet — ●YOSHIHIKO IHARA¹, DMYTRO INOSOV², DARREN PEETS², MOYU KATO¹, and HIROYUKI YOSHIDA¹ — ¹Hokkaido University, Sapporo, Japan — ²TU Dresden, Dresden, Germany

Magnetic ground states in kagome antiferromagnets have been intensively studied to reveal the quantum mechanically disordered magnetic states. By applying high magnetic fields, further intriguing phenomena have been introduced such as the plateau in magnetization curve at the 1/9 of the full saturation value in YCu₃(OH)_{6.5}Br_{2.5}. [S. Jeon et al., Nat. Phys. **20**, 435 (2024), S. Suetsugu et al., PRL **132**, 226701 (2024), G. Zheng et al., PNAS **122**, e2421390112 (2025)]. Although higher magnetic fields induce another magnetization plateau at the 1/3 of the full saturation, the field strength required to access the 1/3 plateau is more than 50 T and is too large to perform most of the microscopic experiments. Thus, we focus on another Cu-based mineral InCu₃(OH)₆Cl₃, which shows the 1/3 plateau around 10 T due to smaller energy scale of exchange interactions [M. Kato et al., Commun. Phys. **7**, 424 (2024)]. This allows us to perform NMR experiments in the entire field range reaching the full saturation. The measured nuclear spin-lattice relaxation rate demonstrates that the magnetic excitations are gapped in the 1/3 plateau state and the gap size increases with fields [M. Kato et al., JPSJ **94**, 083704 (2025)]. We will also discuss the magnetic excitations above the 1/3 plateau based on the results obtained in the high-field magnet in Tohoku Univ.

TT 31.5 Tue 10:30 POT/0361

Evidence for a Near-Ideal Jeff = 1/2 Ground State in Triangular-Lattice Na₂BaCo(PO₄)₂ — ●MIGUEL M. F. CARVALHO^{1,2}, SHENG H. CHEN¹, YU C. KU^{3,4}, ANAGHA JOSE⁵, RYAN MORROW⁵, CHANG Y. KUO^{3,4}, CHUN F. CHANG¹, ZHIWEI HU¹, MAURITS W. HAVERKORT⁶, and LIU H. TJENG¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden — ²Institute of Physics II, University of Cologne — ³Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan — ⁴National Synchrotron Radiation Research Center, Hsinchu, Taiwan — ⁵Institut fuer

Festkörperphysik, Leibniz IFW, Dresden — ⁶Institute for theoretical physics, Heidelberg University

We investigated the local Co 3d electronic structure of Na₂BaCo(PO₄)₂ using polarization-dependent X-ray absorption spectroscopy (XAS) together with full multiplet cluster calculations. To obtain reliable spectra from this strongly insulating material, we employed the line-fitting inverse partial fluorescence yield (IPFY) method. Our combined experimental and theoretical analysis shows that the CoO₆ octahedra exhibit only a very small effective trigonal distortion of about 11 meV, placing the system close to the ideal conditions for a Jeff = 1/2 ground state. Using our cluster model, we are also able to simulate the magnetic susceptibility along different crystallographic directions. Overall, these results establish Na₂BaCo(PO₄)₂ as a promising platform for investigating exotic magnetic behavior linked to Jeff = 1/2 states on triangular lattices.

TT 31.6 Tue 10:45 POT/0361

Dimensional reduction and fractionalized magnetization plateaus in the scalene-distorted triangular-lattice magnet kobyashevite — ●KAUSHICK PARUI¹, ANTON KULBAKOV¹, ROMAN GUMENIUK², MARIA TERESA FERNANDEZ-DIAZ³, SERGEY GRANOVSKY¹, SERGEI ZVYAGIN⁴, DMYTRO INOSOV¹, and DARREN PEETS^{1,5} — ¹TU Dresden, Germany — ²TU Bergakademie Freiberg, Germany — ³ILL, France — ⁴HZDR, Germany — ⁵ct.qmat, TU Dresden, Germany

Quantum magnetism intertwined with lattice distortion can give rise to exotic ground states, yet studies on scalene-distorted triangular-lattice antiferromagnets remain scarce. Here, we report the crystal and magnetic structures, as well as magnetic and thermodynamic properties, of kobyashevite, Cu₅(SO₄)₂(OH)₆·4H₂O. This compound hosts a scalene-distorted triangular lattice and exhibits antiferromagnetic order at 4 K, with a possible second transition at 0.64 K. High-field magnetization and specific-heat measurements reveal a cascade of field-induced states, manifested as magnetization plateaus, suggestive of a rich magnetic phase diagram. Neutron diffraction uncovers a dimensionally-reduced commensurate magnetic structure with propagation vector $\mathbf{k} = (00 \frac{1}{2})$, consisting of coupled alternating ferromagnetic and antiferromagnetic spin chains, while the Cu4 spins remain idle at 1.5 K. Collectively, these results establish kobyashevite as a promising platform for exploring the interplay of frustration, distortion, and dimensional reduction in quantum magnets.

15 min break

TT 31.7 Tue 11:15 POT/0361

Atomically sharp magnetic solitons for racetrack memory at the spatial limit — K ALLEN¹, K DU², J BOUAZIZ³, S MISHRA¹, G BIHLMAYER³, Y ZHANG¹, Y HAO⁴, V UKLEEV⁵, C LUO⁵, F RADU⁵, Y GAO¹, CH LANE⁶, J-X ZHU⁶, M YI¹, H CAO⁴, S-W CHEONG², ●STEFAN BLÜGEL³, and EMILIA MOROSAN¹ — ¹Dept. of Physics and Astronomy & Rice Center for Quantum Materials, Rice University, Houston, 77005, TX, USA — ²Dept. of Physics and Astronomy, Rutgers University, Piscataway, 08854, NJ, USA — ³Peter-Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — ⁴Neutron Scattering Division, Oak Ridge Natl Lab, Oak Ridge, 37831, TN, USA — ⁵Helmholtz-Zentrum Berlin, 14109 Berlin, Germany — ⁶Theoretical Division, Los Alamos Nat. Lab., Los Alamos, 87545, NM, USA

We discuss the physics of a metallic square-net lattice rare-earth compound that exhibits RKKY interactions leading to magnetic frustration whose effective exchange interactions competes with the uniaxial anisotropy resulting in a rare ferrimagnetic up-up-down phase. Applying magnetic fields, atomically sharp solitons can be precipitated that have all the foundational credentials for a racetrack memory at the spatial limit. We present DFT calculations relating the RKKY interaction and the magnetic anisotropy to the electronic structure. We performed atomistic spin-dynamics calculations relating the interaction parameters to the soliton formation. A combination of experiments will be presented that provide evidence of the 1D magnetic solitons.

TT 31.8 Tue 11:30 POT/0361

Guest*Controlled Quantum Magnetism in a Flexible Metal-Organic Framework — ●FANG LIU¹, ARMIN SCHULZ², AXEL LUBK⁴, ALEXEJ PASHKIN³, SERGEJ GRANOVSKI¹, SHUHAN WANG¹, WEINEL KRISTINA⁴, HERZOG MAX⁴, and STEFAN KAISER¹ — ¹Institute of Solid State and Materials Physics, Dresden University of Technology — ²Max Planck Institute for Solid State Research,

Stuttgart — ³Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden — ⁴Leibniz Institute for Solid State and Materials Research, Dresden

Metal-organic frameworks provide an unusual setting where magnetic frustration and structural flexibility coexist. In our system, two distinct states emerge: a guest-stabilized regime with signatures of a potential quantum spin liquid, and a guest-free state exhibiting weak magnetic ordering. Raman and infrared spectroscopy reveal pronounced differences in lattice modes between these phases. Complementary Raman and THz measurements further uncover contrasting magnetic backgrounds. These findings establish a guest-controlled route to tuning magnetic quantum states in MOFs.

TT 31.9 Tue 11:45 POT/0361

Investigation of spin-correlated phases in quasi two-dimensional layered honeycomb oxide — ●APRAJITA JOSHI¹, ANJALI KUMARI^{2,3}, SHALINI BADOLA¹, ANUP KUMAR BERA^{2,3}, and SURAJIT SAHA¹ — ¹Indian Institute of Science Education and Research Bhopal, 462066, India — ²Bhabha Atomic Research Centre, Mumbai 400085, India — ³Homi Bhabha National Institute, Mumbai 400094, India

Honeycomb oxides are an intriguing class of materials characterised by low dimensionality and strong magnetic frustration, which leads to exotic quantum spin correlations. Here, we investigated a quasi-two-dimensional magnetic oxide Na₂Co₂TeO₆, which exhibits several intriguing magnetic phases, including the zigzag antiferromagnetic interaction and Kitaev paramagnetic spin interactions. We explored the intricate relationship between these phases and phonons using temperature-dependent Raman measurements. Our findings reveal the signature of magnetoelastic coupling across the long-range and short-range magnetic ordering temperatures. Furthermore, Na₂Co₂TeO₆, which has a non-centrosymmetric crystal structure, showcases ferroelectric order below 80 K. The evolution of Raman spectra reveals the presence of a ferroelectric order coupled phonon mode in Na₂Co₂TeO₆ below this temperature.

TT 31.10 Tue 12:00 POT/0361

Characterizing entanglement at finite temperature: how does a paramagnet become a quantum spin liquid? — SNIGDH SABHARWAL^{1,2}, ●MATTHIAS GOHLKE¹, PAUL SKRZYPCZYK², and NIC SHANNON¹ — ¹Okinawa Institute of Science and Technology, Onna, Japan — ²H. H. Wills Physics Lab., University of Bristol, Bristol, UK

Quantum spin liquids (QSL) are generically many body entangled

states of matter that form when quantum fluctuations meet the extensive ground state degeneracy of a classical spin liquid. Entanglement properties have enabled to characterise gapped QSL at zero temperature, however, much less is known about how quantum many body entanglement evolves at finite temperature.

Here, we use entanglement depth and genuine multipartite entanglement (GME) to study how entanglement and its local structure emerge when cooling a frustrated magnet from the high-temperature paramagnet down to the low-temperature QSL state. Within a case study on the Kitaev Honeycomb model, we obtain two characteristic bounds: (1) a lower bound on the upper temperature below which separability breaks and quantum entanglement must be present, while (2) a lower temperature scale is obtained when GME on plaquettes becomes finite signifying the coherent, structured entanglement that is characteristic for QSL ground states [1], i.e. the flux free state of the Kitaev spin liquid. We provide a framework to discuss the relevant temperature scales for QSL in frustrated magnets [2].

[1] L. Lyu, D. Chandorkar, et al., arXiv:2505.18124

[2] S. Sabharwal, M. Gohlke, et al., arXiv:2511.15144

TT 31.11 Tue 12:15 POT/0361

Fate of the Triangular Dirac spin liquid under an external magnetic field — ●SASANK BUDARAJU^{1,2}, JOSEF WILLISHER³, FEDERICO BECCA⁴, JOHANNES KNOLLE^{1,2}, and FRANK POLLMANN^{1,2} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ³Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — ⁴Dipartimento di Fisica, Università di Trieste, Strada Costiera 11, I-34151 Trieste, Italy

We investigate the J₁-J₂ Heisenberg model under an external Zeeman field using the Variational Monte Carlo approach. Simple variational ansatzes are proposed for several candidate ordered states, and their energetics are compared on large clusters to obtain the phase diagram for small/moderate fields. For small J₂, we capture a continuous transition from the Y to the "Up-Up-Down" (UUD) states as predicted by spin-wave theory. Additionally, around the highly frustrated region, we demonstrate that the ground state in the presence of a small field is a condensate of monopoles, which are gapless gauge excitations of the U (1) spin liquid. The monopole condensate is shown to be the ground state for a significant region of phase diagram, which we estimate using finite size numerics. Our results imply that the Dirac spin liquid is unstable to a condensation of monopoles in the presence of external fields.

TT 32: Nanomechanical systems (joint session HL/TT)

Time: Tuesday 10:00–12:45

Location: POT/0051

TT 32.1 Tue 10:00 POT/0051

Mechanical characterization of freely-suspended crystalline YIG nanodevices — ●JONNY QIU^{1,2}, MATTHIAS GRAMMER^{4,5}, SEBASTIAN SAILLER⁶, SEBASTIAN T. B. GOENNENWEIN⁶, MICHAELA LAMMEL⁶, HANS HUEBL^{3,4,5}, and EVA WEIG^{1,2,3} — ¹TUM School of Computation, Information and Technology, Garching, Germany — ²Zentrum für Quantum Engineering, Garching, Germany — ³Munich Center for Quantum Science and Technology, Munich, Germany — ⁴TUM School of Natural Sciences, Garching, Germany — ⁵Walther-Meißner-Institut, BAdW, Garching, Germany — ⁶University of Konstanz, Department of Physics, Konstanz, Germany

Efficient quantum transduction, the reciprocal conversion of quantum signals from one energy level to another, is an ongoing challenge in quantum network applications. Engelhardt et al. [1] proposed a microwave to optical converter (MWOC) that co-localizes microwave, magnetic and elastic excitations within a suspended optomechanical crystal (OMC) made of crystalline yttrium iron garnet (YIG).

In this talk, we report our progress towards realizing the MWOC and present freely-suspended YIG nanodevices. We fabricated YIG cantilevers and beams using an electron beam lithography process and a subsequent crystallization by annealing approach. Piezo-driven interferometric spectroscopy reveals the mechanical response modes of these devices, from which we extract Young's modulus and internal stress to design the OMC as a MWOC. We visualize and thus confirm the corresponding mode shapes via laser doppler vibrometry.

[1] F. Engelhardt, et al., Phys. Rev. Appl. 18, 044059 (2022).

TT 32.2 Tue 10:15 POT/0051

Sensing local temperature changes of a silicon nitride nanomembrane under large-amplitude vibration — ●VALENTIN BARTH, MENGQI FU, and ELKE SCHEER — University of Konstanz, Konstanz, Germany

In MEMS and NEMS, changes in environmental conditions (e.g., a global change in temperature [1]) can alter the motion properties of silicon nitride (SiN) membranes. Vibrational motion may cause the membrane to experience local heating effects.

SiN square membranes (side length: 450 μm, thickness: 500 nm) are used and driven with a piezoelectric actuator. The motion is monitored using digital holographic microscopy. The measurements are carried out with a strong drive, resulting in vibration amplitudes on the order of hundreds of nanometers. Local temperatures are measured via the Seebeck effect using permalloy (Ni₈₁Fe₁₉) and gold as thermocouple, which provides a sensitivity of 20 μV/K and is suitable for micrometer-scale measurements [2]. To improve the signal-to-noise ratio and suppress unwanted contributions, the measurement is performed with a lock-in amplifier, where the temperature signal is demodulated at twice the drive frequency. The measured temperature depends on both the position of the thermometer and the vibration amplitude, with values reaching up to 0.5 mK. Besides the temperature signal of the membrane, signals caused by vibrations from neighboring membranes (distanced 1.5 mm) are also detected.

[1] F. Yang et al., Sens. Actuators A Phys. 354, 114307 (2023).

[2] F. L. Bakker et al., J. Appl. Phys. 111, 084509, (2012)

TT 32.3 Tue 10:30 POT/0051

FEBID and FIBID nanowire field emitters integrated with microcantilevers - fabrication and characterization — ●EWELINA GACKA^{1,2}, GREGOR HLAWACEK¹, KRZYSZTOF KWOKA², TOMASZ PIASECKI², BARTOSZ PRUCHNIK², RENÉ HÜBNER¹, and TEODOR GOTSZALK² — ¹Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328, Dresden, Germany — ²Department of Nanometrology, Wrocław University of Science and Technology, 50-370, Wrocław, Poland

Because micro- and nanomechanical systems are continuously evolving, there is a need to leverage various fabrication technologies. A scanning electron microscope with a gallium focused ion beam, as well as a helium ion microscope, were used to integrate platinum-carbon (Pt-C) and tungsten-carbon (W-C) nanowire field emitters with microcantilevers, serving as deflection sensors. Pt-C and W-C nanocomponents were fabricated using an additive, direct-writing method - focused-electron-/ion-beam-induced deposition (FEBID/FIBID)[1,2]. After growth calibration, the field emission behavior was studied in situ inside a vacuum chamber. The deposited Pt-C and W-C materials were characterized using Kelvin probe force microscopy and transmission electron microscopy. [1] T. Piasecki et al., Nanotechnology 35 (2024), doi: 10.1088/1361-6528/ad13c0. [2] E. Gacka et al., Measurement 234 (2024), doi: 10.1016/j.measurement.2024.114815.

TT 32.4 Tue 10:45 POT/0051

Optimization of Faraday Cage Angled Etching and Its Application Prospects in Silicon Carbide — ●WUZHENG GE^{1,2}, CIARAN FOWLEY¹, JENS ZSCHARSCHUCH¹, CLAUDIA NEISSER¹, ARTUR ERBE^{1,2}, PHILIPP BREDOL³, FELIX DAVID³, and EVA WEIG³ — ¹Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — ²Dresden University of Technology, Faculty of Electrical and Computer Engineering, 01069 Dresden, Germany — ³Technical University of Munich, Chair of Nano and Quantum Sensors, 85748 Munich, Germany

This work presents the optimization of a Faraday Cage Angled Etching (FCAE) approach for ICP-RIE. By reshaping the plasma potential through the cage's mesh geometry, FCAE steers ions along the cage-wall normal, enabling controllable ion incidence angles. Reproducible 3D triangular cross-section structures were demonstrated on silicon, confirming the effectiveness of ion-direction tuning. The results were also applied to silicon carbide nanomechanical resonators. The enhanced directional ion flux enables direct fabrication of free-standing, stress-free structures in bulk, undoped SiC. This capability offers new pathways for advanced SiC-based MEMS.

15 min. break

TT 32.5 Tue 11:15 POT/0051

Probing Mechanical Nonlinearities with Quantum Dots — ●NOAH SPITZNER, JONA RICHTER, EMELINE DENISE SOPHIE NYSTEN, MATTHIAS WEISS, and HUBERT KRENNER — Universität Münster, Münster, Germany

The coupling of quantum dots to mechanical resonances is a well-established approach to investigate the behaviour of mechanical resonators and crystals. Within that approach, the quantum dots (QDs) act as point-like sensors sensitive to dynamical changes to their lattice constant. Vibrations in the host structure modulate the emission energy of the quantum dot, enabling readout of mechanical modes via ultrafast optical detectors. In our hybrid structures, mechanical excitation is achieved by integrating the QD-membrane onto a lithium niobate substrate equipped with finger-like electrodes called interdigitated transducers (IDTs). Applying a radio-frequency (RF) signal to the IDTs generates surface acoustic waves, which propagate on the surface of the substrate, coupling to quantum dots in their path.

This hybrid platform was taken a step further by structuring the QD-membrane into rings hosting mechanical resonances. Frequency sweeps of the RF signal applied to the IDT revealed sharp resonances in the emission-energy modulation exclusively for the quantum dots located within the rings. Interestingly, the resonances appear over a large region of SAW frequencies from 200 MHz to 900 MHz. Moreover, we detect clear signatures of a nonlinear mechanical response e.g. asymmetric lineshapes in the time-modulated optical signal of the QD when the external drive by the IDT is increased.

TT 32.6 Tue 11:30 POT/0051

Dry processing of 3C-silicon carbide nanostring resonators

— ●FELIX DAVID^{1,2,3}, YANNICK KLASS¹, PHILIPP BREDOL^{1,2,3}, and EVA WEIG^{1,2,3} — ¹Technische Universität München, School of Computation, Information and Technology, Garching, Germany — ²Technische Universität München, Zentrum für QuantumEngineering (ZQE), Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), München, Germany

We fabricate string resonators from strongly stressed 3C-silicon carbide (SiC) grown on a silicon substrate. In conventional fabrication processes, electron-beam lithography with PMMA is employed to define a metallic hard mask for the subsequent dry etching step via a liftoff process. This requires some wet-chemical process steps, such as HF etching and metal removal, which can destroy samples. Here, we describe an alternative process that avoids all wet-chemical process steps, enabling superior quality. It involves the use of a negative electron-beam resist as an etch mask, as well as the completely reactive-ion etching-based release of the nanostrings. The dry-processed nanostrings can be fabricated with a high yield and exhibit high mechanical quality factors at room temperature. Due to its high reliability, combined with high process speed, it also allows for quick adaptation to new projects, such as multilayer and hybrid mechanical systems.

TT 32.7 Tue 11:45 POT/0051

The best of two worlds: hexagonal boron nitride exfoliated on stressed silicon carbide string resonators — ●PHILIPP BREDOL¹, FELIX DAVID¹, JUNHUI WU², ANDREY N. ANISIMOV², TAKASHI TANIGUCHI³, KENJI WATANABE³, GEORGY V. ASTAKHOV², ARTUR ERBE², and EVA M. WEIG¹ — ¹TU Munich, Chair of Nano and Quantum Sensors, 85748 Munich, Germany — ²HZDR, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — ³National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan

The boron vacancy (VB) of hexagonal boron nitride (h-BN) is a promising single photon emitter for applications in quantum technologies. Nanomechanical control of the VB would greatly enhance its versatility in such applications, therefore nanomechanical h-BN resonators are of great interest. Here we demonstrate that h-BN can be exfoliated on a chip with a pre-stressed silicon carbide thin-film and subsequently patterned into nanomechanical string resonators with high tensile stress. The resulting h-BN covered string resonators have high mechanical quality factors due to dissipation dilution and show the optically detected magnetic resonance signature of the VB of h-BN. Our fabrication approach allows to decouple the choice of the defect hosting 2D-material from the engineering of the mechanical mode and paves the way to nanomechanical control of single photon emitters in h-BN and other 2D materials.

TT 32.8 Tue 12:00 POT/0051

Cavity optomechanics with van der Waals materials — ●ALOYSIUS FARREL^{1,3}, LUKAS SCHLEICHER^{1,3}, IRENE SÁNCHEZ ARRIBAS^{1,3}, LEONARD GEILEN^{2,3}, ALEXANDER MUSTA^{2,3}, ALEXANDER HOLLEITNER^{2,3}, and EVA WEIG^{1,3} — ¹Chair of Nano and Quantum Sensors, TU Munich, Germany — ²Walter Schottky Institute, TU Munich, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Munich, Germany

Freely suspended two-dimensional materials are promising platforms for hybrid quantum systems that combine mechanical, optical, and electronic properties. Coupling the optical and mechanical modes of the resonators would be the first step towards such hybrid quantum system.

Here, we present studies of the mechanical resonators with van der Waals materials, such as hBN, on a SiN membrane. We map the spatial mechanical modes of the freestanding and supported 2D materials. Furthermore, we observe an optical nonlinearity in our high-finesse fiber optic cavity setup, which could couple to the mechanical modes. This result helps us understand the optomechanical coupling of the system and leads the way for a hybrid quantum device by incorporating quantum emitters in the system.

TT 32.9 Tue 12:15 POT/0051

Imaging GHz surface acoustic waves in epitaxial graphene cavities — ●MINGYUN YUAN¹, ALBERTO HERNÁNDEZ-MÍNGUEZ¹, YI-TING LIOU², JENS HERFORT¹, JOAO M. J. LOPES¹, and PAULO V. SANTOS¹ — ¹Paul-Drude-Institut, Leibniz Institut im Forschungsverbund e.V., Berlin, Germany — ²Otto-von-Guericke-Universität Magdeburg, Magdeburg, Germany

The imaging of sound has fascinated scientists and the public alike,

dating back to Chladni's demonstrations in the 19th century. Nowadays, it is possible to image mechanical vibrations at the nanoscale, enabling direct probing of propagation, scattering and diffraction for high-frequency acoustic waves with short wavelengths. Here, we present the imaging of GHz surface acoustic waves (SAWs) in an epitaxial monolayer graphene nanostructure, based on thermal decomposition of SiC, using atomic-force microscopy (AFM). We observe a near-perfect strain transfer that gives rise to rich acoustic patterns in the phononic cavity formed by the graphene nanostructure. Furthermore, the enhanced acoustic intensity in the graphene region indicates a waveguiding effect, with graphene serving as an atomically thin, embedded shorting layer. Within the cavity, signatures of quantum chaos are observed. The high spatial resolution of AFM enables the investigation of SAW strain transferred onto 2D materials with high precision. The results also demonstrate an epitaxial nanophononic platform for both functional acoustic devices and fundamental studies of quantum phenomena.

TT 32.10 Tue 12:30 POT/0051

Nonlinear vibrational dynamics locally probed by time-resolved electron diffraction — •KAI NETTERSHEIM¹, ALEXANDER

SCHRÖDER¹, and SASCHA SCHÄFER^{1,2} — ¹Department of Physics, University of Regensburg, Regensburg, Germany — ²Regensburg Center for Ultrafast Nanoscopy (RUN), Regensburg, Germany

Nonlinear dynamics of micro- and nanoscale electro-mechanical systems can be observed using electrical or optical methods. However, these approaches are often limited in their spatial resolution, which leaves the underlying mechanics only partially accessible. Recent advances in ultrafast electron microscopy (UTEM) enable the highly localized probing of nanoscale oscillators, allowing to retrieve detailed information about their atomic structure and material defects.

Utilizing stroboscopic UTEM imaging techniques, we present the characterization of nonlinear mode dynamics in free-standing silicon membranes employing an event-based electron detector with nanosecond temporal resolution [1]. The high-Q resonator is excited using an optical pulse train driving the sample into the nonlinear regime. Due to the use of event-based converged electron beam diffraction (CBED), phase-accurate measurements of the nanoscale structural motion are provided. Whereas at weak driving, the oscillator displays a simple Duffing-type bistability, higher harmonic overtones as well as period doubling dynamics emerge at higher driving amplitudes.

[1] A. Schröder et al., *Ultramicroscopy* 256, 113881 (2024)

TT 33: Correlated Magnetism – Dynamics and Spectroscopy

Time: Tuesday 11:00–12:30

Location: HSZ/0105

TT 33.1 Tue 11:00 HSZ/0105

Nonlinear spectroscopy of spiral magnets — •WOLFRAM BRENIG — Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig, Germany

Spin systems with noncollinear long range order (NCLRO) allow for light-matter coupling via effective dipole moments which stem from the inverse Dzyaloshinskii-Moriya interaction. This permits to explore spin excitations of quantum magnets using time-dependent electric fields, which is of particular interest in the nonlinear regime, where second harmonic generation and two-dimensional spectroscopy may provide insight into the dynamics beyond linear probes. Here, we present results for such nonlinear response functions, using spin-wave theory and considering quasi two-dimensional magnets with NCLRO arising from frustration.

TT 33.2 Tue 11:15 HSZ/0105

Third-Order Nonlinear Response in Frustrated Magnets: Efficient Calculation in the Frequency Domain — •MARIUS MÖLLER, ROSER VALENTÍ, and DAVID A.S. KAIB — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Strasse 1, 60438 Frankfurt am Main, Germany

Techniques measuring higher-order response functions, such as two-dimensional coherent spectroscopy (2DCS) were proposed as powerful tools to provide deeper insights into the excitations of a system. However, calculating nonlinear response functions can be computationally intensive. Recently, we proposed an efficient Lanczos-based approach to calculate the second order susceptibility $\chi^2(\omega_t, \omega_\tau)$ [1]. Here, we present different approaches and approximations to compute the more commonly probed third-order susceptibilities $\chi^3(\omega_t, \omega_\tau)$ directly in the frequency domain. We compare them in terms of convergence, numerical stability and computational cost. Finally, we apply these techniques to frustrated magnets.

M.M., D.K. and R.V. gratefully acknowledge funding by the DFG (German Research Foundation): TRR 288-422213477.

[1] D.A.S. Kaib, M. Möller, R. Valentí, arXiv:2502.01746 (2025).

TT 33.3 Tue 11:30 HSZ/0105

Terahertz Time-Domain Spectroscopy of Coupled Spin and Low-Energy Excitations in CeCoGe₃ — •DEBANKIT PRIYADARSHI¹, ZEKAI CHEN¹, ERIK W. DE VOS¹, GEETHA BALAKRISHNAN², and MANFRED FIEBIG¹ — ¹ETH Zurich, Switzerland — ²University of Warwick, United Kingdom

We present a direct observation of the interaction between a low-frequency excitation and a spin-wave resonance [1] in the intermetallic heavy-fermion compound CeCoGe₃ using terahertz time-domain spectroscopy. CeCoGe₃ exhibits three low-temperature magnetic transitions at 21 K, 12 K and 8 K [2]. In addition to the observation of a magnon mode below the Néel temperature at 1.04 THz, we find a

temperature-independent low-frequency excitation at 0.4 THz. The absorption intensities of the low-frequency mode and the magnon mode suggest an inverse coupling effect which becomes strongest below the second magnetic transition at 12 K. This hints at strong magnon-phonon coupling emerging at low-temperatures. These results can therefore shed light on how lattice vibrations influence heavy-fermion magnetism. Additionally, optical-pump THz-probe measurements are performed to investigate the role of electronic excitations in order to understand the cross-talk between these three different fundamental degrees of freedom in inter-metallic systems.

[1] M. Smidman et al., *PRB* 88, 134416 (2013).

[2] A. Thamizhavel et al., *J. Phys. Soc. Jpn.* 74, 1858 (2005).

TT 33.4 Tue 11:45 HSZ/0105

Exploring the Nonlinear Magnetic Response of FeI₂ via Two-Dimensional Coherent Spectroscopy — •SAGAR RAMCHANDANI¹, YOSHITO WATANABE¹, SIMON TREBST¹, and CIARÁN HICKEY² — ¹Institute for Theoretical Physics, University of Cologne, Cologne, Germany — ²School of Physics, University College Dublin, Belfield, Dublin 4, Ireland

Nonlinear THz spectroscopy has emerged as a powerful method to extract new information beyond conventional linear response. In this work, we employ a semi-classical approach to 2-dimensional coherent spectroscopy (2DCS), implemented in the context of the Sunny Julia package for modelling atomic-scale magnetism. We apply this framework to explore the nonlinear response of FeI₂, a 2D spin-1 antiferromagnet with hybridized dipolar-quadrupolar fluctuations, to reveal its rich nonlinear dynamics.

TT 33.5 Tue 12:00 HSZ/0105

Measuring Anyonic Exchange Phases Using Two-Dimensional Coherent Spectroscopy — •NICO KIRCHNER¹, WONJUNE CHOI², and FRANK POLLMANN¹ — ¹Technical University of Munich, TUM School of Natural Sciences — ²Theoretical Division, T-4 and Center for Nonlinear Studies, Los Alamos National Laboratory

Identifying experimental signatures of anyons, which exhibit fractional exchange statistics, remains a central challenge in the study of two-dimensional topologically ordered systems. Previous theoretical work has shown that the threshold behavior in linear response spectroscopy can reveal the fractional exchange statistics between an anyon and its antiparticle. In this work, we extend this framework to nonlinear, two-dimensional coherent spectroscopy. We demonstrate by analyzing time-ordered four-point correlation functions that the threshold behavior of nonlinear response functions encodes the fractional statistics between general pairs of anyons that can combine to any composite topological charge. This feature in particular provides a powerful probe for unambiguously distinguishing non-Abelian anyons, which can form multiple composite charges with distinct nontrivial braid statistics.

Our approach is validated using numerical simulations that are consistent with the correct fractional exchange statistics for both the Abelian anyons in the toric code and non-Abelian Ising anyons.

TT 33.6 Tue 12:15 HSZ/0105

Control of chiral topological phases: Dynamics of a chiral spin liquid — ●RUBEN BURKARD and URBAN FRIEDRICH PETER SEIFERT — Institut für Theoretische Physik, Universität Köln, Zùlpicher StraÙe 77a, 50937 Köln, Germany

As recent advances in experiment make it increasingly feasible to realize and control unconventional quantum many-body states, we investigate the out-of-equilibrium dynamics of a chiral spin liquid, with the aim of drawing lessons for the control of topologically ordered phases.

In particular, we consider the Hubbard model on the triangular lattice near the Mott transition, which can be described by an effective spin model with higher-order interaction terms and is believed to host a CSL phase. In order to drive the system out of equilibrium, we apply ultrafast optical pulses, which couple to the spins in the system via magnetoelectric couplings and induce nonthermal, reversible modifications to the system's effective spin Hamiltonian. These can be derived from an appropriate Hubbard model in a Floquet approach. We then formulate a time-dependent parton mean-field theory to study the light-induced dynamics of the magnetic degrees of freedom. From this study, one might also infer lessons for other systems with chiral topological order, such as fractional quantum anomalous Hall (FQAH) states recently observed (and optically controlled) in twisted MoTe₂, or chiral pseudospin liquids in Moiré heterostructures.

TT 34: Members' Assembly

All members of the Low Temperature (TT) Division are invited to join!

Topics:

- Report
- Outlook 2026
- Election Deputy Spokesperson
- Miscellaneous

Time: Tuesday 14:00–15:30

Location: HSZ/0101

TT 35: Cooperative Phenomena: Spin Structures and Magnetic Phase Transitions (joint session MA/TT)

Time: Tuesday 14:00–15:30

Location: POT/0151

TT 35.1 Tue 14:00 POT/0151

Stochastic Simulation of Phase Transitions in the Dissipative 2D XYZ-Model — ●FRANZ PÖSCHL^{1,2,3}, PRZEMYSŁAW ZIELINSKI^{1,2,3}, XIN ZHANG^{1,2,3}, and PETER RABL^{1,2,3} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

The simulation of large, open quantum spin systems is a hard problem and for most cases it is not possible to get exact solutions. Therefore, we use methods in the class of the Truncated Wigner Approximations to tackle this problem. In our work we investigated the hybrid discrete-continuous truncated Wigner approximation and used it to determine the phase diagram of the dissipative 2D XYZ-model. We were able to simulate systems with several thousands of spins due to the linear scaling of the method and numerical optimization of our code. Hence we were able to simulate the phase transitions of the model and also characterize the different phases in the open quantum system.

TT 35.2 Tue 14:15 POT/0151

Large magnetorefectance and optical anisotropy due to 4f flat bands in the frustrated kagome magnet HoAgGe — ●FELIX SCHILBERTH^{1,2}, LUKE DEFREITAS³, KHAN ZHAO^{4,5}, FLORIAN LE MARDELÉ⁶, IVAN MOHELKY⁶, MILAN ORLITA⁶, PHILIPP GEGENWART⁵, HUA CHEN³, ISTVÁN KÉZSMÁRKI¹, and SÁNDOR BORDÁCS² — ¹Experimentalphysik V, University of Augsburg — ²Department of Physics, BME Budapest — ³Department of Physics, Colorado State University — ⁴School of Physics, Beihang University — ⁵Experimentalphysik VI, University of Augsburg — ⁶LNCMI, Université Grenoble Alpes

We report peculiar optical properties of the frustrated itinerant magnet HoAgGe, which exhibits multiple magnetically ordered states obeying the kagome spin-ice rule. The optical conductivity is higher for light polarization perpendicular to the kagome plane both for the free carrier response and the interband transitions. The latter have strong contributions from Ho 4f flat bands located near the Fermi level, as re-

vealed by our *ab initio* calculations, explaining the unusual anisotropy of the optical properties and the pronounced temperature dependence of the interband transitions for out-of-plane light polarization. The key role of Ho 4f states is further supported by the large variation of the magneto-reflectivity, following the field dependence of the magnetization in contrast to that of the magnetotransport data. Such heavy-electron bands near the Fermi level offer an efficient way to control transport and optical properties and we show that their ultrafast magneto-optical response is susceptible to the magnetic order.

TT 35.3 Tue 14:30 POT/0151

Transition between critical antiferromagnetic phases in the J1-J2 spin chain — ADAM MCROBERTS¹, ●CHRIS HOOLEY², and ANDREW GREEN³ — ¹International Centre for Theoretical Physics, Trieste, Italy — ²Coventry University, Coventry, United Kingdom — ³University College London, London, United Kingdom

The J1-J2 spin chain is one of the canonical models of quantum magnetism, and has long been known to host a critical antiferromagnetic phase with power-law decay of spin correlations. We show that there are, in fact, two distinct critical antiferromagnetic phases, where the roles of the local dimer field and its dual field are interchanged: the 'Affleck-Haldane' phase near the Heisenberg point J2 = 0, where the dimer field that parametrises local singlet order is gapless and part of a joint O(4) Neel-singlet order parameter; and the 'Zirnbauer' phase which appears at sufficiently large ferromagnetic J2, where the dimer field is gapped out and its dual field - the instanton density of the O(3) Neel field - is critical instead. The phases are so-named because each realises one of the competing pictures for how the O(3) non-linear sigma model with a topological theta term renormalises to the su(2) level 1 Wess-Zumino-Witten model. We support these predictions with density matrix renormalisation group calculations.

TT 35.4 Tue 14:45 POT/0151

Field-induced transitions in the charge-ordered Kagome metal FeGe — ●LILIAN PRODAN¹, JEREMY SOURD², PAVLO KHANENKO², YURI SKOURSKI², SERGEI ZHERLITSYN², and ISTVÁN KÉZSMÁRKI¹ — ¹EPV, Institute of Physics, University of Augsburg

- Augsburg, Germany — ²HLD-EMFL, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Kagome metals with strong electronic correlations have recently attracted significant interest as fertile platforms for emergent phenomena such as unconventional magnetism, topological transport, and symmetry-breaking instabilities. Among them, FeGe stands out due to its intriguing combination of noncollinear magnetism and charge ordering, making it a prime candidate for studying the coupling between spin, charge, and lattice degrees of freedom [1]. This compound orders antiferromagnetically below ~ 410 K, develops a charge-density-wave state near ~ 110 K, and forms a noncollinear spin structure below ~ 60 K. To explore how these orders interact, we performed magnetization, sound-velocity, and magnetostriction measurements in static and pulsed magnetic fields up to 60 T. Our results reveal previously unreported transitions at high magnetic fields and allow us to construct an extended H-T phase diagram for FeGe. [1] X. Teng, et al., Nature **609**, 490-495 (2022).

TT 35.5 Tue 15:00 POT/0151

Successive field-induced phase transitions in the kagome magnet ErMn_6Sn_6 — ●A. KURTANIDZE^{1,2}, SH. YAMAMOTO¹, K. UHLIROVA³, Y. SKOURSKI¹, S. ZHERLITSYN¹, J. SOURD¹, T. HERRMANSDÖRFER¹, E. WESCHKE⁴, O. PROKHENKO⁴, H. NOJIRI⁵, B. EGGERT⁶, A. AUBERT⁷, K. KUMMER⁸, K. SKOKOV⁷, H. WENDE⁶, and J. WOSNITZA^{1,2} — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — ²Institut für Festkörper- und Materialphysik, TU Dresden, Germany — ³Materials Growth and Measurement Laboratory (MGML), Charles University, Prague, Czech Republic — ⁴Helmholtz-Zentrum Berlin für Materialien und Energie, BESSY II, Berlin, Germany — ⁵Institute for Materials Research, Tohoku University, Sendai, Japan — ⁶Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Germany — ⁷Functional Materials, Material Science, TU Darmstadt, Germany — ⁸ESRF, The European Synchrotron, Grenoble, France

The ternary stannides RMn_6Sn_6 ($R = \text{Sc, Y, Gd-Lu}$) with hexagonal HfFe_6Ge_6 -type structure ($P6/mmm$) are a key platform for exploring coupled topological electronic and magnetic properties. We focused on single crystals of ErMn_6Sn_6 and observed successive field-induced phase transitions. Using element-specific x-ray magnetic circular and linear dichroism (XMCD/XMLD) measurements in pulsed magnetic fields up to 30 T, we revealed the microscopic nature of these transitions, supported by thermodynamic data. We discuss Er and Mn moment reorientations and their link to macroscopic results.

TT 35.6 Tue 15:15 POT/0151

Depinning by shaking of skyrmions by oscillating magnetic fields — ●RAJENDRA LOKE¹, ALLA BEZVERSHENKO², PETRA BECKER BOHATY³, ACHIM ROSCH², and JOACHIM HEMBERGER¹ — ¹II. Physikalisches Institut, University of Cologne, Zùlpicher Str. 77, 50937 Cologne, Germany — ²Institut für Theoretical Physics, University of Cologne, Zùlpicher Str. 77, 50937 Cologne, Germany — ³Institut für Geology und Mineralogy, University of Cologne, Zùlpicher St. 49b, 50674 Cologne, Germany

Here we present our recent result on shaking the skyrmion lattice by oscillating transvers magnetic field. When a transvers field is applied in addition to the longitudinal external field, skyrmion strings try to align themselves parallel to the effective field. To do so, the tips of the skyrmion strings have to move large distances and thus have to overcome pinning forces before being able to follow the field lines. We employ linear and non-linear AC susceptometry as experimental probe. The signature of this pinning-depinning transition is observable as contribution to the magnetic susceptibility, to the magnetic loss, and as well in the higher harmonic susceptibility. According to theoretical predictions, due to the chiral nature of the material the depinning is connected to translational motion of the skyrmions.

[1] Jan Müller et al. PhysRevLett.119.137201 (2017) [2] Felix Rucker et al. arXiv: 2504.01133v1 [3] Nina del Ser et al. SciPost Phys. 15, 065 (2023).

TT 36: Weyl Semimetals (joint session MA/TT)

Time: Tuesday 14:00–15:30

Location: POT/0361

TT 36.1 Tue 14:00 POT/0361

Ferrimagnetism and the causes of discontinuous magnetic behavior in Kagome Weyl-semimetal $\text{Co}_3\text{Sn}_2\text{S}_2$ — ●ABDUL-VAKHAB TCAKAEV¹, BENJAMIN KATTER¹, STEFAN ENZNER², EUGEN WESCHKE³, SEBASTIAN WINTZ³, GOHIL S. THAKUR⁴, MICHAEL RUCK⁴, GIORGIO SANGIOVANNI², and VLADIMIR HINKOV¹ — ¹Experimentelle Physik IV, Fakultät für Physik und Astronomie, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — ²Computational Quantum Materials, Fakultät für Physik und Astronomie, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — ³Helmholtz-Zentrum Berlin for Materials and Energy, Albert-Einstein-Straße 15, 12489 Berlin, Germany — ⁴Technical University of Dresden, Helmholtzstr. 10 01069 Dresden

The Kagome Weyl semimetal $\text{Co}_3\text{Sn}_2\text{S}_2$ shows puzzling magnetic anomalies that have been interpreted as hidden phase transitions. Combining element-specific XMCD, SQUID magnetometry, STXM, DFT, and inelastic neutron scattering, we establish a ferrimagnetic ground state in which Co moments are partially compensated by antiparallel Sn moments and stabilized by strong uniaxial magnetocrystalline anisotropy. Temperature-dependent XMCD and STXM show that the discontinuous drop of remanent magnetization on zero-field warming arises from abrupt domain nucleation controlled by demagnetization effects, rather than from an intrinsic change of the spin structure. This yields a consistent microscopic picture of the magnetism in $\text{Co}_3\text{Sn}_2\text{S}_2$ relevant for its Weyl and anomalous Hall properties.

TT 36.2 Tue 14:15 POT/0361

High-field THz Probing of the Crossover between Weyl and Weyl-Kondo Physics in $\text{Mn}_{3+x}\text{Sn}_{1-x}$ — ●ERIK W. DE VOS¹, ZEKAI CHEN¹, DEBANKIT PRIYADARSHI¹, ANUSREE V. PULERI², URI VOOL², CLAUDIA FELSER², EDOUARD LESNE², and MANFRED FIEBIG¹ — ¹Department of Materials, ETH Zurich, Zurich, Switzerland — ²Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany

We present temperature-dependent high-field THz spectroscopy measurements on a substitution series of the noncollinear antiferromagnet $\text{Mn}_{3+x}\text{Sn}_{1-x}$. When the Mn substitution is increased from $x=0$ to $x=0.5$, $\text{Mn}_{3+x}\text{Sn}_{1-x}$ has been found to transition from a pure Weyl semimetal to a Weyl-Kondo insulator. This is accompanied by the emergence of a hybridization gap of 10.2 meV [1]. Our study uses high-field THz radiation to probe and drive the non-linear response of $\text{Mn}_{3+x}\text{Sn}_{1-x}$ through the onset of Kondo-driven correlations. Via this high-field resonant excitation, we directly probe the dynamic response across the transition from a Weyl semimetal to a Weyl-Kondo insulating state.

[1] Sci. Adv. 6, eabc1977 (2020)

TT 36.3 Tue 14:30 POT/0361

Peierls-induced topological Weyl semimetal in PtBi_2 — ●ANDERS C. MATHISEN¹, STEFANIE S. BRINKMAN¹, XIN L. TAN¹, ØYVIND FINNSETH¹, FABIAN GÖHLER¹, CHUL-HEE MIN¹, JENS BUCK², KAI ROSSNAGEL², GRISHA SHIPUNOV³, ANNA ISAEVA³, JORGE I. FACIO⁴, and HENDRIK BENTMANN¹ — ¹Center for Quantum Spintronics, Department of Physics, NTNU, Norway — ²Kiel University & DESY, Germany — ³Institute of Physics, University of Amsterdam, The Netherlands — ⁴Instituto Balseiro, National University of Cuyo, Argentina

PtBi_2 is attracting interest because of its exotic electronic properties, including bulk Weyl nodes, Fermi-arc surface states, and unconventional surface superconductivity. The emergence of Weyl nodes in materials is commonly attributed to accidental crossings between non-degenerate valence and conduction bands, while little emphasis has been placed on the physical mechanisms that induce Weyl physics. Recent theory indicates that reduced translational symmetry in the Peierls-distorted crystal structure of PtBi_2 constitutes a mechanism for the formation of Weyl nodes [1]. In this talk, we will present an investigation of the bulk electronic structure of PtBi_2 using soft X-ray angle-resolved photoelectron spectroscopy. Based on an analysis of the spectral weight across wide regions in momentum space, we show how

the Peierls-distortion in PtBi_2 promotes the formation of Weyl nodes.

[1] S. Palumbo *et al.*, Interplay between inversion and translation symmetries in trigonal PtBi_2 . *Phys. Rev. B* **112**, 205125 (2025)

TT 36.4 Tue 14:45 POT/0361

Phonon-driven axial fields enable terahertz Kerr rotation in WTe_2 — ●SOMA DUTTA, VISHAL SHOKEEN, RUSLAN CHULKOV, DAVID MURADAS BELINCHÓN, M. VENKATA KAMALAKAR, OSCAR GRÄNÄS, and HERMANN DÜRR — Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden

Weyl semimetals provide a platform for studying the coupling between lattice dynamics and topological electronic structure through the motion of Weyl nodes and their associated Berry curvature (see Sie *et al.*, *Nature* 565, 61, 2019). Here we report the observation of terahertz-frequency Kerr rotation in the non-centrosymmetric Weyl semimetal WTe_2 , generated in the absence of an external magnetic field. Using ultrafast pump-probe polarimetry, we identify coherent oscillations at 0.24 THz and 2.4 THz that originate from interlayer shear vibrations and optical phonon modes, respectively. The 0.24 THz shear mode exhibits maximum amplitude along the *a*-axis and is strongly suppressed along *b*, indicating an odd mirror-symmetry character. By modeling the strain-induced modification of the Weyl-node separation, we show that this shear phonon produces an axial vector potential whose sign depends on the direction of atomic displacement. Spatial gradients of this axial potential generate a pseudo-magnetic field with a sign structure that naturally accounts for the observed phase inversion. Our results provide direct evidence for phonon-driven axial electromagnetic fields in a Weyl semimetal and demonstrate a route for ultrafast control of topological optical responses through coherent lattice motion. *Ab initio* calculations will further clarify the Kerr response mechanism.

TT 36.5 Tue 15:00 POT/0361

Magnetoconductance in Chiral Topological Semimetals — ●RICARDO MANUEL SOUSA BARBOSA and ANNIKA JOHANSSON — Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle (Saale), Germany

Chiral topological semimetals [1] are a class of quantum materials whose crystal symmetries enforce multifold band crossings with nonzero topological charge, hosting symmetry-protected chiral fermionic quasiparticles, long surface Fermi arcs, and enhanced optical and transport responses. These Weyl semimetals [2] are three-

dimensional materials that exhibit multiple Weyl nodes that act as point-like sources and sinks of Berry curvature in momentum space, and provide a condensed-matter realization of the chiral anomaly [3], a field-induced nonconservation of electrons associated with a given Weyl node, which manifests as a positive longitudinal magnetoconductance.

We investigate the magnetotransport properties of compounds in space group 198 [4], which host four- and six-fold degenerate Weyl nodes at the Γ and R points, respectively, with Chern numbers up to ± 4 . Using a semiclassical approach, we compute the resulting magnetoconductance, enabling a detailed analysis of the unconventional electronic responses characteristic of these materials.

[1] N.B.M. Schröter *et al.*, *Nature Physics* **15**, 759-765 (2019); [2] M. Z. Hasan *et al.*, *Annu. Rev. Condens. Matter Phys.* **8**, 289-309 (2017); [3] F. Bladuni *et al.*, *Nat. Commun.* **15**, 6526 (2024) [4] D.A. Pshenay-Severin *et al.*, *J. Phys.: Condens. Matter* **30**, 135501 (2018)

TT 36.6 Tue 15:15 POT/0361

Giant Anomalous Hall Effect Tuned by Atomic Order in Fe_3Pt — ●YIBO WANG and ENKE LIU — Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

The Berry curvature induced anomalous Hall effect (AHE) has attracted considerable interest in recent years [1,2]. In Fe_3Pt , a nodal line situated near the Fermi level generates a pronounced Berry curvature hotspot [3], giving rise to an intrinsic anomalous Hall conductivity (AHC) of 1250 S/cm according to our measurement. Building on this large intrinsic contribution, we sought to enhance the total AHE by deliberately increasing the extrinsic AHC through control of atomic ordering. By annealing Fe_3Pt samples at various temperatures and for different durations, we were able to tune the extrinsic AHC continuously from nearly 0 S/cm up to 550 S/cm. The most striking result was obtained for a specimen that was annealed for ten days; at 2 K this sample exhibited a total AHC of 1892 S/cm. This value is a significant value among magnetic topological materials and represents a 50 % increase over the intrinsic contribution alone. These findings confirm the success of the proposed strategy: leveraging a substantial intrinsic Berry curvature AHC and subsequently amplifying the total AHC through extrinsic AHC through mechanisms such as atomic engineering. The approach provides a practical pathway for achieving exceptionally large anomalous Hall responses in magnetic topological systems. [1]*Nat. Phys.* **14**, 1125-1131 (2018). [2]*Nat. Phys.* **14**, 1119-1124 (2018). [3]*Adv. Mater.* **35**, 2301339 (2023).

TT 37: Ultrafast electron dynamics at surface and interfaces – Poster (joint session O/TT)

Time: Tuesday 14:00–16:00

Location: P2

TT 37.1 Tue 14:00 P2

Nonequilibrium phonon dynamics after laser-excitation — TOBIAS HELD, CHRISTOPHER SEIBEL, MARKUS UEHLEIN, ●SEBASTIAN T. WEBER, and BAERBEL RETHFELD — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

Electron-phonon coupling is a fundamental process governing the energy relaxation dynamics of solids excited by ultrafast laser pulses. While this coupling is often described in terms of an effective electron temperature, recent works have highlighted the important roles of both nonequilibrium electronic distributions and detailed phononic properties.

In this study, we investigate how nonequilibrium electron occupations, phonon stiffness, and wavenumber-resolved coupling collectively shape the energy exchange between electrons and the lattice in metals. We find that deviations from thermal electronic distributions can substantially modify the coupling parameter, challenging the conventional assumption that electron temperature alone determines the coupling strength. We further identify a roughly quadratic scaling of the coupling parameter with phonon stiffness, with high-wavenumber phonon modes consistently dominating the interaction. Finally, we demonstrate that this preferential coupling leads to the emergence of hot phonons near the Brillouin-zone boundary, which in turn induces a collapse of the overall energy transfer rate and significantly delays electron-phonon equilibration.

TT 37.2 Tue 14:00 P2

Comparing temperature change during light-matter interaction of thermal and athermal electron systems — ●FABIO A.

MÜLLER, TOBIAS HELD, CHRISTOPHER SEIBEL, SEBASTIAN T. WEBER, and BAERBEL RETHFELD — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

When an ultrashort laser pulse irradiates a metal, the electronic system initially absorbs energy and is driven far from equilibrium. This transient nonequilibrium distribution modifies the light-matter interaction, in part through changes in Pauli blocking, while electron-electron scattering concurrently drives the system toward a hot Fermi-Dirac distribution. Consequently, ultrashort laser pulses of the same fluence but different duration lead to different absorption, even in the linear regime.

Here, we investigate how the capability of an electron ensemble to absorb photons depends on its instantaneous energy distribution. Specifically, we compare the absorption arising from nonequilibrium electron distributions with that of Fermi-Dirac distributions carrying the same energy density. Our results show that, for realistic materials, the relative absorption is highly sensitive to the photon energy, a behavior that can be traced back to distinct features in the electronic density of states.

TT 37.3 Tue 14:00 P2

Role of non-thermal electrons on energy dissipation and phase transition in laser excited metals — ●LUKAS JONDA, TOBIAS HELD, MARKUS UEHLEIN, CHRISTOPHER SEIBEL, SEBASTIAN T. WEBER, and BAERBEL RETHFELD — Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau

The influence of non-equilibrium electrons on energy dissipation and

phase transitions is not well understood. It is known that during femtosecond laser irradiation of a surface, electrons are excited to a state of non-equilibrium in space and energy. These highly excited electrons then transport energy ballistically into the bulk. On a picosecond timescale, electrons transfer energy to the lattice via electron-phonon collisions. If the transferred energy is large enough to reach the melting point, the crystal lattice can undergo a phase transition.

We developed a hybrid model that combines a kinetic Monte Carlo simulation and a two-temperature model. The latter describes diffusive transport as well as electron-phonon equilibration, and the former describes primary electron excitation by the laser pulse, transport of non-equilibrium electrons, and secondary electron generation.

We present results for gold, where the influence of non-equilibrium electrons on energy transport is expected to be significant, due to the long mean free path of its electrons. Finally, we are interested in the influence of non-equilibrium electrons on the melting process.

TT 37.4 Tue 14:00 P2

Capturing thermalization through electron-electron scattering with machine learning — ●DAVID L. KAISER, TOBIAS HELD, CHRISTOPHER SEIBEL, MARKUS UEHLEIN, SEBASTIAN T. WEBER, and BAERBEL RETHFELD — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

Ultrafast excitation of metals by optical laser pulses induces nonequilibrium energy distributions in the electron system. This nonequilibrium gives rise to complex electron-electron scattering processes, which typically restore a Fermi-Dirac distribution on a femtosecond timescale. Accurately modelling the thermalization requires evaluating the full electron-electron collision integral, which is however computationally costly.

In this study, we explore the possibility to use machine learning to emulate the dynamics generated by the full collision integral. Our goal is to significantly accelerate these calculations, enabling efficient simulations of bulk and multilayer systems. This approach opens the door to uncovering new relaxation pathways and predicting the response of complex material systems to ultrafast excitation.

TT 37.5 Tue 14:00 P2

Studies of laser ablation of band-gap materials — ●MARKUS BONIFER^{1,2}, SEBASTIAN T. WEBER¹, NILS CREMER^{2,3}, GABRIEL SCHAUMANN^{2,3}, and BAERBEL RETHFELD¹ — ¹Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, Germany — ²Focused Energy GmbH, Im Tiefen See 45, 64293, Darmstadt, Hessen, Germany — ³Institute of nuclear physics (IKP), Technische Universität Darmstadt, Darmstadt, Germany

We aim to explore laser ablation as a possible approach for creating clean, well-defined microholes in polymers used for laser fusion targets where symmetry and control of surface roughness are important. Because polymers differ widely in their properties, general insights into laser material interaction are sought through modeling of density-dependent excitation in band-gap materials.

The theoretical models used are based on the density-dependent two-temperature model (nTTM) and extended multiple rate equations (EMRE). These calculations are intended to guide experimental studies carried out in collaboration with Focused Energy to identify suitable processing conditions and improve overall feature quality.

TT 37.6 Tue 14:00 P2

Thermalization of optically excited electrons in metals: electron-electron scattering dynamics — ●STEPHANIE RODEN, CHRISTOPHER SEIBEL, TOBIAS HELD, MARKUS UEHLEIN, SEBASTIAN T. WEBER, and BAERBEL RETHFELD — Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau

When a metal is irradiated with a short-pulsed optical laser, the electron distribution is disturbed into a state far from equilibrium. On a femtosecond timescale, the non-thermal electrons thermalize by collisions with each other, which drives the electrons towards a hot Fermi distribution.

In this work, we present a derivation of the full electron-electron Boltzmann collision integral within the random- k approximation. Building on this approach, we trace the temporal evolution of the electron energy distribution in metals after ultrafast excitation. Furthermore, we examine to which extent the resulting dynamics can be captured by the numerically simpler relaxation time approach, applying a constant and an energy-dependent relaxation time derived from Fermi-liquid theory.

We find a better agreement with the latter, while specific features

caused by the balance of scattering and reoccupation can only be captured with a full collision integral.

TT 37.7 Tue 14:00 P2

Time-resolved PEEM and μ ARPES using a 100 kHz ToF momentum microscope — ●ISABELLA ALEXANDRA HOFMEISTER^{1,2}, MICHAEL HERB^{1,2}, MARIA FEDERL¹, FRANZ SEITZ¹, and ISABELLA GIERZ^{1,2} — ¹University of Regensburg, Regensburg, Germany — ²Regensburg Center for Ultrafast Nanoscopy - RUN, Regensburg, Germany

Momentum microscopy provides energy-resolved imaging in real and reciprocal space with < 100 meV resolution, combining PEEM ($\Delta x < 40$ nm lateral resolution) and μ ARPES ($\Delta k < 0.02 \text{ \AA}^{-1}$) capabilities. We implemented an ultrafast setup with a time-of-flight momentum microscope and a 100 kHz laser system delivering 6 eV probe pulses and pump pulses tunable from the mid-infrared to visible range. Procedures for converting time-of-flight to kinetic energy and for establishing spatial and temporal pump-probe overlap are discussed. Proof-of-principle time-resolved PEEM and μ ARPES experiments on the topological insulator Bi_2Se_3 demonstrate femtosecond-resolved carrier dynamics with high spatial and momentum precision.

TT 37.8 Tue 14:00 P2

First steps with a qPlus-based MIR AFM — ●FURKAN ÖZYIGIT, LUKAS BÖHM, LEONIE WEISS, JAY WEYMOUTH, RUPERT HUBER, and FRANZ GIESSBL — University of Regensburg, 93053 Regensburg

We report initial progress in an ultrafast non-contact atomic force microscope/scanning tunneling microscope (NC-AFM/STM) platform based on qPlus sensors, integrated with a CEP-stabilized mid-infrared (MIR) pump-probe system and tunable optical parametric amplifier (OPA) for versatile excitation. In first experiments, we successfully induced transient tunneling currents on Cu(111) using MIR pulses, demonstrating precise control of ultrafast electronic excitation at the atomic scale via laser-coupled tunneling. While the tunneling current reflects the ultrafast electronic excitation dynamics, the qPlus sensor permits complementary force detection to monitor subsequent structural or electrostatic interaction changes, such as those resulting from induced charge redistribution or lattice relaxation. This enables simultaneous probing of electronic and mechanical dynamics with femtosecond time and sub-nanometer spatial resolution. Beyond investigations of transient electrostatic forces, this versatile system facilitates a broad class of ultrafast nanoscale experiments, including scattering-type scanning near-field optical microscopy (s-SNOM) for imaging carrier and phase dynamics, time-resolved tip-enhanced spectroscopy for molecular states, and pump-probe tunneling spectroscopy.

TT 37.9 Tue 14:00 P2

Image potential states of oxide quasicrystals — ●BARBARA DROBINSKI¹, FRIEDERIKE WÜHRL¹, RICHARD KRASKA¹, KONRAD GILLMEISTER¹, STEFAN FÖRSTER¹, CHENG-TIEN CHIANG², and WOLF WIDDRA¹ — ¹Institute of Physics, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — ²Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan

Quasicrystals are aperiodically ordered materials that lack translational symmetry. Their aperiodic potentials give rise to an infinitely dense set of Fourier components, which can induce gaps and mini-gaps in the electronic band structure. Here, we investigate this phenomenon for nearly free-electron-like image-potential surface states, where electrons propagate in front of the surface while experiencing the aperiodic potential. Using momentum-resolved two-photon photoemission, we determine both the electronic dispersion and relaxation dynamics of oxide quasicrystals (OQCs) based on Ba-Ti-O/Pt(111) [1] and Eu-Ti-O/Pt(111). The latter is obtained via Eu decoration of a Ti_2O_3 honeycomb precursor [2]. In both systems, we observe $n=1$ and $n=2$ image potential states, located 340 meV (360 meV) and 150 meV (190 meV) below the vacuum level for Ba-Ti-O (Eu-Ti-O), respectively. The states exhibit parabolic dispersions without apparent gap openings. We discuss the momentum-dependent electron lifetimes in the context of possible mini-gaps in the underlying aperiodic potential.

[1] S. Förster *et al.*, Nature **502**, 215 (2013)

[2] M. Haller *et al.*, <http://arxiv.org/abs/2510.11426>

TT 37.10 Tue 14:00 P2

Ultrafast Electron Diffraction Study of Lattice Dynamics in Elemental Chromium — ●JUSTUS RICHTER^{1,2}, VICTORIA TAYLOR¹, HYEIN JUNG^{1,2}, RALPH ERNSTOFER^{1,2}, and YOAV WILLIAM WINDSOR^{1,2} — ¹Fritz-Haber-Institut der MPG, Berlin — ²Institut für

Physik und Astronomie, Technische Universität Berlin

Femtosecond electron diffraction (FED) allows to quantitatively study ultrafast atomic motion. Here we use FED to study photoinduced atomic motion in Cr. We saw that measurements taken above- and below T_N exhibit qualitatively different responses from the lattice, hinting to the effect of the spin-induced periodic lattice distortion within the antiferromagnetic Cr phase, though further investigation is required. A two temperature model (TTM) was used to model the energy flow between the electronic and lattice subsystems by which we extract an estimate for the electron-phonon coupling constant $G_{ep} = (4.8 \pm 0.6) \times 10^{17} \text{ Jm}^{-3}\text{K}^{-1}$, which fits into the wide range of values reported in literature. Finally, we measured Cr side-by-side with Pt and demonstrate qualitative differences in their temporal responses, including a significantly faster thermalization of the Cr lattice and differences in the shape of their temporal response.

TT 37.11 Tue 14:00 P2

Ultrafast electron dynamics in the valence-fluctuating intermetallic EuIr_2Si_2 — ●ABEER ARORA¹, TÚLIO DE CASTRO¹, AMINE WAHADA¹, LAWSON LLOYD¹, TOMMASO PINCELLI², KRISTIN KLIEMT³, CORNELIUS KRELLNER³, DENIS V. VYALIKH^{4,5}, YOAV WILL WINDSOR², MARTIN WOLF¹, RALPH ERNSTORFER^{1,2}, and LAURENZ RETTIG¹ — ¹Fritz Haber Institute of the Max Planck Society, Berlin, Germany — ²Institut für Physik und Astronomie, TU Berlin, Germany — ³Physikalisches Institut, Goethe-Universität Frankfurt, Germany — ⁴Donostia International Physics Center, San Sebastián, Spain — ⁵Ikerbasque, Basque Foundation for Science, Bilbao, Spain

EuIr_2Si_2 is a valence-fluctuating intermetallic compound that, despite its non-magnetic bulk, develops 2D ferromagnetic order below 48 K in the topmost Eu layer due to a stable Eu^{2+} configuration. Its heavy Ir ions generate strong Rashba spin-orbit coupling, which interacts with magnetic exchange and influences the surface electronic states. Probing the non-equilibrium dynamics of the 2D electrons in the Si-Ir-Si surface layer offers a direct way to study the coupling of the spin-orbit and surface magnetic interaction. Using femtosecond XUV time- and angle-resolved photoemission spectroscopy, we investigate how the surface states evolve following photoexcitation with a 1.55 eV pulsed laser. Our preliminary results show an ultrafast quenching of the surface-state splitting, which we discuss in terms of demagnetization of the Eu 4f moments and modified spin-orbit coupling.

TT 37.12 Tue 14:00 P2

Ultrafast STEM locked to GHz sample excitation — ●ANDREAS WENDELN¹, ALEXANDER SCHRÖDER¹, SAKAL SINGLA¹, and SASCHA SCHÄFER^{1,2} — ¹Department of Physics, University of Regensburg, Regensburg, Germany — ²Regensburg Center for Ultrafast Nanoscopy (RUN), Regensburg, Germany

Ultrafast transmission electron microscopy (UTEM) has been an established method for investigating nanoscale dynamics for several years, combining the nanometer spatial resolution of TEM with the femtosecond temporal resolution of a pump-probe approach. In recent years, there have been numerous advances in the development of new femtosecond electron sources, such as laser-driven Schottky [1] or cold-field emitters [2]. A combination of these sources with advanced electron optical elements, such as a probe aberration corrector, is expected to deliver even smaller electron spot sizes and to increase the available pulsed current but was not yet demonstrated. Here, we present a measurement scheme for ultrafast STEM with a focus on magnetic imaging, utilizing an aberration corrector and a laser-driven cold-field emitter. In initial measurements using a continuous photoelectron beam, the measurement method is characterized regarding experimental parameters, such as probe currents, focal spot sizes, and stability. Subsequently, we report the locking of femtosecond electron pulse train at repetition rates between 100 kHz up to 80 MHz to GHz radiofrequency currents which we aim to employ for DPC and ptychography imaging schemes of current-driven magnetic dynamics. [1] Feist et al., *Ultramicroscopy*, 2017. [2] Schröder et al., *Ultramicroscopy*, 2025.

TT 37.13 Tue 14:00 P2

Probing Ultrafast Structural Dynamics in Multilayer Graphene Using ULEEM — ●SIMON BRIESENICK^{1,2,4}, JOHANNES OTTO^{1,2,4}, LEON BRAUNS^{1,2}, PHILIP SCHÄDLICH³, and CLAUDIUS ROPERS^{1,2} — ¹Department of Ultrafast Dynamics, Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — ²4th Physical Institute, University of Göttingen, Göttingen, Germany — ³Institute of Physics, TU Chemnitz, Chemnitz, Germany — ⁴authors contributed equally

Multilayers of graphene (MLG) exhibit electronic and structural properties that vary strongly with, e.g., layer number and stacking order, making MLG a suitable model platform for studying ultrafast phenomena in two-dimensional materials [1]. We investigate the behavior of MLG after excitation with ultrashort light pulses using our newly developed ultrafast low-energy electron microscope (ULEEM) [2]. The instrument allows for the investigation of surface structural dynamics with sub-picosecond and nanometer spatial resolution, utilizing low-energy ($\leq 100 \text{ eV}$) ultrashort probe electron pulses. We present first data on the light-induced Debye-Waller effect in MLG, demonstrating the potential of ULEEM studies for resolving ultrafast structural behavior in MLG.

[1] K. V. Emtsev, et al. *Phys Rev B*. 77, 155303 (2008) [2] J. Otto et al. (in preparation)

TT 37.14 Tue 14:00 P2

Hot-electron dynamics in moiré structures studied with resonant scanning tunneling spectroscopy — ●MARTIN LÜLFF, MARTA PRZYCHODNIA, MACIEJ BAZARNIK, and ANIKA SCHLENHOFF — Institute of Physics, University of Münster, Germany

To study hot-electron dynamics in Gr-metal heterostructures, image-potential states (IPSS) serve as ideal model system. While their energies are known to be highly sensitive to the respective Gr-metal distance variation within the moiré unit cell [1, 2], recent two-photon photoemission experiments suggest moiré-site dependent lifetimes [3].

Here, utilizing the high spatial resolution of resonant scanning tunneling microscopy (STM) and spectroscopy (STS) we study the moiré-site dependent IPSS' lifetimes for highly corrugated Gr/Fe/Ir(111) and Gr/Ir(111), respectively. Comparing these resonant STS data with those recorded on bare Fe/Ir(111) and Ir(111), respectively, enables the influence of the varying Gr-metal distance on the lifetimes to be distinguished from that of the underlying metal substrate. We analyse the IPSS' lifetimes for a Stark shift in their energies by applying various electric field strengths in current-dependent STS series, and discuss the results in terms of their resulting energetic positions with respect to the underlying unoccupied electronic band structure. Our work contributes to an in-depth understanding of electron transfer processes at Gr-metal interfaces.

[1] M. Bazarnik and A. Schlenhoff, *ACS Nano* **19**, 25812 (2025)

[2] N. Armbrust *et al.*, *New J. Phys.* **17**, 103043 (2015)

[3] N. Armbrust *et al.*, *Phys. Rev. Lett.* **108**, 056801 (2012)

TT 37.15 Tue 14:00 P2

Photo-induced electron pressure drives THz phonon in Platinum-Copper superlattice — ●JAN-ETIENNE PUELL¹, MAXIMILIAN MATTERN^{2,3}, MARC HERZOG², ALEXANDER VON REPPERT², DANIEL SCHICK³, CHANDAN SINGH⁴, PETER M. OPPENEER⁴, MICHEL HEHN⁵, ULRIKE BOESENBERG¹, ANGEL RODRIGUEZ-FERNANDEZ¹, ROMAN SHAYDUK¹, WONHYUK JO¹, JOHANNES MÖLLER¹, JÖRG HALLMANN¹, JAMES WRIGLEY¹, MATIAS BARGHEER^{2,6}, and ANDERS MADSEN¹ — ¹European XFEL — ²University Potsdam — ³MBI, Berlin — ⁴Uppsala University — ⁵IJL, Université Lorraine — ⁶HZB Berlin

Using ultrafast X-ray diffraction (UXRD) at the MID end-station at the European XFEL, we investigate the ultrafast lattice dynamics of metal-metal superlattice (SL) with few atomic layers of Pt and Cu upon femtosecond photoexcitation. Our results reveal that the absorbed optical energy is rapidly localizes within the Pt layers, driving the excitation of a coherent artificial THz phonon mode defined by the superlattice period. The signal's amplitude and phase modulation of the SL Bragg peaks induced by the lattice excitation i.e. the artificial THz phonon, are predominantly driven by electron pressure within the first picosecond. This response is faster than the Debye-Waller effect, which is limited by the electron-phonon coupling time.

TT 37.16 Tue 14:00 P2

Experimental realization of an interferometric XUV-trARPES experiment with phase-stabilized IR pulses — ●ANTONIUS NAUJOK¹, GREGOR ZINKE^{1,2}, FRANZ SPARTZ¹, SEBASTIAN HEDWIG¹, TOBIAS EUL², MARTIN AESCHLIMANN¹, and BENJAMIN STADTMÜLLER² — ¹Department of Physics and Re search Center OPTIMAS, RPTU University Kaiserslautern- Landau, 67663 Kaiserslautern, Germany — ²Experimental Physics II, Institute for Physics, University of Augsburg, 86159 Augsburg

Layered 2D van der Waals materials, such as TMDCs, have been extensively studied for their optical properties and coherent responses. However, exploring coherent excitations and dephasing processes in

such materials using time-resolved ARPES is challenging because the key points of the materials' band structure cannot be accessed using phase-stabilized pulses in the visible regime, as has been done in most experiments thus far [1]. To overcome this limitation, we introduce a modified version of coherent multidimensional spectroscopy. This new method is based on time-resolved ARPES and utilizes a pair of phase-stabilized femtosecond infrared (fs-IR) pulses in combination with femtosecond XUV pulses for photoionization. We demonstrate the feasibility of our approach by focusing on the A-exciton excitation and the subsequent carrier dynamics in WSe₂. Through temporal Fourier-analysis of the entire ARPES spectrum, we're able to resolve distinct frequency components within characteristic features of the WSe₂ electronic band structure. [1] M. Aeschlimann et al., Phys. Rev. B. 105, 205415 (2022)

TT 37.17 Tue 14:00 P2

Implementation of white light continuum probing for pump-probe spectroscopy — ●JORIS WICKER, TIM TITZE, MAXIMILIAN STAABS, JACOB KUTZNER, STEFAN MATHIAS, and DANIEL STEIL — University of Göttingen, 1. Institute of Physics, Göttingen, Germany

We integrated a white-light continuum (WLC) probe together with a prism spectrometer in a conventional two-color femtosecond pump-probe setup. Further, we developed a custom measurement program using Microsoft's .NET Framework and Python, enabling instrument control, automated measurement sequences, and preliminary data analysis. To test the modified setup and software, we investigated the transient evolution of the reflectivity in metallic thin film systems and perovskite oxides using 1030 nm pumping. Spectrally and temporally resolved reflectivity variations were observed, confirming the proper functionality of the system. Furthermore, the stability of the WLC source was characterized. Possible future improvements include integrating a Wollaston prism to enable spectrally and time-resolved magneto-optical Kerr effect (MOKE) measurements.

TT 37.18 Tue 14:00 P2

Investigation of the light-dressed bandstructure of graphene — ●LINA SEGERER¹, MARCO MERBOLDT¹, MATTIS LANGENDORF¹, PAUL WERNER¹, JAN PHILIPP BANGE¹, JUNDE LIU¹, WIEBKE BENNECKE¹, MARCEL REUTZEL², and STEFAN MATHIAS¹ — ¹Georg-August-Universität Göttingen, I. Physikalisches Institut, Germany — ²Philipps-Universität Marburg, Germany

Time-periodic driving of solids with strong laser fields enables optical control of material properties. Photon-driven systems not only exhibit replicas of their equilibrium band structure, known as Floquet-Bloch states, but can undergo non-trivial topological phase transitions when excited with circularly polarized light. Recent advances in angle-resolved photoemission spectroscopy (ARPES) have shown that Floquet-Bloch states can be generated in graphene using linear polarized laser pulses [1,2]. However, the oblique incidence angle of the pump pulse so far has limited the realization of a purely circularly polarized light field. In this study, we overcome this challenge by integrating an extra beam path in our ultrafast momentum microscopy (MM) setup enabling backside normal-incidence excitation with linearly and strictly circularly polarized IR pump pulses. We observe light-induced Floquet-Bloch states and investigate the polarization dependence of Floquet-Volkov interference as well as modifications in the light-dressed band structure of epitaxial graphene.

[1] M. Merboldt *et al.*, Nat. Phys. **21**, 1093 (2025).

[2] D. Choi *et al.*, Nat. Phys. **21**, 1100 (2025).

TT 37.19 Tue 14:00 P2

Table-top 3D ultrafast momentum microscopy with a time-preserving EUV-monochromator — ●LENNART WEINHAGEN¹, WIEBKE BENNECKE¹, JAN PHILIPP BANGE¹, DAVID SCHMITT¹, MARCO MERBOLDT¹, BENT VAN WINGERDEN¹, THI LAN DINH², FABIO FRASETTO³, LUCA POLETTI³, MARCEL REUTZEL¹, DANIEL STEIL¹, D. RUSSEL LUKE², STEFAN MATHIAS¹, and G.S. MATTHIJS JANSEN¹ — ¹1st Institute of Physics, University of Göttingen, Göttingen, Germany — ²Institute for Numerical and Applied Mathematics,

University of Göttingen, Göttingen, Germany — ³Institute for Photonics and Nanotechnologies CNR-IFN, Padova, Italy

Photoemission momentum microscopy with tunable probe-photon energy gives unique access to electronic and molecular structures, enabling Fermi-surface imaging, photoemission electron diffraction (PED) and 3D orbital tomography (3D-POT). However, such measurements have largely relied on synchrotron radiation, thus limiting their use in femtosecond-resolved experiments. Here, we present a table-top EUV source with a time-preserving monochromator driven by a 1030 nm femtosecond laser, using an off-plane grating at grazing incidence to reduce spatial chirp. Integrated into our time-resolved momentum microscope [1], it delivers femtosecond, photon-energy-tunable EUV probe pulses. Demonstrated on PTCDA/Ag(110), the setup enabled full 3D reconstruction of the frontier orbitals highlighting the potential of laboratory-scale, energy-selective momentum microscopy [2].

[1] Schmitt *et al.*, Nature 608, 499-503 (2022).

[2] Bennecke *et al.*, arXiv:2502.18269 (2025).

TT 37.20 Tue 14:00 P2

Multimode momentum microscopy of cleaved 1T-TaS₂ crystals — ●BENT VAN WINGERDEN¹, OLENA TKACH², HASHIMA MARUKARA¹, JAN PHILIPP BANGE¹, WIEBKE BENNECKE¹, MARCEL REUTZEL³, JUNDE LIU¹, GERD SCHÖNHENSE², and STEFAN MATHIAS¹ — ¹Georg-August-Universität Göttingen, Germany — ²Johannes Gutenberg-Universität Mainz, Germany — ³Philipps-Universität Marburg, Germany

Ultrafast momentum microscopy has evolved as one of the most powerful tools to study non-equilibrium electronic structure dynamics of 2D quantum materials [1]. However, the large electric field strength generated by the immersion lens limits its versatility in terms of sample systems. One critical issue is related to vacuum-cleaved van-der-Waals-crystals that often show microscopic protrusions, which are prone to field-induced electron emission and flashovers, both of which can destroy the sample itself as well as the microscope's electronics. In our work, we test the momentum imaging capabilities of a newly designed multimode momentum microscope [2,3] in combination with an EUV table-top HHG source. Using vacuum-cleaved bulk crystals of 1T-TaS₂, we show that operating in modes of reduced electric field strength at the sample position suppresses field emission, while still preserving the field-of-view and imaging quality. We carry out detailed comparisons of different operating modes with the new lens system.

[1] Reutzel, Jansen, Mathias, *Adv. in Phys. X* **9**, 2378722 (2024).

[2] Tkach & Schönhense, *Ultramicroscopy* **276**, 114167 (2025).

[3] Tkach et al., arXiv:2401.10084 (2024).

TT 37.21 Tue 14:00 P2

Towards time-resolved momentum microscopy of plasmon excited quantum materials — ●MATTIS LANGENDORF¹, LINA SEGERER¹, PAUL WERNER¹, MARCO MERBOLDT¹, JONAS PÖHLS¹, TOBIAS MEYER¹, DANIEL STEIL¹, JUNDE LIU¹, JAN PHILIPP BANGE¹, WIEBKE BENNECKE¹, G. S. MATTHIJS JANSEN¹, R. THOMAS WEITZ¹, MARCEL REUTZEL², and STEFAN MATHIAS¹ — ¹Georg-August-Universität Göttingen, Germany — ²Philipps-Universität Marburg, Germany

For the realization of Floquet-Bloch engineering as well as for the study of formation and propagation of excitons in two-dimensional quantum materials using time- and angle-resolved photoemission spectroscopy (ARPES), a highly localized excitation on a micron scale seems ideal [1]. However, achieving such spatial confinement poses a significant experimental challenge. Surface plasmon polaritons (SPPs) offer a promising solution, as these collective charge-carrier oscillations enable strong electromagnetic field localization and can therefore provide the required tightly focused excitation conditions [2]. In combination with femtosecond momentum microscopy that enables spatiotemporal access to electron and exciton dynamics [3], we investigate the concept of exploiting SPPs as a driving field to excite quantum materials.

[1] Merboldt *et al.*, Nat. Phys. **21**, 1093*1099 (2025).

[2] Dreher *et al.*, Nanophotonics **11**, 3687-3694 (2022).

[3] Reutzel, Jansen, Mathias, *Adv. in Phys. X* **9**, 2378722 (2024).

TT 38: Topology and symmetry protected materials & Topological insulators – Poster (joint session O/TT)

Time: Tuesday 14:00–16:00

Location: P2

TT 38.1 Tue 14:00 P2

Manipulation of topological surface states by switchable molecules. — LUKAS STAIGER¹, JANNIS LESSMEISTER¹, •RALF HEMM¹, JULIUSZ WOLNY¹, VOLKER SCHÜNEMANN¹, MARTIN AESCHLIMANN¹, and BENJAMIN STADTMÜLLER² — ¹Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, 67633 Kaiserslautern, Germany — ²Institute of Physics, University of Augsburg, 86159 Augsburg, Germany

Three-dimensional topological insulators host spin-momentum-locked surface states protected by time-reversal symmetry, giving them potential for spintronic devices. Controlling these states remains challenging but is crucial for opening gaps, shifting the Dirac point and tailoring spin textures for applications. In our work, we utilize a monolayer of the spin-crossover complex Fe(phen)₂(SCN)₂ on the topological insulator Bi₂Se₃ to break the time-reversal symmetry of the substrate. Employing angle-resolved photoemission spectroscopy, we trace the evolution of the electronic structure as a function of molecular coverage and temperature. Despite a conspicuous energy shift and modified dispersion, there is no clear evidence for a band gap opening after deposition of a molecular monolayer. Concurrently, additional spectral weight from molecular orbitals emerges, and thermally and optically driven spin-crossover transitions in the Fe(phen)₂(SCN)₂ layer induce changes in the Dirac-point energy and spectral weight. Our findings demonstrate that a spin-crossover overlayer can quantitatively alter the dispersion of topological surface states, while allowing them to exist due to strong interactions between molecules and surfaces.

TT 38.2 Tue 14:00 P2

Deciphering the complex surface of the topological phase in the polar semiconductor BiTeI — •ADRIAN WEINDL, CHRISTOPH SETESCAK, and FRANZ J. GIESSIBL — Faculty of Physics, University of Regensburg, D-93053 Regensburg, Germany

BiTeI is a semiconductor consisting of polar layers that can form Rashba spin-split p-n junctions on its surface due to stacking faults. It has been shown that gentle annealing can transform the surface of BiTeI into a topological insulator with spin-polarized surface modes exhibiting linear dispersion. Previous LEED and RHEED measurements revealed that the surface undergoes a structural change from a non-centrosymmetric triple-layer structure to a quintuple-layer structure. However, the exact surface structure remains elusive. Using scanning tunneling microscopy, atomic force microscopy, and Kelvin probe force spectroscopy we study the surface before and after annealing with atomic resolution. We show that the annealing results in different surface phases that are highly sensitive to the annealing temperature: a chemically homogeneous phase at around 240°C and an inhomogeneous phase with strong charge disorder at 250°C. We determine the termination of each phase and confirm that the surface ex-

hibits the signature of a topological surface state even in the strongly disordered phase.

TT 38.3 Tue 14:00 P2

THz-driven nonlinear dynamics studied with high-power THz sources — ATIQA ARSHAD^{1,2}, JAN-C DEINERT², IGOR ILYAKOV², ANDREAS GEBAUER², ANJAN KUMAR N M¹, and •STEFAN KAISER¹ — ¹TU Dresden, Germany — ²HZDR, Dresden, Germany

THz pump-photoelectron spectroscopy (ARPES) probe is currently being implemented at the THz facility TELBE at Helmholtz-Zentrum Dresden-Rossendorf. This unique combination of high-field terahertz excitation and tr-ARPES probe will enable groundbreaking experiments on solid surfaces and interfaces. To this aim we have set up a high-repetition rate THz source driven by a 180 W laser source yielding > 50 mW THz output power. We report on the THz generation and characterization scheme as well as on first experiments. A highly promising material class to be studied with these light sources is BiTeI, a dual topological insulator that exhibits two different types of surface states on different interfaces. We present our study on the complex nonlinear dynamics, in particular THz harmonic generation in these compounds.

TT 38.4 Tue 14:00 P2

The quasi one-dimensional van der Waals material α -Bi₄Br₄ — •JONATHAN K. HOFMANN^{1,2}, SERHII KOVALCHUK^{1,3}, MINGQIAN ZHENG⁴, YUQI ZHANG⁴, VASILY CHEREPANOV¹, TIMOFEY BALASHOV¹, JIN-JIAN ZHOU⁴, ZHIWEI WANG⁴, YUGUI YAO⁴, IREK MORAWSKI³, F. STEFAN TAUTZ^{1,2}, FELIX LÜPKE^{1,5}, and BERT VOIGTLÄNDER^{1,2} — ¹Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, Germany — ²Experimentalphysik IV A, RWTH Aachen University, Germany — ³Institute of Experimental Physics, University of Wrocław, Poland — ⁴Key Laboratory of Advanced Optoelectronic Quantum Architecture and Measurement, Beijing Institute of Technology, China — ⁵II. Physikalisches Institut, Universität zu Köln, Germany

α -Bi₄Br₄ is a quasi-one-dimensional material: covalently bonded Bi₄Br₄ chains are arranged in parallel, side-by-side and layer-by-layer, with van der Waals gaps in between. Bulk α -Bi₄Br₄ is higher-order topological insulator. At step edges on the (001) surface, quantum spin Hall (QSH) edge states are present. Using a scanning tunneling microscope (STM), we observe a significant shift of the chains, relative to each other, which we attribute to shear stress. Scanning tunneling spectroscopy reveals that the edge states are robust against the strain. Density functional theory confirms that a strained monolayer of Bi₄Br₄ is a QSH insulator with $Z_2 = 1$. Furthermore, we use a four-tip STM to analyze the electrical transport of α -Bi₄Br₄ *in situ*.

TT 39: Focus Session: Nickelate Superconductivity: Insights into Unconventional Pairing and Correlation Effects I (joint session TT/DS/MA)

Nickel, a direct neighbor of copper in the periodic table, has been considered a promising candidate for high-temperature superconductivity since the early 1990s. After more than three decades of research, this prediction was confirmed with the discovery of superconductivity in nickelates, marking the beginning of the "nickel age" of superconductivity. Recent advances include Sm-based infinite-layer nickelates with transition temperatures approaching 40 K, as well as bilayer nickelates exhibiting superconductivity above 90 K under pressure and up to 60 K under compressive epitaxial strain. These results highlight the crucial roles of structural engineering, epitaxial strain, and precise synthesis control, and they open new frontiers for both fundamental understanding and materials design. This focus session aims to define key scientific challenges ahead, strengthen collaboration within Germany and Europe, and accelerate progress toward higher superconducting transition temperatures.

Coordinators: Marta Gibert (TU Wien), Mattias Hepting (MPI FKF Stuttgart), Ilya M. Eremin (Ruhr-University Bochum)

Time: Wednesday 9:30–12:45

Location: HSZ/0003

Topical Talk

TT 39.1 Wed 9:30 HSZ/0003

Unconventional Superconductivity in Infinite-layer Samarium Nickelates — •DANFENG LI — City University of Hong Kong, Kowloon, Hong Kong SAR, China

Infinite-layer nickelates have emerged as a frontier platform for studying unconventional superconductivity beyond the cuprates. In this talk, I will present our recent advances on samarium-based infinite-layer nickelate thin films, which exhibit enhanced superconductivity and a mixed two- and three-dimensional superconducting character arising from strong coupling between rare-earth 5d and Ni 3d orbitals. I will further highlight our discovery of robust field-induced re-entrant superconductivity in heavily Eu-doped $\text{Sm}_{0.95-x}\text{Ca}_{0.05}\text{Eu}_x\text{NiO}_2$, where superconductivity suppressed at low fields re-emerges above 6 T and persists to 45 T. This exotic high-field state results from the interplay between NiO-plane superconductivity and Eu^{2+} -sublattice ferromagnetism, revealing a unique coexistence of magnetism and superconductivity within a single material system. These findings demonstrate how rare-earth-site engineering and magnetic-field tuning provide powerful routes for realising and manipulating high-temperature ferromagnetic superconductivity.

- [1] M. Yang, H. Wang, J. Tang, J. Luo et al., arXiv:2503.18346 (2025).
[2] M. Yang, J. Tang, X. Wu, H. Wang et al., arXiv:2508.14666 (2025).

Topical Talk TT 39.2 Wed 10:00 HSZ/0003
Recent insights into infinite-layer nickelate heterostructures from x-ray spectroscopy — •EVA BENCKISER — Max Planck Institute for Solid State Research, Stuttgart, Germany

Nickelates have emerged as an important class of materials for studying unconventional superconductivity. However, the exact cation concentrations and oxygen stoichiometry in infinite-layer nickelates are difficult to determine due to the complex synthesis process. This has so far prevented the clear experimental identification of the nickel valence electron configuration in the superconducting phase.

In my talk, I will discuss our recent x-ray spectroscopy studies on $\text{NdNiO}_x\text{-SrTiO}_3$ heterostructures [1] and PrNiO_x thin films [2] at various intermediate stages of topotactic reduction with $x = 2 - 3$. We find that even the most reduced films do not exhibit a pure $\text{Ni}^{1+}\text{-}3d^9$ configuration. The quantitative analysis shows that there is an average of 1.35 holes in the nickel 3d states and superconducting samples have even higher values [2]. These results challenge previous findings regarding the doping range in which superconductivity occurs in infinite-layer nickelates. Variations between samples are attributed to a complex interplay of ordered, self-doped regions, interfacial reconstructions, and disorder occurring on different length scales in both the cation and anion sublattices.

- [1] R. A. Ortiz et al., Phys. Rev. Materials 9, 054801 (2025).
[2] R. Pons et al., submitted (2025).

Topical Talk TT 39.3 Wed 10:30 HSZ/0003
Theory of infinite-layer nickelate superconductors — •KARSTEN HELD — TU Wien, Austria

The discovery of superconductivity in infinite-layer nickelates [1] marked a new age of superconductivity: the nickel age. Using density functional theory, dynamical mean-field theory and dynamical vertex approximation (DFA [2]), we successfully predicted [3] the phase diagram T_c vs. Sr-doping of $\text{Nd}_{1-x}\text{Sr}_x\text{NiO}_2$ with –for an unconventional superconductor– unprecedented accuracy with defect free films synthesized only 3 years later [4]. Also, the normal state spin spectrum well agrees with resonant inelastic x-ray spectroscopy (RIXS) [5] and the one-particle spectrum with angular-resolved photoemission spectroscopy (ARPES) [6], which both enter into the calculation of T_c . With this excellent agreement to later experiments, we can now with some confidence calculate the phase diagram of finite-layer nickelates [7] and predict that infinite-layer nickelates have a much higher T_c under 100GPa of pressure even without any chemical doping [8].

This work has been supported by the ERC project 101201037 and the FWF project I5398.

- [1] D. Li et al., Nature 572, 624 (2019).
[2] G. Rohringer et al., Rev. Mod. Phys. 90, 25003 (2018).
[3] M. Kitatani et al., npj Quantum Materials 5, 59 (2020).
[4] K. Lee et al., Nature 619, 288 (2023).
[5] L. Si et al., Phys. Rev. Res. 6, 043104(2024).
[6] P. Worm et al., Phys. Rev. B 109, 235126 (2024).
[7] A. Hausoel et al., npj Quantum Mater. 10, 69 (2025).
[8] S. Di Cataldo et al., Nature Comm. 15, 3952 (2024).

15 min. break

Topical Talk TT 39.4 Wed 11:15 HSZ/0003
Disorder and distortions: what electrons tell us about nickelate superconductivity — •BERIT H. GOODGE — MPI-CPS, Dresden, Germany

Recent realizations of superconductivity in both square-planar and bilayer Ruddlesden-Popper nickelates have opened a host of opportunities to explore fundamental questions of high-temperature superconductivity, while simultaneously posing unique synthetic challenges. Despite recent breakthroughs in sample synthesis, however, the highest quality thin films still pose immense challenges for investigation of fundamental characteristics, such as the pairing symmetry of the superconducting order parameter. Systematically introducing point-like disorder with high-energy electron irradiation consistently suppresses the superconducting transition, pointing towards a sign-changing order parameter in square-planar nickelates [1]. In parallel, epitaxial stabilization of superconductivity in bilayer nickelate thin films has opened the door to investigate local atomic structure and bonding environments. Leveraging the highest accessible spatial resolution and light-element sensitivity enabled by state-of-the-art multislice electron ptychography, we survey a series of bilayer nickelate thin films spanning a full series of tensile and compressive strain. We combine these experimental with strain-decomposed DFT calculations to investigate correlations between the observed atomic structure and superconductivity [2].

- [1] Ranna et al., PRL 135, 126501 (2025).
[2] Bhatt et al., arXiv:2501.08204 (2025).

Topical Talk TT 39.5 Wed 11:45 HSZ/0003
Superconducting gap structure and bosonic mode in $\text{La}_2\text{PrNi}_2\text{O}_7$ thin films at ambient pressure — •HAI-HU WEN — Hankou Rd. 22, Gulou, Nanjing, China

The recent discovery of high temperature superconductivity in nickelate systems has generated tremendous interests in the community. The core issue to understand the pairing mechanism is about the superconducting gap and its symmetry. We have successfully synthesized the superconducting thin films of $\text{La}_2\text{PrNi}_2\text{O}_7$ with $T_{c\text{ onset}} = 41.5$ K, and measured the superconducting tunneling spectra after we expose the superconducting layer by using the tip-excitation technique. The spectrum shows a two-gap structure with $\Delta_1 = 9$ meV, $\Delta_2 = 6\text{-}8$ meV, and fittings based on the Dynes model indicate that the dominant gap should have an s-wave structure with low anisotropy, this allows us to select the s^{+-} -pairing symmetry among the two possibilities s^{+-} and d-wave. Furthermore, a clear bosonic mode with energy $\Omega = 30 \pm 2$ meV is observed, which further supports a sign reversal gap[1]. Our results shed new light in understanding the mystery of superconductivity in bilayer nickelate superconductors.

Collaborators: Huan Yang, Ilya M. Eremin, Shengtai Fan, Mengjun Ou, Marius Scholten, Qing Li, Zhiyuan Shang, Yi Wang, Jiasen Xu
[1] S. Fan et al., arXiv: 2506.01788

TT 39.6 Wed 12:15 HSZ/0003
Investigation of Ruddlesden-Popper nickelates and the monolayer-trilayer polymorph using Raman spectroscopy — •VIGNESH SUNDARAMURTHY¹, ABHI SUTHAR¹, PASCAL PUPHAL^{1,2}, HASAN YILMAZ³, MASAHIKO ISOBE¹, MATTEO MINOLA¹, BERNHARD KEIMER¹, and MATTHIAS HEPTING¹ — ¹Max-Planck-Institute for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart, Germany — ²2nd Physics Institute, University of Stuttgart, 70569 Stuttgart, Germany — ³University of Stuttgart, Institute for Materials Science, Materials Synthesis Group, Heisenbergstraße 3, 70569 Stuttgart, Germany

Ruddlesden-Popper nickelates have attracted intense interest following the discovery of superconductivity in several members of the series, including bilayer $\text{La}_3\text{Ni}_2\text{O}_7$, trilayer $\text{La}_4\text{Ni}_3\text{O}_{10}$, and structural polymorphs composed of monolayer-bilayer or monolayer-trilayer (ML-TL) units. In this talk, we explore the phononic and electronic Raman responses of high-quality ML-TL single crystals and contrast them with those of the other nickelate phases, using samples with optimized oxygen content.

TT 39.7 Wed 12:30 HSZ/0003
Multiorbital density wave in the trilayer nickelate $\text{La}_4\text{Ni}_3\text{O}_{10}$ — ABHI SUTHAR¹, VIGNESH SUNDARAMURTHY¹, MATIAS BEJAS², CONGCONG LE³, PASCAL PUPHAL¹, PABLO SOSA-LIZAMA¹, MASAHIKO ISOBE¹, PETER A. VAN AKEN¹, Y. EREN SUYOLCU¹, MATTEO MINOLA¹, ANDREAS P. SCHNYDER¹, XIANXIN WU⁴, BERNHARD KEIMER¹, GINIYAT KHALIULLIN¹, ANDRES GRECO², and

•MATTHIAS HEPTING¹ — ¹Max-Planck-Institute for Solid State Research, Stuttgart, Germany — ²UNR-CONICET, Rosario, Argentina — ³RIKEN, Saitama, Japan — ⁴Institute of Theoretical Physics, Beijing, China

Ruddlesden–Popper nickelates exhibit high-temperature superconductivity closely intertwined with charge and spin density wave order. However, fundamental questions persist regarding the orbital character and symmetry underlying the density wave instabilities. Using

polarized Raman scattering on trilayer $\text{La}_4\text{Ni}_3\text{O}_{10}$, we resolve characteristic phonon anomalies and a redistribution of electronic spectral weight across the density wave transitions. Momentum-selective electronic Raman responses, combined with multiorbital model calculations, reveal a density-wave-induced gap with incoherent, non-mean-field opening and contributions from both $\text{Ni-}d_{x^2-y^2}$ and d_{z^2} states [1]. These results reconcile conflicting experimental reports of the density wave gap and underscore its multiorbital character.

[1] A. Suthar *et al.*, arXiv:2508.06440 (2025).

TT 40: Focus Session: Quantum Sensing with Solid State Spin defects II (joint session TT/HL/MA)

Time: Wednesday 9:30–10:30

Location: HSZ/0101

TT 40.1 Wed 9:30 HSZ/0101

Locally Imaging the Insulator to Metal Transition of Ca_2RuO_4 with Single Spin Magnetometry — •HAYDEN BINGER¹, CISSY SUEN², YOUNG-GWAN CHOI¹, YEJIN LEE¹, HAOLIN JIN¹, MAX KRAUTLOHER², YUCHEN ZHAO¹, LUKE TURNBULL¹, ELINA ZHAKINA¹, JEFFREY NEETHIRAJAN¹, LOTTE BOER¹, BERIT GOODGE¹, PIOTR SURÓWKA³, RODERICH MOESSNER⁴, BERNHARD KEIMER², CLAIRE DONNELLY¹, and URI VOOL¹ — ¹MPI CPFS, Dresden, Germany — ²MPI FKF, Stuttgart, Germany — ³Wrocław University of Science and Technology, Wrocław, Poland — ⁴MPI PKS, Dresden, Germany

The current-driven insulator to metal transition (IMT) in Ca_2RuO_4 is a fascinating phenomenon where increasing current driven across a sample causes a smaller voltage difference to develop. We have created devices of size 10-20 μm by 10-20 μm and 100 nm thick using Focused Ion Beam (FIB) milling. Through the utilization of Nitrogen Vacancies (NV), optically addressable spin-1 defects acting as a qubit at room temperature, we probe the local magnetic field at the defect via the Zeeman interaction. We are thus able to image the local character of the insulator to metal transition in Ca_2RuO_4 . At low currents we image the formation of a singular conducting channel at the edge of the device, which gradually grows throughout the entire device as more current is applied until eventually current flows evenly across the device. We explore reasons why local current channels nucleate at the edge, such as strain, defects, and crystalline lattice orientation.

TT 40.2 Wed 9:45 HSZ/0101

Topological Ambiguity in Stray Field Magnetometry — •SHIRSOPRATIM CHATTOPADHYAY^{1,2} and APARAJITA SINGHA^{1,2} — ¹IFMP, TU Dresden, Germany — ²Würzburg-Dresden Cluster of Excellence (ct.qmat)

Inferring magnetic topology from stray field measurements is central to characterizing skyrmions, vortices, and other topological textures. Yet, the uniqueness of such reconstructions remains poorly characterized. We present a computational framework to systematically generate pairs of magnetization configurations with distinct topological charges ($|\Delta Q| = q$, where q can be set by the user) that produce nearly identical stray fields (Normalized Root Mean Square Error ~ 0.8 -4 percent). Our approach uses constrained optimization with a physics informed loss to jointly evolve magnetization pairs towards field degeneracy while preserving topological distinction. Across 200 randomized trials with varied initializations, we demonstrate rapid and reliable generation of adversarial pairs spanning skyrmions, merons, fractional defects and uniform domain textures. We theoretically analyse the relation between topological charge and stray field and construct an explicit example of near identical stray field from distinct topologies. Our adversarial dataset enables rigorous assessment of magneti-

zation reconstruction algorithms and guides the design of measurement strategies capable of resolving topological ambiguity.

TT 40.3 Wed 10:00 HSZ/0101

Towards Cryogenic Scanning Nitrogen Vacancy Magnetometry — •LOTTE BOER¹, KILIAN SROWIK¹, HAYDEN BINGER¹, YOUNG-GWAN CHOI¹, AHMET ÜNAL¹, EDOUARD LESNE¹, MATHEUS BARBOSA², BERND BÜCHNER², ALEXEY POPOV², and URI VOOL¹ — ¹MPI CPFS, Dresden, Germany — ²IFW Dresden, Germany

In scanning nitrogen vacancy (NV) magnetometry, an atomic force microscopy tip is replaced with a diamond pillar containing a single NV center, which acts as a highly sensitive magnetic field sensor. Scanning over a sample then allows to map the magnetic stray field. This method has been widely used at room temperature to investigate, for example, magnetic textures in thin films or local current flow patterns. However, a wide range of interesting material properties, such as emergent magnetic phases and superconductivity only occur at lower temperatures. As the NV center retains its ability to sense magnetic fields at low temperatures, we are developing a variable temperature cryogenic scanning NV system. This will not only allow for the imaging of materials at low temperatures, but also allow for the unique opportunity of mapping magnetic phase transitions in quantum materials.

Building a cryogenic NV setup presents several challenges, as the NV requires optical access for readout and microwave pulses for control, all within tight spatial confines and while preventing sample heating. In this talk, we will discuss our setup, which is in its final stages of development, and show preliminary measurement results at few Kelvin temperatures.

TT 40.4 Wed 10:15 HSZ/0101

CISS from Vibrationally Assisted Tunneling in Chiral Molecules — •FEDOR BARANOV, VIRGINIA GALI, and MAXIM BREITKREIZ — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Chiral-induced spin selectivity (CISS) remains a puzzling phenomenon, despite extensive experimental evidence. A possible explanation emerges when recognizing that charge transport through chiral insulating molecules occurs in the tunneling regime, where even small spin-orbit coupling becomes crucial inside the barrier. This enhancement leads to a spin-dependent potential that gives different tunneling probabilities for different spin orientations. Because this tunneling alone produces extremely small currents, one has to take into account the vibrational degrees of freedom of the system that in the static limit increases the current while preserving the spin splitting nature. Together, these ingredients offer a transparent physical mechanism underlying the CISS effect.

TT 41: Topological Semimetals

Time: Wednesday 9:30–12:30

Location: HSZ/0103

TT 41.1 Wed 9:30 HSZ/0103

Pushing transport to the edge: Inducing superconductivity in WTe₂ — ●MARIEKE ALTENA, GUIDO WIERSMA, JORT VERBAKEL, ESRA VAN 'T WESTENDE, PANTELIS BAMPOULIS, ALEXANDER BRINKMAN, and CHUAN LI — MESA+ Institute for Nanotechnology, University of Twente, 7500 AE, Enschede, The Netherlands

WTe₂ is a type-II Weyl semimetal hosting higher-order topological states (HOTS) protected by crystal symmetries and characterized by quantum spin Hall-like spin-momentum locking. These states are of particular interest for quantum computing. Recent studies have reported anomalous edge-enhanced supercurrents in WTe₂-based Josephson junctions [1,2].

To reveal the topological nature and test the robustness of HOTS, we measured the electronic transport properties of thin, nanometer sized WTe₂ devices at low temperatures. Superconductivity was successfully induced into the WTe₂ flakes by using superconducting Nb-contacts. We observe a strong enhancement of the supercurrent at the edge of the WTe₂ flake by studying single junctions. Interestingly, the enhancement of the supercurrent at the edge is also observed at a step in the middle of the flake. The current-phase relation is also measured via superconducting quantum interference devices (SQUID), which provides the insight to its topological properties. The topological nature of these states is studied with RF Shapiro measurements and DC SQUID measurements.

[1] Choi et al., Nat. Mater. 19, 974 (2020).

[2] Endres et al., Nano Letters 23, 4654 (2023).

TT 41.2 Wed 9:45 HSZ/0103

Terahertz third-harmonic generation of lightwave-driven Weyl fermions far from equilibrium — ●PATRICK PILCH¹, CHANGQING ZHU¹, SERGEY KOVALEV^{1,2}, RENATO M. A. DANTAS^{3,4}, AMILCAR BEDOYA-PINTO^{5,6}, STUART S. P. PARKIN⁵, and ZHE WANG¹ — ¹TU Dortmund University, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf, Germany — ³University of Basel, Switzerland — ⁴University of Minho, Portugal — ⁵Max Planck Institute for Microstructure Physics, Halle, Germany — ⁶University of Valencia, Spain

We report on time-resolved ultrafast terahertz third-harmonic generation spectroscopy of nonequilibrium dynamics of Weyl fermions in a nanometer thin film of the Weyl semimetal TaP [1]. Terahertz third-harmonic generation is observed at room temperature under the drive of a multicycle narrowband terahertz pulse with a peak field strength of down to tens of kV/cm. The observed terahertz third-harmonic generation exhibits a perturbative cubic power-law dependence on the terahertz drive. By varying the polarization of the drive pulse from linear to elliptical, we realize a sensitive tuning of the third harmonic yield. By carrying out theoretical analysis based on the Boltzmann transport theory, we can properly describe the experimental results and ascribe the observed THz nonlinearity to field-driven kinetics of the Weyl fermions.

[1] P. Pilch et al., *Nano Lett.* (2025), DOI: 10.1021/acs.nanolett.5c04143

TT 41.3 Wed 10:00 HSZ/0103

Quantum Geometric Origin of Intrinsic Nonlinear Hall effects — ●YANNIS URICH^{1,2}, JOHANNES MITSCHERLING³, LAURA CLASSEN^{1,2}, and ANDREAS SCHNYDER¹ — ¹Max Planck Institute for Solid State Research, D-70569 Stuttgart, Germany — ²School of Natural Sciences, Technische Universität München, D-85748 Garching, Germany — ³Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, D-01187 Dresden, Germany

We decompose the intrinsic second-order nonlinear Hall effect (NLHE) of a generic multiband system into quantum geometric contributions using a fully quantum-mechanical projector formalism. Expanding the nonlinear conductivity in powers of the quasiparticle lifetime τ , we recover the established Berry curvature dipole at order τ and clarify discrepancies in prior work concerning the (interband) quantum metric dipole (also called Berry curvature polarizability) at order τ^0 . Our method further reveals an additional order- τ^0 term, determined by the *intraband* quantum metric dipole (intraQMD), which originates from virtual interband transitions captured only within the fully quantum-mechanical treatment. The intraQMD is generically nonzero in systems with broken time-reversal symmetry and can be identified inde-

pendently by symmetry. We highlight candidate materials expected to exhibit a large intrinsic NLHE, including the topological antiferromagnet Yb₃Pt₄. Finally, we discuss the extension of this framework to higher-order nonlinear responses, which requires a structured understanding of higher-order quantum geometry beyond Berry curvature and quantum metric.

TT 41.4 Wed 10:15 HSZ/0103

Raman spectroscopic evidence for linearly dispersed nodes and magnetic ordering in the topological semimetal V_{1/3}NbS₂

— ●SHREENANDA GHOSH^{1,2}, CHRIS LYGOURAS¹, ZILI FENG³, MINGXUAN FU³, SATORU NAKATSUJI^{1,3}, and NATALIA DRICHKO¹ — ¹Institute for Quantum Matter and William H. Miller III Department of Physics and Astronomy, Johns Hopkins University, Baltimore, USA — ²Institute of Physics, University of Münster, Germany — ³Department of Physics, University of Tokyo, Japan

We report polarization-resolved magnetic and electronic Raman scattering of the intercalated transition metal dichalcogenide V_{1/3}NbS₂, proposed as a Weyl semimetal [1,2]. The electronic scattering reveals a linear with frequency continuum of excitations, as the signature of electronic transitions within the proposed Weyl nodes in a 2D electronic structure [3]. Additionally, two-magnon excitations of V moments are observed near 15 meV in the magnetically ordered phase below 50 K[3], which are well reproduced by calculations using spin wave exchange parameters [4] and confirm the antiferromagnetic character of the order. These magnetic and electronic scattering, observed in the same spectra, provide independent spectroscopic evidence for a collinear antiferromagnetic Weyl semimetal state in V_{1/3}NbS₂.

[1] M. K. Ray et al., Nat Com 16, 3532 (2025).

[2] H. Wang et al., Phys. Rev. B 107, 134436 (2023).

[3] S. Ghosh et al., arXiv:2504.04590 (2025).

[4] K. Lu et al., Phys. Rev. Mat 4, 054416 (2020).

TT 41.5 Wed 10:30 HSZ/0103

Large tunability of the magnetism in the Dirac semimetal EuMnBi₂ under uniaxial pressure — ●CAITLIN I. O'NEIL¹, HILARY M.L. NOAD¹, ANDREW P. MACKENZIE¹, HIDEAKI SAKAI², and ELENA GATI^{1,3} — ¹MPI-CPS, Dresden — ²Tohoku University, Japan — ³Goethe University Frankfurt

Uniaxial pressure provides a controlled method for breaking lattice symmetries in crystals, and it has therefore become a powerful tool for tuning quantum materials. Although uniaxial-pressure techniques have been widely used in recent years to probe the coupling between correlated electrons and the lattice [1-2], their use to investigate the interplay between topological electrons, magnetism, and the lattice has been less common. We report on the discovery of a strong uniaxial pressure response in the magnetic Dirac semimetal EuMnBi₂. In this material, there are layers of localised Eu²⁺ moments alternating with Bi square nets that host Dirac fermions. By measuring the AC Young's modulus [3], we map out the phase diagram as a function of [100] uniaxial pressure and magnetic field, revealing a strong sensitivity of the Eu²⁺ magnetic order to strain, including the observation of multiple magnetic phases. We suggest that the pronounced tunability of the Eu²⁺ order arises from its coupling to a low-energy electronic structure that is sensitive to symmetry-breaking strains.

Work is supported by the DFG through TRR 288-422213477.

[1] Gati et al., Sci. Adv. 2, e1601646 (2016)

[2] Noad et al., Science 382, 447 (2023)

[3] O'Neil et al., RSI 95, 073909 (2024)

15 min. break

TT 41.6 Wed 11:00 HSZ/0103

Novel difference-frequency quantum oscillations in MoSi₂

— ●IVAN VOLKAU¹, NICO HUBER², LOUW FEENSTRA¹, ANDREAS BAUER^{1,4}, CHRISTIAN PFLEIDERER^{1,3,4}, and MARC A. WILDE^{1,4} — ¹Technical University of Munich (TUM) — ²Cornell University — ³MCQST, Munich — ⁴TUM Zentrum für Quantum Engineering

Recently, we established temperature-stable quantum oscillations of the quasiparticle lifetime (QPLOs) in CoSi (space group $P2_13$) [1]. QPLOs may shed new light on scattering processes in materials, since they arise in transport properties at finite coupling between semi-

classical Onsager orbits. MoSi_2 (space group $I4/mmm$) exhibits a difference frequency in its SdH spectra, composed of distinct low- and high-temperature (LT and HT) components. The temperature stability and the absence in thermodynamic properties of the HT component is consistent with the theoretical framework of QPLOs [2]. Conversely, the LT component cannot be attributed to QPLOs, as it is observed in both SdH and dHvA measurements. Furthermore, its phase shift of approximately $0.75(10)\pi$ relative to the HT component is inconsistent with standard non-Onsager mechanisms, such as magnetic breakdown, magnetic interaction, or chemical potential oscillations [3]. In this work, we present a detailed study of quantum oscillations in MoSi_2 , analyzing the interplay between these components to clarify the nature of the scattering mechanisms involved.

[1] Huber et al., *Nature* **621**, 276 (2023)

[2] Leeb et al., *PRB* **108**, 054202 (2023)

[3] Leeb et al., *APR*, V14, Is4 2400134 (2025)

TT 41.7 Wed 11:15 HSZ/0103

Probing the Fermi Surface of NdAgSb_2 through Large Linear Magnetoresistance and Quantum Oscillations — ●AARTI GAUTAM¹, HARIBRAHMA SINGH¹, PRABUDDHA KANT MISHRA³, RIE. Y UMETSU⁴, and ASHOK KUMAR GANGULI^{1,2} — ¹Indian Institute of Technology Delhi, Hauz Khas New Delhi — ²Indian Institute of Science Education and Research, Berhampur — ³Institute of Low Temperature and Structure Research, Polish Academy of Sciences, ul. Okolna 2, 50-422 Wrocław, Poland — ⁴Institute for Materials Research, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

We present a comprehensive study of the magnetic, transport, and magnetotransport properties of single-crystalline NdAgSb_2 . The compound exhibits anisotropic magnetic behavior, with an antiferromagnetic ground state for fields applied in the *ab* plane and de Haas van Alphen oscillations observed along the *c* axis. Magnetotransport measurements reveal a large linear magnetoresistance (450 % at 2 K under 9 T), indicative of a clean-limit electronic structure with suppressed scattering. Notably, both de Haas van Alphen and Shubnikov de Haas quantum oscillations are observed simultaneously, enabling a detailed mapping of the Fermi surface. Analysis of the oscillation frequencies, effective masses, and Berry phases provides insight into the low-energy electronic states governed by the two-dimensional Sb square-net topology, highlighting NdAgSb_2 as a model system to explore the interplay of anisotropic magnetism, high-mobility carriers, and quantum oscillations in layered rare-earth pnictides.

TT 41.8 Wed 11:30 HSZ/0103

Topological Dirac Semimetal Carbon Nanoscroll — ●TZU-CHING HSU¹, JHIH-SHIH YOU¹, HSIU-CHUAN HSU², and ION COSMA FULGA³ — ¹Department of Physics, National Taiwan Normal University, Taipei, Taiwan, — ²Graduate Institute of Applied Physics, National Chengchi University, Taipei, Taiwan — ³Institute for Theoretical Solid State Physics, IFW Dresden, Dresden, Germany

Carbon nanoscrolls (CNS), rolled-up structures formed from single-layer graphene, have recently attracted significant attention owing to their distinctive geometry. In this work, we theoretically investigate the topological properties of a series of CNS under different axial magnetic fields and various edge alignment conditions, within the large-radius approximation. As a function of magnetic field strength and the number of turns in the scroll, these systems host topologically protected Dirac cones, which survive even when chiral symmetry is broken. Furthermore, the number of Dirac cones, their real-space probability density, and the magnetic flux at which they occur can be controlled deterministically, being dictated by the system's symmetries. Our results establish a foundation for further studies of the fundamental physics and potential applications of CNS and other two-dimensional materials with similar geometries.

TT 41.9 Wed 11:45 HSZ/0103

End spin formation in capped carbon nanotubes — ●ISTVÁN MARKÓ¹, DOMINIK SZOMBATHY^{1,2}, CĂTĂLIN P. MOCA^{4,2}, and GERGELY ZARÁND^{1,3} — ¹Budapest University of Technology and Economics, Budapest, Hungary — ²Nokia Bell Labs Budapest site, Hungary — ³HUN-REN-BME Quantum Dynamics and Correlations, Budapest, Hungary — ⁴University of Oradea, Oradea, Romania

Semiconducting open carbon nanotubes (CNTs) have been shown to exhibit topological bound states within the spectral gap [1], giving rise to spin formation at the ends of the nanotube [2]. However, the production of open-ended CNTs is difficult. Here, we investigate the electronic properties of capped topological CNTs using exact diagonalization and Chebyshev expansion methods to identify local resonances and bound states in the density of states at the end of long tubes [3]. While capping removes topological states, non-topological bound states and resonances localized on the pentagons appear, presumably related to Euler topology. We observe an abundance of local resonances and bound states, and about 20% of the investigated stable caps are predicted to produce end spins [4]. We identify a specific CNT of chirality (6,5) which produces well-defined end spins. This type of CNT can be produced with ultra-high purity (>95%) [5], and is an excellent candidate for a geometrically controlled spin qubit.

[1] W. Izumida, et al. *Phys. Rev. B* **93**, 195442 (2016).

[2] C. P. Moca, et al. *Phys. Rev. Lett.* **125**, 056401 (2020).

[3] A. Weiße, et al. *Rev. Mod. Phys.* **78**, 275 (2006).

[4] I. Markó, et al. unpublished

[5] S. Shiina, et al. *ACS Nano* **18**, 23979 (2024)

TT 41.10 Wed 12:00 HSZ/0103

Anomalous Fractional Chiral Currents in Step Edges of Weyl Semimetals — ●OSKAR SCHWEIZER¹, VIRGINIA GALI¹, PIET BROUWER¹, GAL LEMUT¹, ADAM YANIS CHAOU², and MAXIM BREITKREIZ¹ — ¹Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany — ²Donostia International Physics Center (DIPC), 20018 Donostia-San Sebastián, Spain

Bulk-boundary correspondence predicts surface states in Weyl semimetals (WSM) only when the 3d bulk Weyl-node separation projects nontrivially onto a given 2d surface. However recent experiments report states on surfaces where no such protected modes are expected, localized instead to 1d step-edge defects. We study such WSM surfaces with step edges and find chiral currents bound to the steps, even though the surface itself hosts no protected modes. Remarkably, these currents can take fractional, non-integer values determined solely by the bulk Weyl-node separation.

TT 41.11 Wed 12:15 HSZ/0103

Correlated Hopf Insulators — ●KONSTANTINOS LADOVRECHIS¹ and SHOUVIK SUR² — ¹Ruhr Universität Bochum, Germany — ²Rice University, USA

Hopf insulators represent an exceptional class of topological matter, unanticipated by the periodic table of topological invariants. These systems point to the existence of previously unexplored states of matter with unconventional topology. In this work, we take a step toward exploring this direction by investigating correlation-driven instabilities of Hopf insulators. Organizing our analysis around the topological quantum critical point that separates the Hopf insulating phase from a trivial insulator, we demonstrate the emergence of unconventional Weyl semimetallic and topological insulating states. Notably, upon doping, the Weyl semimetal supports non-reciprocal superconductivity and a Bogoliubov-Fermi surface, potentially providing a novel framework for realizing the superconducting diode effect. Finally, we highlight the interconnectedness of the effective descriptions of correlated Hopf insulators, two-dimensional quadratic band-touching semimetals, and Luttinger semimetals.

TT 42: Other Transport Topics

Time: Wednesday 9:30–12:45

Location: HSZ/0105

TT 42.1 Wed 9:30 HSZ/0105

Enhancement of the thermopower of Anderson impurity by Van Hove singularities in graphene nanoribbons — ●DAMIAN KRYCHOWSKI and KRZYSZTOF WÓJCIK — Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznań, Poland

We present results from the numerical renormalization group theory of spin-1/2 ad-atom coupled to contacts made of zigzag graphene nanoribbons (ZGNRs). We propose tuning ZGNRs with a transverse electric field [1] and back gates such that they exhibit one of their asymmetric power-law Van Hove singularities at the Fermi level. We demonstrate that, under these conditions, the local spectral density of the ad-atom spin exhibits a sharp and asymmetric pseudo-gap despite complete Kondo screening. This ensures weak charge conductance and a large Seebeck coefficient at low and moderate temperatures, leading to a high figure of merit over a wide temperature range and impurity energy level. A similar enhancement of the Seebeck coefficient is observed in magic-angle twisted bilayer graphene with a highly particle-hole asymmetric band, though it occurs at a different energy scale [2]. At a set temperature, the sign of thermopower of Kondo-correlated system can be further tuned by dragging the singularity through the Fermi level with gate voltage.

- [1] Y.-W. Son, M. L. Cohen and S. G. Louie, *Nature* 347, 444 (2006).
[2] A. K. Paul et al., *Nat. Phys.* 18, 691 (2022).

TT 42.2 Wed 9:45 HSZ/0105

Dynamical current as a spin-state discriminator in open-shell GNR's — ●NICO LEUMER¹, GEZA GIEDKE², and THOMAS FREDERIKSEN² — ¹Wrocław Tech — ²Donostia International Physics Center

The recent advances of surface synthesis unlocked the potential of open-shell physics in graphene nanoribbons (GNRs) which ever since have gained significant attention. Normally chemically unstable, these structures feature unpaired, localized p_z -electrons pinned at zero energy, giving rise to the unique phenomenon of π -magnetism. At half-filling certain GNRs host quasi degenerate spin singlets/triplets states with a vanishing energy gap for long ribbons and without significantly increasing the gap conventional current-based measurements hardly distinguish these spin textures.

In our setup charge current $I(t)$ discriminates between the responsible states –even for a vanishing gap– by means of a Spin-Pauli blockade (SPB). We discuss how our setup preserves the states, how their distinct spatial profile causes different charging energies and such that a variation of the reservoirs chemical potentials allow the isolation of singlet/triplet signals.

Rather than considering only ensembles of measurements or repetitions, our setup allows for single-shot experiments simulated by Monte-Carlo trajectories. From relative frequencies, we estimate overhaul time-scale $\Delta t = 6\hbar/T$ for a successful identification of the spin. For experiments on shorter time scales, we report on the fidelity and the necessary time for a confident identification of the state.

TT 42.3 Wed 10:00 HSZ/0105

Single Spin-Flip Dynamics in the Ising Model — ●LUCA CERVELLERA, FRED HUCHT, and BJÖRN SOTHMANN — University of Duisburg-Essen, Duisburg, Germany

We investigate the real-time spin-flip dynamics of the 1D Ising model by means of waiting time distributions between subsequent spin flips. At large temperatures the waiting time distribution shows an exponential decay due to thermal excitation and relaxation of spins. At low temperatures, the waiting time distribution is dominated by an algebraic decay caused by domain wall motion. The latter can be suppressed by an external magnetic field. Our results are relevant to understand the dynamics of dimer flipping on the Si(001) surface [1].

- [1] C. Brand et al., *Phys. Rev. Lett.* 130, 126203 (2023).

TT 42.4 Wed 10:15 HSZ/0105

Universal relations between thermoelectrics and noise in mesoscopic transport across a tunnel junction — ●ANDREI PAVLOV¹ and MIKHAIL KISELEV² — ¹TKM, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²The Abdus Salam International Centre for Theoretical Physics, Strada Costiera 11, I-34151

Trieste, Italy

We develop a unified theory of weakly probed differential observables for currents and noise in transport experiments. Our findings uncover a set of universal transport relations between thermoelectric and noise properties of a system probed through a tunnel contact, with the Wiedemann-Franz law being just one example of such universality between charge and heat currents. We apply this theory to various quantum systems, including multichannel Kondo, quantum Hall and Sachdev-Ye-Kitaev quantum dots, resonant impurity and two-stage Kondo models, and demonstrate that each of the microscopic theories is characterized by a set of universal relations connecting conductance and thermoelectrics with noise. Violations of these relations indicate additional energy scales emerging in a system.

TT 42.5 Wed 10:30 HSZ/0105

Relaxation to persistent and oscillating currents in simply and doubly frustrated spin systems coupled to fermionic baths — ●NIKODEM SZPAK¹, GERNOT SCHALLER², RALF SCHÜTZHOLD^{2,3}, and JÜRGEN KÖNIG¹ — ¹Fakultät für Physik and CENIDE, Universität Duisburg-Essen, Germany — ²Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — ³Institut für Theoretische Physik, Technische Universität Dresden, Germany

We study relaxation dynamics in a strongly-interacting three and four-site Fermi-Hubbard system (quantum dots) coupled to environment represented by fermionic baths. We analyze the simply frustrated (trimer) and doubly frustrated (tetrahedron) spin geometries to observe the relaxation to steady states containing persistent or oscillating spin currents. Due to high sensitivity of these results to the coherence of the final state, we can test several variants of the Lindblad master equations, derived under different assumptions and parameter regimes: local and global, secular and coherent.

- [1] E. Kleinherbers, N. Szpak, J. König, and R. Schützhold, *Phys. Rev. B* 101, 125131 (2020)
[2] G. Schaller, F. Queisser, N. Szpak, J. König, and R. Schützhold, *Phys. Rev. B* 105, 115139 (2022)
[3] N. Szpak, G. Schaller, R. Schützhold and J. König, *Phys. Rev. B* 110, 115131 (2024)

TT 42.6 Wed 10:45 HSZ/0105

Fluctuation Spectroscopy and Filament Simulations on HfO₂ RRAM devices — ●DEMIAN RANFTL¹, YINGXIN LI², TRISTAN STADLER¹, ESZTER PIROS², PHILIPP SCHREYER², TAEWOOK KIM², LAMBERT ALFF², and JENS MÜLLER¹ — ¹Institute of Physics, Goethe University, Frankfurt am Main, Germany — ²Institute of Materials Science, TU Darmstadt, Darmstadt, Germany

Low-frequency noise spectroscopy plays a crucial role in understanding resistive switching mechanisms and filament dynamics in RRAM devices [1]. In this work, we compare the noise characteristics of undoped [2] and La-doped [3] HfO₂-based devices across multiple resistance states and during DC cycling. Measurements are complemented by phenomenological simulations that assume various states of a stable filament with differing amounts of surrounding defects. The results provide new insights into the roles of filament geometry and defect densities on resistance and noise behaviour. We identify multi-stage resistance-noise scaling relationships, highlighting the competition between trap numbers and system size. These findings offer deeper insight into switching dynamics and the role of doping in modulating noise sources, contributing to the optimisation of RRAM configurations for neuromorphic applications.

- [1] J. Müller, *Contemporary Physics* 29 (2025)
[2] P. Schreyer, N. Kaiser *et al.*, *ACS Appl. Mater. Interfaces* (2025)
[3] T. Kim, M. Major *et al.*, *Adv. Electron. Mater.* (2025)

15 min. break

TT 42.7 Wed 11:15 HSZ/0105

Symmetry breaking in the non-degenerate parametric oscillator — ●JONATHAN SCHLUCK, STEVEN KIM, and FABIAN HASSLER — Institute for Quantum Information, RWTH Aachen University, 52074 Aachen, Germany

Two harmonic oscillators that are parametrically driven at the sum of their natural frequencies exhibit an instability once the driving

strength exceeds the damping. Close to and beyond this instability threshold, nonlinearities must be taken into account. As a consequence of the instability, the system develops a separation of time scales, which can be used to derive an effective Liouvillian describing the long-time dynamics. The effective model possesses a $U(1)$ -symmetry akin to that of a laser. Above the transition, a symmetry-broken state with a fixed phase exhibits an extended lifetime, indicating the symmetry breaking. The phase coherence of this state increases with increasing photon number, following the conventional Schawlow-Townes limit. We propose a measure of symmetry breaking that compares the photon lifetime to the dephasing time in the lasing regime.

TT 42.8 Wed 11:30 HSZ/0105

Reconfigurable Optoelectronics at the Single-Molecule Level — ●ATIF GHAFOR — Department of Physics, Nanoscience Center, University of Jyväskylä, Jyväskylä, Finland.

Controlling exciton and its coupling at the single-molecule scale is a fundamental challenge for nanoscale optoelectronics and quantum technologies. The ability to precisely reposition individual atom within a single-molecule to alter transition dipole moment, thereby enabling on-demand switching of light emission, remains an unrealized yet transformative goal in single-molecule optoelectronics. Here, by displacing the central metal atom of a planar phthalocyanine molecule adsorbed on decoupling layer, we demonstrate active control over its transition dipole moment, leading to suppression or enhancement of light emission via scanning tunneling microscopy-induced luminescence. Through this atomic-scale control, we designed a tunable homogenous dimer in three distinct optical states: a non-emissive state, a single-molecule-like emissive state, and a coupled state (subradiant and superradiant modes) directly revealing intermolecular dipole-dipole coupling. Furthermore, we realized a heterodimer, in which resonant energy transfer can be switched on or off simply by controlling the dipole of the acceptor molecule. Our strategy for manipulating transition dipole moment and optical emission, not only enables deeper exploration of plasmon-exciton coupling, tunable dipole-dipole interaction, and tunable energy transfer dynamics at the single-molecule level but also stimulates the development of single-molecule quantum engineering and atomically reconfigurable optoelectronic devices.

TT 42.9 Wed 11:45 HSZ/0105

Negative electronic friction and non-Markovianity in charge transport through molecular nanojunctions — ●RILEY PRESTON¹, SAMUEL RUDGE¹, DANIEL KOSOV², and MICHAEL THOSS¹ — ¹Institute of Physics, University of Freiburg — ²College of Science and Engineering, James Cook University

The electronic friction approach is a popular mixed quantum-classical method for modeling the dynamics of atoms and molecules at metal or semiconductor surfaces. If the electrons are far from equilibrium, such as in molecular nanojunctions at high bias voltages, the electronic friction coefficient can become negative, meaning it acts to amplify the nuclear vibrations in the molecular bridge rather than dampen them, triggering bond rupture and a loss of device functionality. The physicality of negative electronic frictions has long been debated, owing to the hierarchy of underlying assumptions upon which the electronic friction method is built. We investigate the emergence of negative electronic friction in a donor-acceptor model of a molecule in a molecular nanojunction. We observe that negative electronic frictions arise predictably at high bias voltage according to the geometry of the donor and acceptor on the molecular bridge, resulting in large vibrational excitations that are validated by comparison to numerically exact quantum data calculated with the hierarchical equations of motion approach. However, we also show that the same physical conditions that give rise to negative electronic friction are also suggestive of non-Markovian dynamics, challenging the underlying assumptions of the electronic friction approach.

TT 42.10 Wed 12:00 HSZ/0105

Vibrational Instabilities in Molecular Nanojunctions - The Role of Anharmonic Nuclear Potentials — ●MARTIN MÄCK, SAMUEL RUDGE, RILEY PRESTON, and MICHAEL THOSS — Institute of Physics, University of Freiburg

Current-induced vibrational excitation is a key factor determining the

stability of molecular nanojunctions. Beyond conventional Joule heating, a different mechanism caused by nonconservative current-induced forces has been reported for models with multiple vibrational modes, leading to vibrational instabilities already at low bias voltages [1].

So far, this mechanism has only been investigated for harmonic nuclear potentials [1,2]. A natural question, is whether this effect can also be observed in more realistic models with anharmonic potentials and if it has a measurable impact on observables such as the dissociation probability of the junction. In this contribution, we apply a mixed quantum-classical approach based on electronic friction and Langevin dynamics [2,3] to different anharmonic model systems, studying the influence of anharmonicity on the reported instability and the dissociation dynamics of the junction. The results show that, in our models, anharmonic nuclear potentials destroy the mechanism leading to vibrational instabilities.

[1] J.-T. Lü, M. Brandbyge, P. Hedegård, T. Todorov, D. Dundas, Phys. Rev. B **85**, 245444 (2012)

[2] M. Mäck, M. Thoss, S. Rudge, Phys. Rev. B **112**, 075430 (2025)

[3] R. J. Preston and D. S. Kosov, J. Chem. Phys. **158**, 224106 (2023)

TT 42.11 Wed 12:15 HSZ/0105

Thermodynamic and kinetic uncertainty relations in topological surface states — ●PHILLIP MERCEBACH¹, PABLO BURSET¹, and SUN-YONG HWANG² — ¹Department of Theoretical Condensed Matter Physics and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain — ²Theoretische Physik, Universität Duisburg-Essen and CENIDE, D-47048 Duisburg, Germany

Strong fluctuations in nanoscale devices can hinder output precision, while the unavoidable entropy production is detrimental to performance. Device operation can be optimized to achieve a strong output signal while minimizing noise, entropy, and frenesy. However, there are fundamental constraints between the output and these drawbacks: the thermodynamic uncertainty relation (TUR) quantifies the trade-off between signal-to-noise ratio (SNR) and entropy, while the kinetic uncertainty relation (KUR) describes the trade-off between SNR and frenesy. Both relations are especially interesting as quantum coherent processes can yield output precisions surpassing classical limits. Here, we study TUR and KUR in a ballistic junction comprised of a 3D topological insulator (3DTI) in proximity to a ferromagnet. The 3DTI surface states, in combination with the ferromagnet, enable near-Carnot efficiency, indicating low entropy production [1]. We demonstrate that the SNR in this device becomes very high at optimum temperatures and voltage bias, where the thermal and shot noises are rather suppressed.

[1] P. Mercebach et. al., arXiv:2508.20969

TT 42.12 Wed 12:30 HSZ/0105

Electromagnetic chiral anisotropy of the semiconducting LaRhC₂-enantiomorphs — ●VOLODYMYR LEVYTSKYI¹, ULRICH BURKHARDT², MARKUS KÖNIG², ETERI SVANIDZE², YURI GRIN², and ROMAN GUMENIUK¹ — ¹Institut für Experimentelle Physik, TU Bergakademie Freiberg, Freiberg, Germany — ²Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

In past decades, the majority of research is focused on chiral crystalline solids due to their non-trivial spin and charge transport properties. However, the preparation of mono-chiral samples is a complicated task – perhaps explaining why the influence of chirality on electrical properties has remained almost unexplored. EBSD (electron backscatter diffraction) -based enantiomorph distribution maps allow the extraction and shaping of suitable microdevices from polycrystalline material by the FIB (focused ion beam) micropreparation method. Here, we present results on the electrical transport studied on the mono-chiral, crystallographically oriented, single-crystalline LaRhC₂ (space groups $P4_1$ or $P4_3$) microdevices. Significant anisotropy of the electrical resistivity is observed for each enantiomorph, both parallel to and normal to the fourfold screw axis. The different linear coefficients of the longitudinal magnetoresistivity probed along the fourfold screw axis for the nonmagnetic right-handed (4_1 -axis) and left-handed (4_3 -axis) LaRhC₂ crystals in the oriented magnetic field parallel and antiparallel to the current flow direction (dc regime), confirm the electromagnetic chiral anisotropy (eMChA) – a rarely studied effect.

TT 43: Superconducting Electronics: Qubits

Time: Wednesday 9:30–12:45

Location: CHE/0089

TT 43.1 Wed 9:30 CHE/0089

Analysis of Flux Noise in Charge Qubits — •DANIEL KRUTI and ROMAN-PASCAL RIWAR — Peter Grünberg Institute, Theoretical Nanoelectronics, Jülich Research Centre, Jülich, D-52425, Germany & Cologne University

Improving the lifetime of quantum information stored in superconducting qubits is a focal point of contemporary research. However, the modelling of time-dependent flux noise has long been based on simplified lumped-element approaches, neglecting details of the device layout and flux distribution. Building on a recently developed quantum geometric description of Faraday's law of induction, we provide an in-depth analysis of charge qubit relaxation and decoherence rates for various flux noise sources, such as surface spins and the surrounding qubit control hardware. Contrary to standard circuit theory, our treatment reveals that a circuit does not require flux-tunability (e.g. a dc-SQUID) in order to be affected by flux noise, as flux-induced relaxation persists in the single junction limit. We link relaxation and dephasing by a geometry-dependent form factor, allowing experimental $1/f$ flux noise spectra to be used for quantitative estimates. These suggest that, while surface spins are likely negligible for current qubit performances, far-field flux sources due to the surrounding hardware can, in principle, contribute significantly.

TT 43.2 Wed 9:45 CHE/0089

Observation of two-level systems in superconducting titanium-aluminum-nitride films — •MARIUS FROHN^{1,2}, FLORIAN MEZGER¹, MAXIMILIAN KRISTEN¹, JAN NICOLAS VOSS¹, HANNES ROTZINGER^{1,2}, and ALEXEY USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruhe Institute for Technology (KIT), Germany — ²Institute for Quantum Materials and Technologies (IQMT), Karlsruhe Institute for Technology (KIT), Germany

Thin films of disordered superconductors are currently the subject of extensive study due to their potential applications in modern quantum circuits and kinetic inductance detectors. While many materials are possible candidates, those with low microwave loss and a high degree of disorder are especially interesting for high impedance circuits. The disordered microscopic structure also favors the presence of intrinsic material defects, some of which behave as two-level systems (TLS)[1]. Found in dielectrics such as surface oxides or tunneling barriers, TLS are a significant source of electromagnetic loss, which limits the coherence of superconducting qubits. It has been recently proposed [2], that applied direct-currents in the disordered superconductors are influencing the observable TLS coupling, e.g. to a microwave resonator. We present microwave spectroscopy measurements of ultracompact, high impedance resonators made from titanium-aluminum-nitride films. By applying electric fields, we observe TLS strongly interacting with the resonator modes.

[1] M. Kristen et al., Phys. Rev. Lett. 132, 217002 (2024)

[2] T. Liu et al., Phys. Rev. B 111, L180502 (2025)

TT 43.3 Wed 10:00 CHE/0089

Embedding Superconducting Quantum Circuits in a Millimeter-Wave Environment — •JAKOB LENSCHEN¹, SERGEI MASIS¹, JÜRGEN LISENFELD¹, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany — ²Institut für Quantenmaterialien und Technologie (IQMT), Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany

Superconducting mm-wave quantum circuits operating at around 100 GHz offer many interesting new possibilities. Compared to microwave implementations, the higher photon energy and wider bandwidth enhance resilience to thermal fluctuations, and speed up qubit manipulations. However, mm-wave measurements at ultra-low temperatures are largely unexplored, and technical challenges demand alternative approaches [1]. The coherence and energy relaxation of superconducting quantum circuits is sensitive to a variety of loss mechanisms, e.g. interference with parasitic modes in the sample box and within the chip. Particular attention is required for mm-waves, as their wavelength is comparable to the dimensions of the dielectric substrate and many other structures in a conventional sample box. We have developed several approaches for coupling superconducting quantum circuits to waveguides, utilizing machined ridge gap waveguides and other

techniques. In this presentation, we will discuss embedded superconducting mm-wave quantum chips, parasitic modes, and ways to inhibit or channel them out. We will compare our simulations with the experimental results.

[1] Lensch et al., arXiv:2411.15058 (2024)

TT 43.4 Wed 10:15 CHE/0089

Niobium-based Josephson junctions for superconducting mm-wave qubits — •URS STROBEL¹, BENEDICT ROTHMUND¹, JAKOB LENSCHEN¹, JONAS KAEMMERER¹, LUCAS RADKE¹, SERGEI MASIS¹, JINJI LUO-HOFMANN³, DANNY REUTER³, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), KIT, 76131 Karlsruhe, Germany — ²Institut für Quantenmaterialien und Technologien (IQMT), KIT, 76131 Karlsruhe, Germany — ³Fraunhofer-Institut für Elektronische Nanosysteme (ENAS), Chemnitz, Germany

Superconducting quantum circuits operating at millimeter-wave frequencies are an exciting area of research and offer the potential to maintain functionality at temperatures considerably higher than their widely studied centimeter-wave counterparts. The reduced wavelength allows for a smaller circuit footprint and faster qubit manipulation. Implementing such millimeter-wave qubits requires a superconductor with an energy gap above 100 GHz, which renders aluminum unsuitable. However, other conventional superconductors with larger gaps, such as niobium, are available with the technology to produce submicrometer Josephson junctions, key elements for superconducting quantum circuits.

To reduce dielectric losses, we use the low-loss substrate to eliminate extra dielectric layers present in classical niobium-based junction techniques [1]. We will present the concept, design constraints, and low-temperature characteristics. (2024)

[1] Patent pending DPO:02025132612.6 (2025)

TT 43.5 Wed 10:30 CHE/0089

fluxonium qubits inductively coupled to granular aluminum based readout resonators — •LI-WEI CHANG, ASEN LYUBENOV GEORGIEV, FABIAN KAAP, CHRISTOPH KISSLING, VICTOR GAYDAMACHENKO, SERGEY LOTKHOV, MARK BIELER, and LUKAS GRÜNHaupt — Physikalisches-Technische Bundesanstalt, Braunschweig, Germany

The fluxonium qubit is a specific type of superconducting qubit, which has garnered significant interest due to its coherence time in the millisecond range, high gate fidelities on the order of 99.9%, and a large anharmonicity up to several GHz. Recent years have also seen a surge in material studies related to this type of qubit, with a particular focus on high kinetic inductance materials such as granular aluminum (grAl). Three basic components form a fluxonium qubit: a Josephson junction, a capacitor, and a so-called superinductor with an impedance larger than the resistance quantum $R_Q = \frac{h}{4e^2}$. To enable dispersive readout, we employ a high-quality granular aluminum based readout resonator which is inductively coupled to the qubit through a shared inductor. Here, we present our methodology of qubit design, fabrication process and first experimental results.

TT 43.6 Wed 10:45 CHE/0089

Low-crosstalk modular flip-chip architecture with superconducting kinetic-inductively coupled flux-qubit-resonator circuits — •SÖREN IHSEN¹, SIMON GEISERT¹, GABRIEL JAUMA^{2,3}, PATRICK WINKEL^{1,4,5}, MARTIN SPIECKER¹, NICOLAS ZAPATA¹, MANUEL PINO^{2,7}, JUAN JOSE GARCIA-RIPOLL², and IOAN M. POP^{1,6,8} — ¹IQMT, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²Institute of Fundamental Physics IFF-CSIC, Calle Serrano 113b, 28006 Madrid, Spain — ³Applied Physics Department, Salamanca University, Salamanca 37008, Spain — ⁴Departments of Applied Physics and Physics, Yale University, New Haven, CT 06520, USA — ⁵Yale Quantum Institute, Yale University, New Haven, CT 06520, USA — ⁶PHI, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ⁷Nanotechnology Group, USAL-Nanolab, Salamanca University, Salamanca 37008, Spain — ⁸Physics Institute 1, Stuttgart University, 70569 Stuttgart, Germany

We introduce a flip-chip architecture for arrays of coupled superconducting qubits in which each circuit component is placed inside its

own microwave enclosure. Unlike conventional flip-chip designs, our qubit chips are electrically floating, enabling straightforward modular assembly of capacitively coupled elements while strongly suppressing microwave crosstalk. We demonstrate the architecture using a chain of three nearest-neighbor coupled generalized flux qubits, where the central qubit serves as a frequency-tunable coupler. This system achieves a transverse coupling on/off ratio of 50, zz-crosstalk of 0.7 kHz between resonant qubits, and >60 dB isolation between outer enclosures.

15 min. break

TT 43.7 Wed 11:15 CHE/0089

Investigation of tunable interactions between qartion flux qubits — ●HOSSAM TOHAMY¹, ALEX KREUZER¹, THILO KRUMREY¹, HANNES ROTZINGER^{1,2}, and ALEXEY V. USTINOV^{1,2} — ¹Physikalisches Institut (PHI), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — ²Institute for Quantum Materials and Technologies (IQMT), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Tunable qubits are useful in superconducting quantum processors because they enable high-performance quantum gates. Although transmon-based multiqubit systems are widely used in recent architectures, the qartion flux qubit [1] emerges as a promising alternative, offering a positive anharmonicity that is three to five times larger than in typical transmons. In this work, we present an experimental investigation of qartion flux qubits in a capacitively coupled multiqubit architecture. The qubit inductances are realized using a novel stacked-junction fabrication technology [2]. We performed microwave spectroscopy and time-domain measurements on coupled qubits, demonstrating tunable capacitive coupling between the qubits. We benchmarked the measured coupling strengths against analytical models and RF simulations and found good agreement.

[1] F. Yan et al., arXiv:2006.04130 (2020).

[2] A. Kreuzer et al., arXiv:2503.11437 (2025).

TT 43.8 Wed 11:30 CHE/0089

Improving performance of planar tantalum resonators and transmon qubits on silicon using advanced deposition techniques — MACIEJ W. OLSZEWSKI¹, LINGDA KONG², ●SIMON REINHARDT², DANIEL TONG², SHILLING DU³, GABRIELE DI GIANLUCA⁴, HAORAN LU², SASWATA ROY¹, ALEKSANDRA BIEDRON⁵, DAVID A. MULLER², and VALLA FATEMI² — ¹Department of Physics, Cornell University, USA — ²School of Applied and Engineering Physics, Cornell University, USA — ³Cornell NanoScale Facility, USA — ⁴Department of Physics, University of Florida, USA — ⁵NY Creates, USA

The cubic phase of tantalum is a very promising material for superconducting transmon qubits, due to its self-limiting surface oxide, low bulk losses, and low kinetic inductance.

We present a novel method of growing high-crystallinity tantalum films on silicon with magnetron sputtering, using a significantly lower substrate temperature than found in literature. Using coplanar waveguide resonators, we measure the losses and microwave performance of our films, achieving single photon quality factors above four million for resonators with gap size of 3- μm . We present first results on transmon qubits based on these low loss tantalum films.

Funding: This prototype was primarily supported by the Microelectronics Commons Program, a DoW initiative, under award number N00164-23-9-G061. Funding for shared facilities used in this prototype was provided by the Microelectronics Commons Program, a DoW initiative, under award number N00164-23-9-G061.

TT 43.9 Wed 11:45 CHE/0089

Microwave pulse shape optimization for enhanced spin excitation in a ³¹P:²⁸Si ensemble coupled to a superconducting resonator — PATRICIA OEHL^{1,2}, ●ANA STRINIC^{1,2}, TAHEREH SADAT PARVINI^{1,2}, and HANS HUEBL^{1,2,3} — ¹Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — ²School of Natural Sciences, Technical University of Munich, Garching, Germany — ³Munich Center for Quantum Science and Technology, Munich, Germany

Phosphorus donors in silicon are considered as promising candidates for the realization of microwave quantum memories due to their electron spin transitions in the GHz regime with exceptionally long coherence times [1]. Here, we investigate the transduction of pulsed coherent microwave signals to spin excitations of a spin ensemble. This effec-

tively pulsed electron spin resonance experiment uses a hybrid system consisting of a superconducting lumped-element microwave resonator coupled to a spin ensemble of phosphorus donors in isotopically engineered silicon. By modeling the system using an input-output formalism, we identify optimal pulse shapes and coupling parameters for enabling this excitation transfer. The understanding and optimization is of importance for the implementation of efficient quantum state storage protocols, which are of relevance for microwave quantum memory applications as well as quantum sensing.

[1] M. Steger et al., Science 336, 1280 (2012)

TT 43.10 Wed 12:00 CHE/0089

Quantum dynamics of two XY interacting PT-symmetric non-Hermitian qubits: enhancement of quantum annealing — ●YANA KOMISSAROVA, MIKHAIL V. FISTUL, and ILYA M. EREMIN — Institut für Theoretische Physik III, Ruhr-Universität Bochum, Bochum 44801, Germany

Quantum information processing devices enable the realization of analog quantum simulations, such as quantum annealing, and offer a promising route toward solving complex computational and combinatorial optimization problems. In this work, we introduce a new type of quantum information platform based on a network of interacting parity-time (PT) symmetric non-Hermitian qubits. The quantum dynamics of individual PT-symmetric non-Hermitian qubits have already been demonstrated experimentally using several approaches, including dilation schemes with digital coupling to an auxiliary qubit. These experiments carried out on a variety of platforms, such as NV centers, superconducting qubits, and superconducting and trapped-ion qutrits, have revealed exceptional points of different orders, as well as PT-symmetry-preserving and symmetry-breaking quantum states. A key next step is the investigation of coherent quantum dynamics in systems of interacting PT-symmetric non-Hermitian qubits. Here, we study both time-independent and time-dependent Hamiltonians relevant for quantum annealing in an exemplary two-qubit non-Hermitian network based on the XY model. We analyze the system in both PT-symmetric and PT-broken regimes to identify conditions that maximize the probability of reaching the ground state after quantum annealing.

TT 43.11 Wed 12:15 CHE/0089

Strongly interacting phases of spins and bosons in circuit QED — ●ADRIAN PAUL MISSELWITZ^{1,2,3}, JACQUELIN LUNEAU^{1,2,3}, ENRICO DI BENEDETTO⁴, and PETER RABL^{1,2,3} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — ⁴Università degli Studi di Palermo, Dipartimento di Fisica e Chimica-Emilio Segrè, Via Archirafi 36, I-90123 Palermo, Italy

The scalability of superconducting circuit hardware is a promising route for the implementation and exploration of complex many-body systems. In this work, we study emerging phases of matter in a waveguide QED framework, arising from the interplay of competing forces of atom-bound state localization and Kerr-type photon-photon interactions. In addition, we extend our analysis to 1D flatband systems, map out the phase space and characterize the flatband states, which take on a unique form due to the nonlinear photonic dynamics of circuit QED.

TT 43.12 Wed 12:30 CHE/0089

Light-controlled transport across impurities in cavity quantum materials — LUKAS KRIEGER¹, ●DEBASHISH MONDAL^{1,2}, AHANA CHAKRABORTY³, and PETER P. ORTH^{1,2} — ¹Department of Physics, Saarland University, Campus, 66123 Saarbrücken, Germany — ²Center for Quantum Technologies (QuTe), Saarland University, Campus, 66123 Saarbrücken, Germany — ³Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803, USA

We investigate quantum materials placed inside optical cavities in the deep-strong and ultra-strong light-matter coupling regimes. In these regimes, standard perturbative techniques and approximation from quantum electrodynamics such as rotating-wave approximation become unreliable. To address this challenge, we employ the asymptotic decoupling (AD) transformation, a unitary approach that shifts the minimal-coupling interaction to the renormalization of electronic mass and shift of the electronic position.

We examine how strong light-matter coupling affects electron scat-

tering at the impurity site in a one dimensional system. We are analyzing these effects using both low-order perturbation theory and Green-function-based methods to capture higher-order scattering contributions. This work aims to build a framework for understanding scatter-

ing phenomena in cavity-embedded quantum materials and to guide future simulations and analytical studies in non-perturbative coupling regimes.

TT 44: Nonequilibrium Quantum Systems I (joint session TT/DY)

Time: Wednesday 9:30–12:45

Location: CHE/0091

TT 44.1 Wed 9:30 CHE/0091

Quantum geometric force in nonlinear phononics — ●SOTA KITAMURA and TAKAHIRO MORIMOTO — University of Tokyo, Tokyo, Japan

When phonons are resonantly excited by intense laser fields, nonlinear effects can dynamically alter the crystal structure. The field of controlling material properties through such processes is referred to as nonlinear phononics. In conventional theoretical frameworks of nonlinear phononics, the electron dynamics are typically assumed to be adiabatic. However, this assumption generally breaks down under strong driving, and nonadiabatic corrections become essential.

Using nonequilibrium Green function methods, we investigate the electron dynamics under resonant phonon excitation beyond the adiabatic approximation, thereby exploring nonadiabatic effects appearing in the phonon equations of motion. Our analysis reveals that quantum geometric contributions originating from the electronic Berry curvature give rise to unconventional forces on phonons. These quantum geometric corrections are then applied to the dynamical control of crystal chirality, i.e., right- or left-handedness of chiral crystals, using a minimal tight-binding model coupled to the Peierls phonon.

TT 44.2 Wed 9:45 CHE/0091

Macroscopic mechanical torque for lattice and electronic chirality measurement — ●NIKOLAI PESHCHERENKO¹, NING MAO¹, CLAUDIA FELSER¹, and YANG ZHANG^{2,3} — ¹Max Planck Institute for Chemical Physics of Solids, 01187, Dresden, Germany — ²Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996, USA — ³Min H. Kao Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville, Tennessee 37996, USA

The concept of chirality is known to be critical for a number of phenomena related either to a structural asymmetry or topological electronic band crossings. In the present work we develop a robust chirality probe of TR-symmetric systems with mechanical torque measurement. Namely, we show that driving a system out of equilibrium with temperature gradient (or electric field to excite electrons) would result in uncompensated angular momentum and mechanical torque. Calculations are made for both phonons (insulating case) and electrons (metallic case) carrying angular momentum. For phonons, our theoretical findings stand in reasonable agreement with a recent experiment [1]. For electronic subsystem, we discuss both cases of structural and topological electronic chirality probe.

[1] H. Zhang, N. Peshcherenko, F. Yang, T. Ward, P. Raghuvanshi, L. Lindsay, C. Felser, Y. Zhang, J.-Q. Yan, H. Miao, Nat. Phys. 1 (2025)

TT 44.3 Wed 10:00 CHE/0091

Hybrid quantum–classical matrix-product state and Lanczos methods for electron–phonon systems with strong electronic correlations: Application to disordered systems coupled to Einstein phonons — ●HEIKO GEORG MENZLER¹, SUMAN MONDAL², and FABIAN HEIDRICH-MEISNER¹ — ¹Institut für Theoretische Physik, Georg-August-Universität Göttingen, D-37077 Göttingen, Germany — ²Max Planck Institute for the Physics of Complex Systems, Dresden

We present two quantum-classical hybrid methods for simulating the time-dependence of electron-phonon systems that treat electronic correlations numerically exactly and optical-phonon degrees of freedom classically. These are a time-dependent Lanczos and a matrix-product state method, each combined with the multi-trajectory Ehrenfest approach. Due to the approximations, reliable results are expected for the adiabatic regime of small phonon frequencies. We discuss the convergence properties of both methods for a system of interacting spinless fermions in one dimension and provide a benchmark for the Holstein chain. As a first application, we study the decay of charge density wave order in a system of interacting spinless fermions coupled to Einstein oscillators and in the presence of quenched disorder. We investigate

the dependence of the relaxation dynamics on the electron-phonon coupling strength and provide numerical evidence that the coupling of strongly disordered systems to classical oscillators leads to delocalization, thus destabilizing the (finite-size) many-body localization in this system.

This research is supported by the DFG (Deutsche Forschungsgemeinschaft) via SFB 1073 and FOR 5522.

TT 44.4 Wed 10:15 CHE/0091

Frozen non-equilibrium dynamics of exciton Mott insulators in moiré superlattices — SHIBIN DENG¹, ●JONAS REIMANN², HEONJOON PARK³, JONAS M. PETERSON¹, AMMON FISCHER², XIAODONG XU³, DANTE M. KENNES^{2,4}, and LIBAI HUANG¹ — ¹Department of Chemistry, Purdue University, West Lafayette, IN 47907, USA — ²Max Planck Institute for the Structure and Dynamics of Matter, Center for Free Electron Laser Science, 22761 Hamburg, Germany — ³Department of Physics, University of Washington, Seattle, WA 98195, USA — ⁴Institut für Theorie der Statistischen Physik, RWTH Aachen University, 52056 Aachen, Germany

Moiré superlattices, such as those formed from transition metal dichalcogenide heterostructures, have emerged as an exciting platform for exploring quantum many-body physics. A key open question is the coherence and dynamics of the quantum phases arising from photoexcited moiré excitons, particularly amid dissipation. Here we use transient photoluminescence and ultrafast reflectance microscopy to image non-equilibrium exciton phase transitions. Counterintuitively, experimental results and theoretical simulations indicate that strong long-range dipolar repulsion freezes the motion of the Mott insulator phase for over 70 ns. In mixed electron-exciton lattices, reduced dipolar interactions lead to diminished freezing dynamics. These findings challenge the prevailing notion that repulsion disperses particles, whereas attraction binds them. This talk focuses on the theoretical efforts that support the experimental data.

TT 44.5 Wed 10:30 CHE/0091

Cavity-induced Eliashberg effect: superconductivity vs charge density wave — ●MD MURSALIN ISLAM^{1,2}, MICHELE PINI^{1,2}, RAFAEL FLORES-CALDERÓN², and FRANCESCO PIAZZA^{1,2} — ¹Theoretical Physics III, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — ²Max Planck Institute for the Physics of Complex Systems, Nothnitzer Straße 38, 01187 Dresden, Germany

Recent experiments have shown that non-equilibrium effects can play a key role in cavity-based control of material phases, notably in systems with charge-density-wave order. Motivated by this, we extend the theory of the Eliashberg effect, originally developed for superconducting phases, to charge-density-wave phases. Starting from a minimal electronic model where superconductivity and charge-density-wave order are equivalent at equilibrium, we introduce coupling to cavity photons, which are in turn coupled to an environment at a temperature different from the one of the electronic environment. This drives the system into a non-thermal steady state, which breaks the equivalence between superconductivity and charge-density-wave order. In the superconducting case, we recover the known behavior: a shift from continuous to discontinuous phase transitions with bistability. In contrast, the charge-density-wave case displays richer behavior: tuning the cavity frequency induces both continuous and discontinuous transitions, two distinct ordered phases, and a bistable regime ending at a critical point. These findings demonstrate that the scope of cavity-based non-thermal control of quantum materials is broader than at thermal equilibrium, and strongly depends on the targeted phases.

TT 44.6 Wed 10:45 CHE/0091

Quantum Monte Carlo Nonequilibrium work estimator of Rényi negativities — ●JANNIS KASTELL and DAVID LUITZ — Universität Bonn, Bonn, Germany

We develop a Quantum Monte Carlo method for the calculation of

Rényi generalizations of the logarithmic negativity, an entanglement measure for mixed states. Extending previous works using the replica trick and nonequilibrium-work-based estimators of Rényi entanglement entropy, we adapt this framework to the moments of the partially transposed reduced density matrix at finite temperature. Using the stochastic series expansion (SSE) method, we compute these moments in bi- and tri-partitioned systems. We apply this approach to the spin-1/2 isotropic Heisenberg antiferromagnet on a 3D simple cubic lattice, analysing the scaling of the higher order moments with subsystem size for both contiguous and disjoint partitions. Our results demonstrate that this approach provides an efficient and scalable method for estimating mixed-state entanglement measures in large quantum many-body systems.

15 min. break

TT 44.7 Wed 11:15 CHE/0091

Enhancing quantum metric using periodic driving — ●DHRUV TIWARI, RODERICH MOESSNER, and JOHANNES S. HOFMANN — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

The advent of periodically driven systems has revolutionized modern condensed matter physics by offering two transformative opportunities. First, they enable the realization of nonequilibrium analogs of well-established equilibrium phases under highly tunable conditions. Second, they facilitate the emergence of novel phases with no equilibrium counterparts. In this work, we focus on the former, leveraging the tunable parameters of periodically driven systems to enhance the quantum metric in flat-band models. The quantum metric, a fundamental geometric property of the band structure, plays a crucial role in stabilizing various correlated phases. Here, we present results demonstrating that an appropriately chosen periodic drive can amplify the quantum metric and modify density-density interactions. Using both numerical and analytical techniques, we map out the phase diagram of the resulting model.

TT 44.8 Wed 11:30 CHE/0091

Scattering in periodic fields: Floquet resonances — ●SEBASTIAN EGGERT, CHRISTOPH DAUER, and AXEL PELSTER — University of Kaiserslautern-Landau (RPTU)

An alternative mechanism of tuning many-body interactions in atomic systems is proposed, which is based on dynamically creating Floquet bound states using time-periodic fields. By developing a Floquet-scattering theory we show that sharp Floquet resonances occur at which the effective interaction can be tuned to very large attractive or repulsive values. The resulting predictions explain recent experimental data and provide additional tuning possibilities. Analytic predictions are given for adjusting amplitude, frequency and mean of the applied oscillating field in order to accurately choose location and width of scattering resonances over a wide range. This paves the road to a versatile toolbox of tailored interactions in setups with multiple atomic species.

TT 44.9 Wed 11:45 CHE/0091

A comparative study of perturbative and nonequilibrium Green's function approaches for Floquet sidebands in periodically driven quantum systems — ●KARUN GADGE¹, MARCO MERBOLDT², WIEBKE BENNECKE², JAN PHILIPP BANGE², MARCEL REUTZEL³, STEFAN MATHIAS², MICHAEL A SENTEF⁴, MICHAEL SCHÜLER⁵, and SALVATORE R MANMANA¹ — ¹Institute for Theoretical Physics, Georg-August-University Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany — ²I. Physikalisches Institut, Georg-August-University Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany — ³Fachbereich Physik, Philipps-University Marburg, Marburg, Germany — ⁴Institute for Theoretical Physics and Bremen Center for Computational Materials Science, University of Bremen, 28359 Bremen, Germany — ⁵Laboratory for Materials Simulations, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland

We compare two complementary theoretical approaches to compute and interpret Floquet sidebands in periodically driven quantum ma-

terials: a first-order perturbative approach (PB1) and time-dependent nonequilibrium Green's functions (tdNEGF). Using graphene as a model Dirac system, we disentangle in pump-probe setups Floquet-dressed initial states, Volkov-dressed final states (also known as laser-assisted photoelectric effect, LAPE), and their interference. We quantify how photoemission matrix elements, polarization, incidence angle, and near-surface screening shape the momentum-resolved sideband intensity observed in tr-ARPES.

TT 44.10 Wed 12:00 CHE/0091

Towards Floquet-GW: interacting electrons in time-periodic potentials — ●AYAN PAL^{1,2}, ERIK G C P VAN LOON^{1,2}, and FERDI ARYASETIAWAN^{1,3} — ¹Division of Mathematical Physics, Lund University, Professorgatan 1, 223 63, Lund, Sweden — ²NanoLund, Lund University, Professorgatan 1, 223 63, Lund, Sweden — ³LINXS Institute of advanced Neutron and X-ray Science, Lund, Sweden

The Floquet theory of time-periodic systems provides a middle ground between equilibrium and far-from-equilibrium physics, making it ideal for studying non-equilibrium steady states. We employ this framework to interacting electrons exposed to spatially and time-periodic potentials by combining Floquet theory with RPA and GW. This is applied to both the homogeneous electron gas and lattice Hamiltonians, allowing us to resolve the interplay between periodic driving, electronic correlations, and collective charge excitations. We compute Floquet-induced Greens function, dielectric function, and screened interaction; and demonstrate the formation of Bloch-Floquet sidebands in the electronic spectral function and in direct and inverse photoemission spectra. The periodic modulation further induces plasmonic sidebands and generates additional Floquet-umklapp regions for the electron-hole continuum. Our analysis highlights how the structure of the travelling drive - frequency, amplitude, and momentum controls the redistribution of spectral weight and the renormalisation of collective modes. This framework provides a route for predicting the plasmonic, dielectric, and optical response properties of weakly to moderately correlated materials under periodic laser driving.

TT 44.11 Wed 12:15 CHE/0091

Emergent Floquet Fermi Surfaces from Disorder — INTI SODEMANN VILLADIEGO, AKIHIRO OZAWA, and ●FELIX FREDERKING — Institut für Theoretische Physik, Universität Leipzig, Brüderstraße 16, 04103 Leipzig, Germany

We investigate the non-equilibrium steady states of periodically driven fermions coupled to a fermionic heat bath and in the presence of disorder (i.e. random impurities). In the absence of disorder, the steady state occupation would be a "stair-case" version of the Fermi-Dirac distribution, which is smooth at finite temperatures. Remarkably, however, we have found that disorder induces non-analyticities in the occupation of states that behave as emergent Fermi surfaces. We will discuss the physical phenomena arising from these non-equilibrium emergent Fermi surfaces and make the case for the feasibility of their detection in ultra-clean 2D materials subjected to low frequency radiation.

TT 44.12 Wed 12:30 CHE/0091

Emergent Fermi surfaces from non-equilibrium heat baths: exact results from Keldysh formalism — ●AKIHIRO OZAWA and INTI SODEMANN VILLADIEGO — Institut für Theoretische Physik, Universität Leipzig, 04103, Leipzig, Germany

Recent studies have shown that periodically driven fermions coupled to a boson bath display non-analyticities in their occupation functions of momentum that behave like emergent Fermi surfaces. Remarkably, we have found that analogous non-equilibrium emergent Fermi surfaces can arise when the system is coupled to two baths at different temperatures, even without external periodic driving. The mechanism driving the formation of these non-equilibrium Fermi surfaces, is a kind of transfer from non-analyticities from the density of states into the occupation of states which is only allowed away from equilibrium, in the absence of detailed balance in the scattering rates. We demonstrate that this result is exact at weak coupling using the Keldysh formalism and propose a numerical scheme to investigate the fate of these non-analyticities at finite coupling.

TT 45: Many-body Systems: Equilibration, Chaos, and Localization (joint session DY/TT)

Time: Wednesday 9:30–12:45

Location: HÜL/S186

TT 45.1 Wed 9:30 HÜL/S186

Compression of Floquet random circuits — •FRANCESCA DE FRANCO^{1,2}, DAVID LUITZ³, DANTE KENNES⁴, MATTEO RIZZI^{1,5}, and MARKUS SCHMITT^{1,2} — ¹FZ Juelich, Institute of Quantum Control (PGI-8) — ²University of Regensburg — ³University of Bonn — ⁴RWTH Aachen University — ⁵University of Cologne

Current quantum computing hardware suffers from significant dissipation due to the coupling to the environment. This limits the depth of unitary quantum circuits which can be applied with high fidelity and hence the physical timescales reachable by digital quantum simulation. Here, we show that the reachable timescale in practice depends strongly on the physics of the many-body system under investigation: For systems deep in a many-body localized phase, we can find shallow circuit representations of the evolution operator U to late times, while in a chaotic regime this is not possible. The associated compressibility of the late time evolution operator is hence associated with the accessibility of long times on noisy quantum hardware. Moreover, we compare the performance of these compressed, variationally obtained circuits to tensor-network simulations, which allow us to compute quantum-information-spreading diagnostics such as entanglement entropy and out-of-time-ordered correlators.

TT 45.2 Wed 9:45 HÜL/S186

Spectral pairing statistics in Floquet time crystals — ALEXANDER-GEORG PENNER¹, •HARALD SCHMID^{1,2,3}, LEONID I. GLAZMAN⁴, and FELIX VON OPPEN¹ — ¹Dahlem Center for Complex Quantum and Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany — ²Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ⁴Department of Physics, Yale University, New Haven, Connecticut 06520, USA

Floquet time crystals are characterized by the subharmonic behavior of temporal correlation functions. Studying the paradigmatic time crystal based on the disordered Floquet quantum Ising model, we show that its temporal spin correlations are directly related to spectral characteristics and that this relation provides analytical expressions for the correlation function of finite chains, which compare favorably with numerical simulations. Specifically, we show that the disorder-averaged temporal spin correlations are proportional to the Fourier transform of the splitting distribution of the pairs of eigenvalues of the Floquet operator, which differ by π to exponential accuracy in the chain length. We find that the splittings are well described by a log-normal distribution, implying that the temporal spin correlations are characterized by two parameters. We discuss possible implications for the phase diagram of Floquet time crystals.

TT 45.3 Wed 10:00 HÜL/S186

Spin-Spin Correlations and Multifractality in 1D disordered $SU(2)$ -Invariant Heisenberg Spin Chains — •DEBASMITA GIRI, JULIAN SIEGL, and JOHN SCHLIEMANN — Institute for Theoretical Physics, University of Regensburg, Regensburg, Germany

Disorder and interactions in one-dimensional quantum spin chains give rise to rich non-ergodic phenomena that lie beyond the conventional eigenstate thermalization hypothesis (ETH). In the presence of sufficiently strong quenched disorder, many-body localization (MBL) can emerge: transport is frozen, entanglement growth is logarithmically slow, and local operators retain memory of their initial conditions even at infinite temperature. On the contrary, studies on models with non-Abelian symmetries have demonstrated that continuous symmetries, such as $SU(2)$, can obstruct the construction of local integrals of motion and thus hinder full localization. We investigate spin correlations in one-dimensional $SU(2)$ -invariant Heisenberg chains with exchange disorder for spin lengths $S = 1/2$ and $S = 1$. In the weak-disorder regime, the eigenmodes of the spin-spin correlation matrix are delocalized, consistent with ergodic behavior. Under strong disorder, the system enters a quasi-localized multifractal phase characterized by exponentially decaying, dimer-like spin correlations. Finite-size scaling of the inverse participation ratios of the correlation-matrix eigenmodes yields a correlation dimension, $D_2 \approx 0.37 - 0.39$, confirming the presence of a multifractal regime that is distinct from both the ergodic limit ($D_2 = 1$) and the fully localized limit ($D_2 = 0$).

TT 45.4 Wed 10:15 HÜL/S186

Timescales for Deep and Full Thermalization — •TABEA HERRMANN¹, FELIX FRITZSCH², and ARND BÄCKER¹ — ¹TU Dresden, Institut für Theoretische Physik, Dresden, Germany — ²Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Isolated quantum systems typically approach thermal equilibrium as described by the Eigenstate Thermalization Hypothesis (ETH). Going beyond this involves either higher order correlators (full ETH) or the approach of moments of the reduced density matrix towards thermal equilibrium (deep thermalization). In this talk we compare these two types of thermalization using extensive numerical studies within a paradigmatic model for chaotic many-body quantum dynamics. For this we find exponential relaxation for both types: For deep thermalization all moments relax with the same rate, which approximately equals the relaxation rate of two-point correlation functions within full ETH. In contrast, all higher order correlation functions approach equilibrium twice as fast.

TT 45.5 Wed 10:30 HÜL/S186

Free Cumulants and Full Eigenstate Thermalization from Boundary Scrambling — •FELIX FRITZSCH, GABRIEL O. ALVES, MICHAEL A. RAMPP, and PIETER W. CLAEYS — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Out-of-time-order correlation functions (OTOCs) represent important probes of quantum information dynamics and scrambling. We introduce a solvable many-body quantum circuit model, which we term boundary scrambling, for which the full dynamics of OTOCs is analytically tractable. These dynamics support a decomposition into free cumulants and unify recent extensions of the eigenstate thermalization hypothesis (full ETH) with predictions from random quantum circuit models. We moreover obtain exact expressions for higher-order correlations between matrix elements as predicted by the full ETH. The solvability is enabled by the identification of a higher-order Markovian influence matrix, capturing the effect of the full system on a local subsystem.

TT 45.6 Wed 10:45 HÜL/S186

Mechanism of Eigenstate Thermalization Breakdown — •RAFAŁ ŚWIETEK^{1,2,3} and LEV VIDMAR^{2,3} — ¹Institut für Theoretische Physik, Georg-August-Universität Göttingen, D-37077 Göttingen, Germany — ²Department of Theoretical Physics, J. Stefan Institute, SI-1000 Ljubljana, Slovenia — ³Department of Physics, Faculty of Mathematics and Physics, University of Ljubljana, SI-1000 Ljubljana, Slovenia

Establishing a common framework for ergodicity-breaking transitions has many potential applications and provides insight into the nature of non-ergodic phases. In this work, we show that the softening of fluctuations within the recently established fading ergodicity framework can be derived directly from the emergence of the Fermi Golden Rule (FGR), ultimately classifying fading ergodicity as manifestation of FGR physics in quantum many-body systems. We show that this framework identifies the width of the local density of states and the fractal nature of eigenstates in the unperturbed basis as building blocks for fading ergodicity. Furthermore, we argue that our theory can be also applied to integrability-breaking transitions, where the critical point drifts exponentially with system size to a singular point, providing a common framework for ergodicity breaking in RMT models and integrability-breaking in local Hamiltonians.

15 min. break

TT 45.7 Wed 11:15 HÜL/S186

Entanglement in bipartite systems with symmetry: coupled chaotic kicked Bose-Hubbard systems — •JAN HIMMELSBACH¹, MAXIMILIAN F.I. KIELER^{1,2}, and ARND BÄCKER¹ — ¹TU Dresden, Institut für Theoretische Physik, Dresden, Germany — ²CESAM research unit, University of Liège, B-4000 Liège, Belgium

We study the eigenstate entanglement of a time-periodically driven Bose-Hubbard system in a bipartite setting with a tunable coupling between two subsystems. By incorporating the symmetry of the particle conservation and employing perturbation theory we find that the entanglement transition for varying coupling strength is described by

a universal transition parameter. It turns out that the entanglement transition is governed by localization for the particle conservation symmetry and a thermalizing process between the subsystems.

TT 45.8 Wed 11:30 HÜL/S186

Dynamical Pictures for Growth of Entanglement and Decay of Correlators in $U(1)$ Conserving Random Circuits — ●MARCO LASTRES^{1,2}, OLEXEI I. MOTRUNICH³, and SANJAY MOUDGALYA^{1,2} — ¹Technical University of Munich, School of Natural Sciences, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ³Department of Physics, Caltech, Pasadena, CA, USA

We study the dynamics of random circuit models with a global $U(1)$ charge conservation law. Prior work showed that systems without conservation laws exhibit linear growth of entanglement, linked to domain wall dynamics in an effective ferromagnetic model. In contrast, rigorous upper bounds for $U(1)$ -conserving systems indicate that diffusive charge transport constrains Rényi entropies to grow only diffusively as \sqrt{t} . We study the second Rényi entropy in $U(1)$ -conserving random circuits by mapping its dynamics onto the low-energy physics of an effective interacting Hamiltonian. This approach explicitly demonstrates the microscopic mechanism which produces diffusive growth of entanglement in the effective replica model. We also show that the same effective model naturally captures the recently discovered subexponential decay of non-hydrodynamic correlations through a closely related mechanism. Further, we demonstrate that in a different regime this model can also describe the dynamics of entanglement in noisy free-fermion systems, which also exhibit diffusive entanglement growth, but through a different mechanism. Finally, we discuss extensions to other continuous symmetries and to higher Rényi entropies.

TT 45.9 Wed 11:45 HÜL/S186

Correspondence principle, dissipation, and Ginibre ensemble — ●DAVID VILLASEÑOR, HUA YAN, MATIC OREL, and MARKO ROBNIK — CAMTP - Center for Applied Mathematics and Theoretical Physics, University of Maribor, Mladinska 3, SI-2000 Maribor, Slovenia, European Union

The correspondence between quantum and classical behavior has been essential since the advent of quantum mechanics. This principle serves as a cornerstone for understanding quantum chaos, which has garnered increased attention due to its strong impact in various theoretical and experimental fields. When dissipation is considered, quantum chaos takes concepts from isolated quantum chaos to link classical chaotic motion with spectral correlations of Ginibre ensembles. This correspondence was first identified in periodically kicked systems with damping, but it has been shown to break down in dissipative atom-photon systems [Phys. Rev. Lett. 133, 240404 (2024)]. In this contribution, we revisit the original kicked model and perform a systematic exploration across a broad parameter space, reaching a genuine semiclassical limit. Our results demonstrate that the correspondence principle, as defined through this spectral connection, fails even in this prototypical system. These findings provide conclusive evidence that Ginibre spectral correlations are neither a robust nor a universal diagnostic of dissipative quantum chaos.

TT 45.10 Wed 12:00 HÜL/S186

Quantum Mpemba effect from Stark localization — ●NICO ALBERT¹, MASUDUL HAQUE¹, and SHOVAN DUTTA² — ¹TU Dresden,

Dresden, Germany — ²Raman Research Institute, Bangalore, India

In the Mpemba effect a system prepared at a higher temperature cools down faster to a target equilibrium state than the same system prepared at a lower temperature. We investigate how quantum effects can influence the occurrence of such an effect. As an example we consider a bosonic chain subject to a suitable onsite potential that is dissipatively cooled to its ground state, and find that Stark localization significantly enhances the Mpemba effect compared to analogous classical systems.

TT 45.11 Wed 12:15 HÜL/S186

Robustness of interference-caged QMBS under real-space local perturbations: analysis through the Fock-space local interference pattern — ●TAO-LIN TAN¹ and YI-PING HUANG^{1,2,3} — ¹Department of Physics, National Tsing Hua University, Hsinchu 30013, Taiwan — ²Physics Division, National Center for Theoretical Sciences, Taipei 10617, Taiwan — ³Institute of Physics, Academia Sinica, Taipei 115, Taiwan

Quantum many-body scars (QMBS) represent a notable violation of the eigenstate thermalization hypothesis (ETH), hosting non-thermal eigenstates embedded in an otherwise thermal spectrum. Despite recent progress, a systematic understanding of their stability under real-space local (r-local) perturbations remains lacking. Building on recent insights of interference-caged quantum many-body scars (ICQMBS), protected by exact many-body destructive interference on Fock-space graphs, we develop an interference-based diagnostic to assess the robustness of ICQMBS in various lattice Hamiltonians. Applying this framework to quantum link models (QLM) and quantum dimer models (QDM), we analyze how r-local perturbations deform the underlying Fock-space local (f-local) interference structure, thereby identifying heuristic mechanisms that stabilize or destabilize ICQMBS. Our results broaden the applicability of the interference-based perspective beyond previously studied models and provide practical criteria for evaluating the persistence of ICQMBS in experimentally relevant Hamiltonians.

TT 45.12 Wed 12:30 HÜL/S186

Scrambling and Scarring in Topological Materials — ●NICHOLAS SEDLMAYR, DOMINIK SZPARA, and SZCZEPAN GŁODZIK — Institute of Physics, M. Curie-Skłodowska University, 20-031 Lublin, Poland

Topological insulators and superconductors have recently attracted considerable attention, and many different theoretical tools have been used to gain insight into their properties. Here we investigate how perturbations can spread through exemplary one-dimensional topological insulators and superconductors using out-of-time ordered correlators. Out-of-time ordered correlators are often used to consider how information becomes scrambled during quantum dynamics. The wavefront of the out-of-time ordered correlator can be ballistic regardless of the underlying system dynamics, and here we confirm that for topological free fermion systems the wavefront spreads linearly at a characteristic butterfly velocity. We pay special attention to the topologically protected edge states, finding that information can become trapped in the edge states and essentially decoupled from the bulk, surviving for relatively long times - a form of scarring. We further investigate what happens due to the chiral and helical edge modes of two dimensional topological models. The information travels around the edge, carried by the edge mode, but again is not scrambled over very long time scales.

TT 46: Spin Transport and Orbitronics, Spin-Hall Effects I (joint session MA/TT)

Time: Wednesday 9:30–12:45

Location: POT/0112

Invited Talk

TT 46.1 Wed 9:30 POT/0112

Exploring the interplay between spin and chirality — ●ANGELA WITTMANN — Johannes Gutenberg University Mainz, Germany

Chirality is omnipresent in nature, bridging magnetic and molecular spin phenomena. At the core of this connection lies the chiral-induced spin selectivity (CISS) effect, describing the highly efficient generation of spin polarized currents in chiral molecules. Despite extensive experimental evidence, the underlying mechanisms of CISS remain debated. Here, we explore how chirality is directly linked to the intrinsic magnetic moments in molecules and how molecular design can be harnessed to control spin phenomena at hybrid chiral molecule magnetic interfaces [1]. Our findings pave a pathway towards functional "chiralitronic" devices - turning a fundamental puzzle into a technological opportunity.

[1] A. Moharana, AW et al., Sci. Adv.11, eado4285 (2025)

TT 46.2 Wed 10:00 POT/0112

Chiral Molecule-Induced Magnetic Anisotropies — ●SIMON SOCHIERA¹, ASHISH MOHARANA¹, Yael KAPON², FABIAN KAMMERBAUER¹, SHIRA YOCHELIS², MATHIAS KLÄUI¹, YOSSEI PALTIEL², and ANGELA WITTMANN¹ — ¹Johannes Gutenberg University, Mainz, Germany — ²Hebrew University of Jerusalem, Jerusalem, Israel

The chiral-induced spin selectivity effect promises novel spintronic devices. Despite numerous interdisciplinary experiments revealing its implications and trends, this phenomenon challenges our theoretical understanding of the interplay between spin and chirality, particularly regarding apparent time-reversal symmetry breaking. This symmetry breaking can be observed by measuring a magnetic thin film's anisotropy upon chiral-molecule adsorption. We quantify this phenomenon by measuring the magnetic anisotropy through electrical magnetotransport measurements. Upon chiral-molecule adsorption, we observe a 35% change in out-of-plane hard-axis anisotropy. This approach enables sensitive probing of magnetic property changes induced by different chiral molecular systems on various conductive or insulating magnetic thin films. Correlating molecular properties, such as spin-orbit coupling, with their impact on magnetic anisotropy will be crucial for understanding the fundamental mechanisms of chiral-induced spin selectivity and for facilitating the design of spintronic devices that require a precisely tuned anisotropy.

TT 46.3 Wed 10:15 POT/0112

Generation, Transmission, and Conversion of Orbital Torque by an Antiferromagnetic Insulator — ●SHILEI DING^{1,2}, PAUL NOËL², GUNASHEEL KAUWTILYAA KRISHNASWAMY², NICCOLÒ DAVITTI², GIACOMO SALA², MARZIA FANTAUZZI³, ANTONELLA ROSSI^{2,3}, and PIETRO GAMBARELLA² — ¹School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371, Singapore — ²Department of Materials, ETH Zürich, 8093 Zürich, Switzerland — ³Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Cagliari, Campus di Monserrato S.S. 554, Italy

Orbital currents and orbital torques have recently emerged as powerful tools for controlling magnetization, yet their transport has been studied almost exclusively in metals. We report the first demonstration of orbital generation, transport, and conversion through an insulating antiferromagnet CoO. By inserting CoO between Cu* and Co, we show that orbital transport is preserved and the orbital-torque efficiency is strongly enhanced. Temperature-dependent measurements indicate that orbital transport above the Néel temperature is mediated by thermal fluctuations, while antiferromagnetic order and exchange bias provide additional transport channels at low temperature. These results identify insulating antiferromagnets as effective mediators of orbital angular momentum and highlight transition-metal oxides with unquenched orbital moments as promising materials for efficient spin-orbitronic technologies.

TT 46.4 Wed 10:30 POT/0112

Modern theory of the Orbital Hall effect from Wannier Representation — ●MIRCO SASTGES^{1,2}, INSU BAEK³, HOJUN LEE³, HYUN-WOO LEE³, YURIY MOKROUSOV^{1,2}, and DONGWOOK GO⁴ — ¹Peter Grünberg Institut and Institute for Advanced Simula-

tion, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — ²Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany — ³Department of Physics, Pohang University of Science and Technology, Pohang, Kyungbuk 37673, South Korea — ⁴Department of Physics, Korea University, Seoul 02841, South Korea

In the field of orbital dynamics and orbital transport a particularly important quantity is the so-called orbital Hall conductivity (OHC), which is expressed in terms of operators of velocity and orbital angular momentum (OAM). To overcome the difficulties in treating the unbounded position operator, very often the so-called atom-centered approximation (ACA) is used. However, while being very practical, this approach captures only some local contributions to the OAM operator. Here, we will report on developing a new approach to quantify the OAM operator in the basis of Wannier functions, which is based on the modern theory of orbital magnetization. This method allows us to capture both local and itinerant contributions to the OHC. By performing first principles calculations for selected transition metals we show that a significant correction to the OHC due to non-local contributions arises, while the local effects are captured in accordance to the ACA. Our approach is very promising since it improves our understanding of OAM and allows for a precise estimation of the OHC.

TT 46.5 Wed 10:45 POT/0112

Chirality-induced orbital Edelstein effect in an analytically solvable model — ●LENNART SCHIMPF, BÖRGE GÖBEL, and INGRID MERTIG — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg

Chirality-induced spin selectivity (CISS), a phenomenon wherein chiral structures selectively determine the spin polarization of electron currents flowing through the material, has garnered significant attention due to its potential applications in areas such as spintronics, enantioseparation, and catalysis. The underlying physical effect is the Edelstein effect that converts charge to angular momentum. Besides a spin contribution, there exists a contribution based on the orbital angular momentum but the precise mechanism for its generation remains yet to be understood. Here, we introduce the minimal model for explaining the phenomenon based on the orbital Edelstein effect [1]. We consider nonlocal intersite contributions to the current-induced orbital angular momentum and reveal the underlying mechanism by analytically calculating the Edelstein susceptibilities in a tight-binding and Boltzmann approach. While the orbital angular momentum is directly generated by the chirality of the crystal, the spin contribution of each spin-split band pair relies on spin-orbit coupling. Using tellurium as an example, we show that the orbital contribution surpasses the spin contribution by orders of magnitude.

[1] B.Göbel, L. Schimpf, I. Mertig, Phys. Rev. Res. 7, 033180 (2025)

15 min break

TT 46.6 Wed 11:15 POT/0112

Spin-charge and Orbital-charge Interconversion on SrTiO₃-based Two-dimensional Electron Gases: A Semiclassical Approach — ●LE VIET DUC PHAM and ANNKA JOHANSSON — Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle (Saale), Germany

Two-dimensional electron gases (2DEGs) at SrTiO₃-based oxide interfaces display large, gate-tunable Rashba-like spin-orbit coupling (SOC) that enables spin-charge interconversion via the spin Edelstein effect [1, 2]. It has also been demonstrated that the orbital Edelstein effect, i.e., current-induced orbital magnetization, is larger than the spin Edelstein effect by more than one order of magnitude [3]. Yet, most transport studies assume a constant relaxation time [1, 3], potentially underestimating the role of anisotropic relaxation times and scattering-in contributions. Here, we systematically study charge-spin and charge-orbital conversion in SrTiO₃-based 2DEGs, combining the Boltzmann semiclassical transport theory and various ansatzes for the scattering terms, such as constant relaxation time, momentum relaxation time, as well as scattering on various impurity potentials. Comparing different scattering approaches, we gain insights into the influence of impurity scattering on charge-spin and charge-orbital interconversion phenomena.

[1] Vaz, Diogo C., et al. Nature Materials 18.11 (2019): 1187-1193.

[2] Caviglia, A. D., et al. Physical Review Letters 104.12 (2010): 126803. [3] Johansson, Annika, et al. Physical Review Research 3.1 (2021): 013275.

TT 46.7 Wed 11:30 POT/0112

Quantum geometry for orbital magnetization and spintronics from parallel transport of Bloch states — ●JOHANNES MITSCHERLING, JAN PRIESSNITZ, and LIBOR ŠMEJKAL — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany

Quantum geometry emerges as a unifying, quantitative guiding principle for the linear and nonlinear response functions of quantum matter. Going beyond current-current responses [1,2], we identify the generator of parallel transport of Bloch states, given by the commutator of the band projector and its momentum derivative, as a further essential building block of quantum geometry [3]. I will show that orbital magnetism arises from the non-commutativity of adiabatic transport in orthogonal directions. We will see that the spin Berry curvature and the spin quantum metric, which control the linear spin conductivity, are not fundamentally geometric but yield three geometric contributions of distinct physical origin. Our theory enables efficient numerical and analytical evaluations for general Bloch Hamiltonians with an arbitrary number of potentially degenerate bands. I will exemplify the results in application to altermagnets [4] and p-wave magnets [5].

[1] Avdoshkin*, Mitscherling*, and Moore, PRL 135, 066901 (2025). [2] Mitscherling*, Avdoshkin*, and Moore, PRB 112, 085104 (2025). [3] Mitscherling and Šmejkal, to be submitted. [4] Šmejkal, Sinova, and T. Jungwirth, PRX 12, 031042 (2022). [5] Birk Hellenes, Jungwirth, Jaeschke-Ubiergo, Chakraborty, Sinova, and Šmejkal, arXiv:2309.01607v3.

TT 46.8 Wed 11:45 POT/0112

Signatures of magnon dispersion in spin transport — ●SEBASTIAN SAILLER, DENISE REUSTLEN, MICHAELA LAMMEL, SEBASTIAN T. B. GOENNENWEIN, and RICHARD SCHLITZ — Department of Physics, University of Konstanz, 78457 Konstanz, Germany

The spin Hall magnetoresistance (SMR) provides electrical access to the magnetization of a magnetically ordered material. It recently became clear that changes in the net magnetization due to magnon creation and annihilation can be observed in the SMR. However, the number of magnons - and thus the magnetization - can also be modified by changing the energy of the system. In this work, we experimentally demonstrate that the changes of magnon occupation due to magnetic fields and crystal orientation sensitively modify the SMR response. Higher magnetic fields reduce the magnon population by pushing the magnon manifold to higher energies, leading to an increase of magnetization and thus the SMR. In turn, the influence of the anisotropic magnon gap in yttrium iron garnet films leads to a crystal orientation dependence of the SMR. The magnetic field and orientation dependence can be rationalized in terms of the changing magnon occupation. Our results showcase that magnetoresistive effects not only probe the properties of the static magnetization, but also reveal information about the dynamics, i.e., the magnons.

TT 46.9 Wed 12:00 POT/0112

Non-reciprocal spin-orbital-charge interconversion via magnon transport in nonlocal devices — ●JOSE OMAR LEDESMA-MARTIN¹, SACHIN KRISHNIA¹, EDGAR GALINDEZ-RUALES¹, DUC TRAN¹, MARCEL GASSER¹, DONGWOOK GO^{1,2}, GERHARD JAKOB¹, YURIY MOKROUSOV^{1,2}, and MATHIAS KLÄUI¹ — ¹Institute of Physics, Johannes Gutenberg University Mainz, Mainz, Germany — ²Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, Jülich, Germany

In magnetic systems, angular momentum is carried by electrons' spin and orbital angular momentum. We use devices based on Pt nanowires on insulating magnets to study angular-momentum transport mediated by magnons, enabling angular-momentum information to prop-

agate without charge flow. In these systems, magnons are generated by spin accumulation from the Spin Hall Effect (SHE) and detected via the inverse Spin Hall Effect (iSHE). In conventional Pt-YIG non-local geometries, this spin-charge interconversion is fully reciprocal: interchanging the injector and detector yields equal efficiencies. We further confirm that this power-to-power efficiency remains reciprocal when the thickness of one Pt wire is varied. However, when Ru is used as a source and detector of orbital currents via the orbital Hall effect (OHE) and inverse OHE, the reciprocity is broken. In our devices, the combined SHE + OHE-driven magnon generation, followed by detection through the iSHE, becomes ~35% more efficient than the reverse process, demonstrating nonreciprocity in the system. (1)

(1) J.O. Ledesma-Martin, Nano Lett. 2025, 25, 8, 3247-3252

TT 46.10 Wed 12:15 POT/0112

Giant orbital magnetoresistance in orbital magnets — ●SACHIN KRISHNIA¹, CHRISTIN SCHMITT¹, EDGAR GALINDEZ RUALES¹, TAKASHI KIKKAWA², TIMO KUSCHEL¹, EIJI SAITOH², OLENA GOMONAY¹, YURIY MOKROUSOV¹, and MATHIAS KLÄUI¹ — ¹Institute of Physics, Johannes Gutenberg-University Mainz, Mainz, Germany — ²Department of Applied Physics, The University of Tokyo, Tokyo, Japan

Generation and transport of large orbital angular momentum (OAM) currents have recently emerged as a key research area in the field of orbitronics. In contrast to spin currents, whose generation depends on weak spin-orbit coupling, OAM currents arise directly from the coupling between crystal momentum and electronic OAM even in light and environmentally friendly materials (Cu, Al, Cr)[1]. A major challenge has been to exploit these giant orbital currents in magnetic systems, where static magnetization is dominated by spin. We show that this limitation can be overcome by employing magnetic materials in which OAM contributes significantly to the static magnetization. Using these orbital magnets, we demonstrate two orders of enhancement of orbital Hall magnetoresistance, compared to the spin counterpart. This enhancement originates from the interaction of the dynamic OAM generated in light metals with the static orbital moments of the orbital magnet. Our results establish a pathway to harness giant OAM currents for device functionalities that cannot be achieved with conventional spin-dominated magnets[2]. [1] S. Ding et al, PRL 125, 177201 (2020). [2] C. Schmitt, S. Krishna et al. (under review).

TT 46.11 Wed 12:30 POT/0112

Spin-Current Sensitivity in CuSeO₃ Across the Antiferromagnetic Transition — ●ANKITA NAYAK¹, MATHEW JAMES¹, MAXIM MOSTOVOY², and AISHA AQEEL¹ — ¹University of Augsburg, 86135 Augsburg, Germany — ²Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands

Antiferromagnets are promising materials for next-generation spintronics due to their robustness against magnetic fields and ultrafast dynamics. Spin Hall magnetoresistance (SMR) provides a sensitive method to probe spin transport at normal-metal-antiferromagnetic-insulator interfaces. In antiferromagnets, SMR can detect Néel-vector reorientation, spin-flop behaviour, and short-range correlations above the ordering temperature, as shown in systems such as NiO and α -Fe₂O₃.

Here, we use SMR in a Pt/CuSeO₃ bilayer to investigate spin transport in the unconventional antiferromagnet CuSeO₃. An AC current in the Pt Hall bar generates a transverse spin accumulation, whose interface reflection modulates the Pt resistance and enables electrical detection of the magnetic state.

CuSeO₃ consists of Cu(1) spin dimers and Cu(2) spins that order antiferromagnetically below 8 K. SMR measurements between 5 and 100 K with magnetic-field rotation in three planes reveal clear SMR signals, including a finite response above the Néel temperature, indicating persistent spin correlations. The plane-dependent SMR amplitude also reflects the intrinsic magnetic anisotropy of CuSeO₃.

TT 47: Frustrated Magnets II (joint session MA/TT)

Time: Wednesday 9:30–12:45

Location: POT/0361

TT 47.1 Wed 9:30 POT/0361

Finite-size spectral signatures of order by quantum disorder: A perspective from Anderson's tower of states — ●SUBHANKAR KHATUA¹, GRIFFIN C. HOWSON², MICHEL J. P. GINGRAS², and JEFFREY G. RAU³ — ¹IFW Dresden, Germany — ²University of Waterloo, Canada — ³University of Windsor, Canada

In frustrated magnetic systems with a subextensive number of classical ground states, quantum zero-point fluctuations can select a unique long-range ordered state, a celebrated phenomenon referred to as order by quantum disorder (ObQD). While ObQD is well understood in the semiclassical, large spin length limit, its behavior in quantum spin-1/2 systems is less clear. As exact analytical solutions are scarce for frustrated systems, numerical approaches are essential. We show that ObQD can be identified from exact diagonalization (ED) calculations through an analysis akin to the Anderson tower of states associated with spontaneous symmetry breaking. By defining an effective quantum rotor model, we describe the competition between ObQD-induced localization of the rotor and its tunneling between symmetry-related ground states, identifying the crossover lengthscale from the finite-size regime where the rotor is delocalized, to the infinite system-size limit where it becomes localized. This rotor model relates the characteristic splittings in the ED energy spectrum to the ObQD selection energy scale, providing an estimate that can be compared to spin wave calculations. We demonstrate the general applicability of this approach in one-, two- and three-dimensional frustrated spin models that exhibit ObQD.

TT 47.2 Wed 9:45 POT/0361

Magnetic resonance experiments on the quantum spin liquid candidate YbCuSe₂ — MADHURIMA BISWAS¹, ●MARLIS SCHULLER³, KHOKAN BHATTACHARYA¹, YOSHIFUMI TOKIWA², MAMOUN HEMMIDA³, HANS-ALBRECHT KRUG VON NIDDA³, NORBERT BÜTTGEN³, ISTVÁN KÉZSMÁRKI³, and MAYUKH MAJUMDER¹ — ¹Department of Physics, Shiv Nadar Institution of Eminence, IN — ²Advanced Science Research Center, Japan Atomic Energy Agency, JPN — ³EPV, Institut of Physics, University of Augsburg, DE

Frustrated magnetism in triangular-lattice delafossites offers a fertile route to realising quantum spin liquids (QSL) beyond conventional ordered phases. Among these materials a new candidate, YbCuSe₂, stands out as a QSL candidate from the present study. Magnetisation and ESR measurements on high-quality single crystals of YbCuSe₂ reveal easy-plane anisotropy. Furthermore, heat-capacity measurements down to 400 mK and μ SR measurements down to 30 mK show no signatures of long-range magnetic ordering, establishing this compound as a promising QSL candidate. To probe the low-energy spin dynamics, we performed ⁶³Cu ($I = 3/2$) NMR measurements down to 20 mK. We document in-plane and out-of-plane spin-lattice relaxation T_1 as a function of temperature in an applied field of approximately 4 T. A dynamical phase separation was observed below 0.7 K, where one phase corresponds to the disorder-induced state, whereas the temperature evolution of the relaxation rate of the other phase exhibits a power-law divergence indicative of some quantum-critical spin fluctuations due to the proximity to a field-induced ordered state.

TT 47.3 Wed 10:00 POT/0361

Fluctuation driven phases in the triangular lattice — ●P. PETER STAVROPOULOS¹, ROSER VALENTÍ¹, and JOHANNES KNOLLE² — ¹Goethe University, Frankfurt, Germany — ²Technical University of Munich, Garching, Germany

The triangular lattice has proven to be a model platform of frustrated magnetism, with a rich landscape of emergent phases. It is also an experimentally accessible platform, with many family of materials showing quasi-2D triangular arrangements of magnetic ions. Motivated by this, we revisit magnetic exchange models on the triangular lattice. We discuss phases that are stabilized by order by disorder mechanisms, and comment on their observable signatures.

TT 47.4 Wed 10:15 POT/0361

Frustrated spin-1/2 chains in a correlated metal Ti₄MnBi₂ — ●XIYANG LI and MENG LYU — No.8, 3rd South Street, Zhongguancun, Haidian District, Beijing, China, 100190

Electronic correlations lead to heavy quasiparticles in three-

dimensional(3D) metals, and their collapse can destabilize magnetic moments. It is an open question whether there is an analogous instability in one-dimensional (1D) systems, unanswered due to the lack of metallic spin chain materials. We report neutron scattering measurements and density matrix renormalization group calculations establishing spinons in the correlated metal Ti₄MnBi₂, confirming that its magnetism is 1D. Ti₄MnBi₂ is inherently frustrated, forming near a quantum critical point that separates different phases at temperature $T = 0$. One-dimensional magnetism dominates at the lowest T , and is barely affected by weak interchain coupling. Ti₄MnBi₂ is a previously unrecognized metallic spin chain in which 3D conduction electrons become strongly correlated due to their coupling to 1D magnetic moments.

TT 47.5 Wed 10:30 POT/0361

Low-temperature spin-freezing in frustrated zirconates Tb₂Zr_{2-x}Ti_xO₇ — ●FREDERIK LEON CARSTENS¹, SUJATA SINGH², C. S. YADAV², and RÜDIGER KLINGELER¹ — ¹Kirchhoff Institute for Physics, Heidelberg University, Germany — ²School of Physical Sciences, IIT Mandi, India

We report on magnetic studies of polycrystalline Tb₂Zr_{1-x}Ti_xO₇ ($x = 0, 0.5$). The zirconates possess significant cationic disorder due to similar radii of the cations which introduces magnetic frustration. The materials are investigated by means of low-temperature ac and dc magnetization measurements in magnetic fields up to 7 T and down to 400 mK. Long-range magnetic order is not found down to $T = 400$ mK. However, in small magnetic fields, we observe a low-temperature spin-frozen state below $T = 1.4$ K and a slow spin relaxation regime which is significantly enhanced in static magnetic fields, e.g. to 15 K at $B = 2$ T. A similar behavior has been previously reported for the related rare-earth zirconate Ho₂Zr₂O₇ and in the hafnate Tb₂Hf₂O₇ [1,2].

[1] A. Elghandour et al., Phys. Rev. B **110**, 064408 (2024)[2] V. K. Anand et al., Phys. Rev. B **97**, 094402 (2018)

TT 47.6 Wed 10:45 POT/0361

Magnetization plateaus, spin-canted orders and field-induced transitions in a spin-1/2 Heisenberg antiferromagnet on a distorted diamond-decorated honeycomb lattice — ●KATARINA KARLOVA and JOZEF STRECKA — Pavol Jozef Safarik University in Kosice, Slovakia

We investigate the spin-1/2 Heisenberg antiferromagnet on a distorted diamond-decorated honeycomb lattice in an external magnetic field. Using density-matrix renormalization group, sign-problem-free quantum Monte Carlo, exact diagonalization, and an effective lattice-gas approach based on localized-magnon physics, we determine the ground-state phase diagram and analyze the finite-temperature magnetization process.

The model hosts a rich variety of frustration-induced quantum phases, including Lieb-Mattis ferrimagnetic states, spin-canted regimes, monomer-dimer and dimer-tetramer phases, and dimensional-crossover states with 0D or 1D character. Depending on the lattice distortion, we identify robust magnetization plateaus at 0, 1/4, 1/2, and 3/4 of the saturation value, originating from competing local singlet clusters, composite spins, and flat-band localized magnons. Finite-temperature QMC data show how thermal fluctuations progressively smear the plateau structure, while the effective lattice-gas description reliably captures the corresponding low-temperature trends.

Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00403.

15 min break

TT 47.7 Wed 11:15 POT/0361

Effect of Ca-doping on the exotic quantum spin liquid states of Y₃Cu₂Sb₃O₁₄ — ●MUHAMMAD USAMA AKBAR¹, HANS-ALBRECHT KRUG VON NIDDA¹, MAMOUN HEMMIDA¹, AVINASH MAHAJAN², and SAIKAT NANDI² — ¹Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, D-86135 Augsburg, Germany — ²Department of Physics, Indian Institute of Technology, Mumbai, 400076, India

The three-dimensional spin $S = 1/2$ compound Y₃Cu₂Sb₃O₁₄ was re-

cently identified as a promising candidate for novel quantum spin liquid (QSL) behavior, with two inequivalent Cu^{2+} sites in edge-sharing triangles and no long-range order observed in multiple experiments [1]. NMR detects a transition near 120 K, associated with partial singlet formation, while μSR and DFT indicate frustrated antiferromagnetic interactions around both Cu^{2+} sites. ESR shows a Lorentzian line ($g = 2.16$) above 120 K that splits into two components on cooling, with only a part of spins being ESR-active. In the current work, we extend this investigation to Ca-doped $\text{Y}_{1-x}\text{Ca}_x\text{Cu}_2\text{Sb}_3\text{O}_{14}$ ($x = 0.05, 0.10, 0.25$), to examine how chemical substitution at the Y site influences the spin dynamics of the compound.

[1] S. Nandi et al. (2025), arXiv:2509.15835 [cond- mat.str-el]

TT 47.8 Wed 11:30 POT/0361

Synthesis and H - T phase diagram of $\text{Cu}_2(\text{OH})_3\text{HCOO}$ — •ISSEI NIWATA^{1,2}, KAUSHICK K. PARUI¹, MAXIM AVDEEV³, ANTON A. KULBAKOV¹, DMYTRO S. INOSOV¹, and DARREN C. PEETS¹ — ¹TU Dresden, Dresden, Germany — ²Hokkaido University, Sapporo, Japan — ³ANSTO, Sydney, Australia

$\text{Cu}_2(\text{OH})_3X$ (X = monovalent anion) consists of quasi one-dimensional (1D) ferromagnetic (FM) and antiferromagnetic (AFM) chains which alternate to form two-dimensional triangular layers, which are stacked along the c axis. As the interchain interactions are frustrated and interlayer interactions are weak, the system can be regarded as weakly coupled 1D FM and AFM chains. In bulk measurements, these compounds typically show AFM behavior with a Néel temperature (T_N) below 10 K. Because of the coexistence of FM and AFM chains, exotic magnetic excitations are expected. As a matter of fact, for $X = \text{Br}^-$, inelastic neutron scattering revealed magnon excitations and a gapped spinon continuum in the same energy range. In addition, for $X = \text{NO}_3^-$, the realization of a Tomonaga-Luttinger-liquid state in the AFM chain was suggested in magnetic fields around 20 T, where the magnetization shows a half saturation indicating full polarization of the FM chains. Recently, we grew single crystals of the $X = \text{HCOO}^-$ compound. Magnetization measurements showed $T_N = 5.4$ K and a half saturation below 5 T, much lower than $X = \text{NO}_3^-$. This suggests that we can explore the excitation structure in relatively low magnetic fields. I will discuss the phase diagram obtained by physical properties measurements.

TT 47.9 Wed 11:45 POT/0361

H - T Phase Diagram of the Frustrated Quantum Magnet Antlerite, $\text{Cu}_3\text{SO}_4(\text{OH})_4$ — •DARREN C. PEETS¹, NIKOLAI S. PAVLOVSKI¹, ROMAN GUMENIUK², SERGEY GRANOVSKY¹, and DMYTRO S. INOSOV¹ — ¹IFMP, TU Dresden, Germany — ²IEP, TU Bergakademie Freiberg, Germany

The magnetic copper sites in antlerite, $\text{Cu}_3\text{SO}_4(\text{OH})_4$, are arranged in three-leg triangular-lattice ladders, a unique magnetic lattice. In the ground state, the outer legs are ferromagnetic and antialigned, while the central leg is antiferromagnetic. This material has four distinct magnetic states in zero field alone, and we show that the phase diagram in applied fields is also remarkably rich.

TT 47.10 Wed 12:00 POT/0361

Magnetic structure of a geometrically frustrated $\text{Mn}_3\text{V}_2\text{Ge}_3\text{O}_{12}$ garnet oxide — •SAGAR MAL KUMAWAT¹, TSAI-LING LIU¹, CHIN-WEI WANG², JIA-XIANG HSU^{1,3}, EN-PEI LIU³, WEI-TIN CHEN^{3,4,5}, and CHIEN-LUNG HUANG¹ — ¹Department of Physics and Center for Quantum Frontiers of Research & Technology (QFort), National Cheng Kung University, Tainan 701, Taiwan — ²National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan — ³Center for Condensed Matter Sciences, National Taiwan University, Taipei 10617, Taiwan — ⁴Center of Atomic Initiative for New Materials, National Taiwan University, Taipei 10617, Taiwan — ⁵Taiwan Consortium of Emergent Crystalline Materials, National Science and Technology Council, Taipei 10622, Taiwan

We investigated the low-temperature magnetic structure and thermodynamic properties of $\text{Mn}_3\text{V}_2\text{Ge}_3\text{O}_{12}$ (MVGO) using neutron diffraction, magnetic, and heat capacity measurements. MVGO crystallizes in a cubic Ia-3d structure with a minor MnV_2O_4 impurity. Two successive transitions at $T_{N1} = 4$ K and $T_{N2} = 2.4$ K indicate noncollinear antiferromagnetic ordering of the frustrated V^{3+} and Mn^{2+} sublattices. Field-dependent heat capacity shows suppression of the T_{N1} anomaly and a shift of T_{N2} , consistent with magnetic frustration and spin reorientation. The total magnetic entropy reaches approximately 51 J/mol K above 20 K, accounting for $\sim 81\%$ of the theoretical entropy for the full spin system. Temperature-dependent measurements reveal noncollinear antiferromagnetic order below T_{N2} , with peak broadening up to T_{N1} indicating strong spin frustration.

TT 47.11 Wed 12:15 POT/0361

Crystallographic and magnetic structure of Pr_2PdSi_3 : a single crystal neutron diffraction study — •MATTHIAS FRONTZEK — Neutron Scattering Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

The intermetallic compound series $R_2\text{PdSi}_3$ (R = rare earth metal) exhibits intriguing magnetic properties, including giant magnetoresistance, pronounced anisotropy in its electronic behavior, and a generic field-induced phase. The magnetic structures are complex, with large magnetic unit cells arising from the delicate interplay between competing crystal electric-field effects, magnetic exchange interactions, and geometric frustration. Recently, the discovery of a Skyrmion lattice in Gd_2PdSi_3 has renewed interest in the magnetic properties of this series.

In our contribution, we present a detailed neutron single crystal diffraction study using the WAND² diffractometer at the High-Flux Isotope Reactor (HFIR) at ORNL. In heavy rare earth members, Pd/Si ordering lowers the symmetry from hexagonal to monoclinic; in contrast, the Pr_2PdSi_3 compound adopts an orthorhombic structure with a $2 \times a, 2 \times b, 4 \times c$ unit cell relative to the primitive hexagonal cell. Magnetic order setting in at $T_N = 2.1$ K is preceded by broad diffuse scattering around the nuclear reflections, and below T_N a long-wavelength spin-density wave is observed coinciding with the short-range order evidenced by the diffuse scattering.

TT 47.12 Wed 12:30 POT/0361

Dynamical heterogeneity and fractal subdiffusive transport in spin-ice — •MALTE BIERINGER¹, GIANLUCA TEZA^{1,2}, CLAUDIO CASTELNOVO³, and RODERICH MOESSNER¹ — ¹Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — ²Department of Physics, University of Trieste, Strada Costiera 11, 34136 Trieste, Italy — ³TCM Group, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK

Spin ice is a paradigmatic model that, despite its simplicity, enables the exploration of rich and robust emergent phenomena in topological magnets. Here we uncover a novel set of spin-ice phenomenology typically associated with vitrification processes in disordered systems.

We identify a pronounced peak in dynamical heterogeneity in a classical spin-ice model on the three-dimensional pyrochlore lattice, in the complete absence of disorder and - remarkably - in thermal equilibrium. At low temperatures, additional dynamical constraints emerge that confine the motion of magnetic monopole excitations to three-dimensional percolation clusters. This gives rise to ergodic subdiffusion, opposing conventional emergent hydrodynamics. The observed dynamical heterogeneity arises without disorder or ergodicity breaking, distinguishing it from conventional glasses and systems with Hilbert space fragmentation, suggesting a generic feature of topological magnets hosting deconfined quasiparticles.

Our results motivate the search for materials and artificial spin-ice realizations of this physics and propose higher-order dynamical correlations as a distinctive experimental signature of topological magnetism.

TT 48: 2D Materials: Electronic structure, excitations, etc. II (joint session O/HL/TT)

Time: Wednesday 10:30–12:30

Location: TRE/MATH

TT 48.1 Wed 10:30 TRE/MATH

Polarons in epitaxial single-layer MnBr₂ — ●AFFAN SAFEER, OKTAY GÜLERÜZ, GUANGYAO MIAO, WOUTER JOLIE, THOMAS MICHELY, and JEISON FISCHER — II. Physikalisches Institut, Universität zu Köln, Zùlpicher Straße 77, 50937 Köln, Germany

We investigate polaron formation in insulating single-layer MnBr₂ grown by molecular beam epitaxy on three different substrates: graphene on Ir(110), graphene on Ir(111), and Au(111). The polaron number densities and species depend strongly on the underlying substrate, underscoring the crucial role of the substrate. Our findings show that modeling of polarons in such single-layer insulators in contact with conducting substrates must explicitly include the substrate. For MnBr₂ grown on graphene/Ir(110), we identify four distinct polaron species, three of which closely resemble those reported for CoCl₂ on graphite. These polarons can be created, converted, and laterally manipulated by the STM tip when a tunneling current flows at suitable bias voltages. For graphene on Ir(110) as a substrate, mobile polarons in MnBr₂ are guided by the periodic potential imposed by the supermoiré pattern arising from the interaction of MnBr₂ with graphene and Ir(110).

TT 48.2 Wed 10:45 TRE/MATH

Chirality in the Kagome Metal CsV₃Sb₅ — ●TOM P. LAMMERSKÖTTER¹, H.J. ELMERS², G. SCHÖNHENSE², O. TKACH², Y. LYTUVYENKO², H. AGARWAL², S. CHERNOV³, M. HOESCH³, D. KUTNYAKHOV³, M. SCHOLZ³, K. ROSSNAGEL⁴, A. GLOSKOVSKI³, C. SCHLUETER³, A. WINKELMANN⁵, A. HAGHIGHIRAD⁶, M. SCHMITT⁷, T. LEE⁷, R. CLAESSEN⁸, M. LE TACON⁶, J. DEMSAR², and O. FEDCHENKO¹ — ¹Goethe-Universität Frankfurt (Germany) — ²JGU Mainz (Germany) — ³DESY Hamburg (Germany) — ⁴Universität zu Kiel (Germany) — ⁵AGH University of Krakow (Poland) — ⁶KIT Karlsruhe (Germany) — ⁷DIAMOND (UK) — ⁸Universität Würzburg (Germany)

Kagome metals AV₃Sb₅ (A = Cs, K, Rb) exhibit flat bands, Dirac points, and van Hove singularities that drive unconventional charge-density-wave (CDW) order and topological states. We study chirality in CsV₃Sb₅ using angle-resolved photoemission spectroscopy (ARPES) and x-ray photoelectron diffraction (XPD) with circularly polarized photons. XPD reveals a local crystal chirality in the CDW phase. ARPES shows pronounced magnetic circular dichroism (MCD), demonstrating a chiral electronic structure and indicating orbital moments possibly linked to loop-current order. To probe orbital-moment coupling, we study Nb-doped CsV₃Sb₅, where band broadening and enhanced Dirac-like gaps occur. In the CDW phase, the strongly increased MCD indicates time-reversal-symmetry breaking and couples to the three van Hove singularities at the M points.

TT 48.3 Wed 11:00 TRE/MATH

Ab initio and group theory analysis of monolayer BiTeI — ●JOSEP MAS-GARCIA, JORGE CERVANTES-VILLANUEVA, ALEJANDRO MOLINA-SÁNCHEZ, and ALBERTO GARCÍA-CRISTÓBAL — ICMUV - University of Valencia - Spain

Monolayer BiTeI is a prototypical polar semiconductor whose remarkable Rashba spin splitting, rooted in strong spin-orbit coupling and non-centrosymmetric structure, offers a fertile landscape for advancing two-dimensional spintronics. This work presents and ab initio and group-theoretical analysis of BiTeI. Employing fully relativistic density functional theory and GW calculations, we obtain electronic structures that serve as benchmarks for the group-theory based Hamiltonian model. Leveraging the systematic method of invariants, we construct symmetry-constrained k-p Hamiltonians near the Γ point. Our implementation of the method of invariants enables precise fitting of the Hamiltonian eigenvalues to ab initio band dispersions for the determination of the parameters, and yields a highly compact analytic model that reproduces Rashba splitting and symmetry-dependent features. This framework facilitates straightforward evaluation of key physical quantities, such as effective masses or spin textures, and perturbative responses including electric and magnetic fields and strain effects within a unified and transparent formalism. Moreover our methodology establishes a versatile template for the symmetry-guided modeling of nonmagnetic semiconductors with strong spin-orbit coupling.

TT 48.4 Wed 11:15 TRE/MATH

Production of Interstitials in 2D Transition-Metal Dichalcogenides (TMDs) by Ion Irradiation: ab-initio Simulations — ●SILVAN KRETSCHMER¹, JOEL DAVIDSSON², and KRISTIAN S. THYGESSEN¹ — ¹CAMD, Technical University of Denmark — ²Department of Physics, Linköping University, Sweden

Defects critically shape the properties of two-dimensional (2D) materials and can be purposefully introduced to tune magnetic, electronic, and optical behavior. Low-energy ion irradiation has recently emerged as an effective route for generating specific defect types via direct implantation [1,2].

First-principles simulations are essential for understanding irradiation-induced defect formation [3], but DFT-based molecular dynamics (MD) is computationally costly and limits broad exploration of materials and irradiation conditions. Machine-learning (ML) interatomic potentials provide a high-accuracy, low-cost alternative, enabling efficient screening of large datasets such as the Impurities in 2D Materials Database [4].

Here, we benchmark a ML potential against ab-initio MD, emphasizing accurate treatment of the short interatomic distances occurring during ion impacts. We apply the fine-tuned ML to study interstitial defect formation in TMDs under low-energy ion irradiation, providing defect formation probabilities and identifying suitable ion-beam parameters for targeted defect engineering in 2D materials.

[1] 10.1038/s41699-022-00318-4 [2] 10.1021/acsnano.4c03475

[3] 10.1103/PhysRevMaterials.8.114003 [4] 10.11583/DTU.19692238

TT 48.5 Wed 11:30 TRE/MATH

Long-living metastable electronic states in substituted 1T-TaS₂ — ●GAËL REECHT¹, JESUMONY JAYABALAN¹, RICARDS KNIPŠIS², FLORIAN DIEKMANN³, FRIEDEMANN QUEISSER², PING ZHOU¹, WALTER SCHNELLE⁴, KAI ROSSNAGEL^{3,5}, RALF SCHÜTZHOLD², MANUEL GRUBER¹, and UWE BOVENSIEPEN¹ — ¹University Duisburg-Essen, Germany — ²HZ Dresden-Rossendorf, Germany — ³CAU of Kiel, Germany — ⁴MPI for Chemical Physics of Solids, Dresden, Germany — ⁵DESY, Hamburg, Germany

1T-TaS₂ is a prototypical correlated material whose low-temperature phase exhibits a commensurate charge density wave forming Star-of-David (SOD) clusters. Each SOD hosts a single electron close to E_F and, due to strong on-site Coulomb repulsion, the system enters a Mott insulating state. Adding or removing an electron creates doublon or holon excitations, which typically relax within few femtoseconds [1]. Here, we manipulate the lifetime of the quasiparticle excitations by substituting some Ta with an electron richer element. Using LT-scanning tunnelling microscopy and spectroscopy (STM/STS) and time-resolved photoemission spectroscopy, we observe metastable doublons with lifetimes ranging from fs to hours. STM/STS further shows that these excitations are locally confined. The experimental observations are corroborated by a theoretical description based on a Fermi-Hubbard model. The disorder induced by the random substitution leads to a spatial localization of holon and doublon wavefunctions at the origin of the long lifetimes observed experimentally.

[1] M. Ligges et al., Phys. Rev. Lett., **120**, 166401 (2018)

TT 48.6 Wed 11:45 TRE/MATH

Fingerprints of Excitonic Collective Modes in the Two-Dimensional Electron Gas — ●JAKOB WOLFF^{1,2,3}, SILVANA BOTTI^{2,3}, LUCIA REINING^{4,3}, and MATTEO GATTI^{4,3,5} — ¹Institut für Festkörpertheorie- und Optik, Friedrich-Schiller-Universität Jena, Germany — ²Research Center Future Energy Materials and Systems, University Alliance Ruhr and Interdisciplinary Centre for Advanced Materials Simulation, Faculty of Physics and Astronomy, Ruhr University Bochum, Germany — ³European Theoretical Spectroscopy Facility (ETSF) — ⁴LSI, CNRS, CEA/DRF/IRAMIS, École polytechnique, Institut Polytechnique de Paris, France — ⁵Synchrotron SOLEIL, Gif-sur-Yvette, France

We investigate the collective charge excitations of the two-dimensional homogeneous electron gas in the low density regime within the framework of time-dependent density functional theory. We show that beyond the well-known plasmons new collective excitonic modes emerge, which leave characteristic fingerprints in experimentally accessible quantities, such as asymmetric peak structures in the loss function

and enhanced Friedel oscillations. Further, at sufficiently low densities the collective modes become imaginary, indicating an instability towards the formation of a charge-density-wave phase with excitonic origin.

TT 48.7 Wed 12:00 TRE/MATH

Moiré modulated quantum spin liquid candidate 1T-TaSe₂ — ZIYING WANG, ADOLFO O. FUMEGA, ANA VERA MONTOTO, MOHAMMAD AMINI, BÜSRA GAMZE ARSLAN, ALES CAHLIK, YUXIAO DING, JOSE L. LADO, ROBERT DROST, and PETER LILJEROTH — Aalto University, Department of Applied Physics

Quantum spin liquids continue to fascinate with their highly entangled quantum states and promises of fractional many-body excitations. Yet there are few tools to probe these materials, and none sensitive enough for applications in 2D materials. This seriously hampers the study of monolayer QSL candidates such as α -RuCl₃ and 1T-TaSe₂. Scanning tunneling microscopy and spectroscopy may overcome this challenge, as they can access the fundamental excitations of 2D samples through inelastic tunneling spectroscopy. These low-energy excitations can be compared against theoretical models and provide fingerprints of QSL states. We employ this approach against the quantum spin liquid candidate 1T-TaSe₂. We observe the emergence of a root 3 reconstruction driven by the substrate, equivalent spectroscopy across all spin sites, and the coexistence of zero and finite energy excitations. These observations are consistent with a QSL ground state. Our results demonstrate that IETS provides a powerful route to obtain atomic-scale insight into the magnetic excitations of two-dimensional materials. Spectral fingerprints may help to identify exotic phases of matter that are

otherwise difficult to detect.

TT 48.8 Wed 12:15 TRE/MATH

Long-Range Interactions in Twisted Bilayer Materials with Machine Learning for the Electronic Density — ZEKUN LOU¹, ALAN LEWIS², and MARIANA ROSSI¹ — ¹MPI for the Structure and Dynamics of Matter, Hamburg, Germany — ²Department of Chemistry, University of York, York, U.K.

Moiré superlattices in twisted bilayer (TB) 2D materials exhibit extraordinary quantum phenomena, but first-principles understanding remains limited by computational costs. While most machine learning (ML) methods for density functional theory (DFT) acceleration are based on the locality assumption, we demonstrate that accurate moiré electronic structure prediction requires long-range encoding due to charge rearrangement, orbital hybridisation, and moiré potential modulation. Using long-range representations [1] for electronic-density prediction [2,3], we achieve low-energy band-structure predictions with <15 meV errors across twisted bilayer graphene (TBG), hBN, and transition-metal dichalcogenides (TMDCs), while ~100 times faster than DFT. Descriptor requirements are material-dependent: homoatomic systems (e.g., TBG) are well-described by local descriptors, while hBN and TMDCs require long-range encoding. We summarise the physical implications of these findings that marry machine learning and the fundamental physics that governs the electronic density of twisted bilayer materials.

[1] A. Grisafi, M. Ceriotti, JCP 151, 204105 (2019)

[2] A. Lewis, A. Grisafi, M. Ceriotti, M. Rossi, JCTC 17, 7203 (2021)

[3] A. Grisafi, A. Lewis, M. Rossi, M. Ceriotti, JCTC 19, 4451 (2023)

TT 49: Correlated Electrons: Charge Order

Time: Wednesday 10:45–12:45

Location: HSZ/0101

TT 49.1 Wed 10:45 HSZ/0101

Charge density wave and superconductivity interplay in 2H-TaSe₂ — YULIYA TYMOSHENKO¹, AMIR-ABBAS HAGHIGHIRAD¹, ROLF HEID¹, GASTON GARBARINO², LUIGI PAOLASINI², and FRANK WEBER¹ — ¹Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — ²European Synchrotron Radiation Facility, 71 avenue des Martyrs, CS 40220, Grenoble 38043, France

The suppression of an ordered state is often discussed as a pathway to enhancing superconducting (SC) transition temperatures. Transition-metal dichalcogenides (TMDs), where both charge-density-wave (CDW) order and superconductivity arise from electron-phonon coupling, offer an ideal platform to study this interplay.

We performed high-pressure single-crystal X-ray diffraction (XRD) and inelastic X-ray scattering (IXS) on 2H-TaSe₂ and traced the evolution of its CDW superstructure and soft phonon mode over a broad temperature-pressure range. Our measurements show that the suppression of CDW order remains continuous down to low temperatures, demonstrating the persistence of a second-order phase transition, which is a necessary prerequisite for a CDW-related quantum-critical scenario. These findings refine the understanding of how CDW order collapses under pressure and how this behavior relates to the reported maximum superconducting transition temperature near 20 GPa.

Overall, 2H-TaSe₂ emerges as a controlled model system for investigating the interplay between CDW order, lattice dynamics, and superconductivity.

TT 49.2 Wed 11:00 HSZ/0101

Dynamics of CDW puddles in bulk 2H-NbSe₂ — SHREYA KUMBHAKAR^{1,2}, MARINA ESPOSITO³, ANJAN KUMAR N M¹, SUSHMITA CHANDRA⁴, CLAUDIA FELSER⁴, KORNELIUS NIELSCH^{1,2}, NICOLA POCCIA^{2,3}, STEFAN KAISER¹, and GOLAM HAIDER² — ¹TU Dresden — ²IFW Dresden — ³U. Naples — ⁴MPI CPFS

In complex materials, incommensurate charge-density-wave (CDW) is often formed from local commensurate domains or puddles. Measuring the dynamics of these puddles, we probe the effect of lattice pinning, electronic correlations and disorder on emergent phases. Raman scattering reveals a Fano lineshape of the CDW amplitude mode, indicating strong coupling between the interlayer shear vibration and the CDW order. Time-resolved reflectivity shows a coherent overdamped oscillation below the CDW transition temperature, indicating a new

low-frequency hybrid phonon-CDW amplitude mode around 0.15 THz. This we identify as the CDW puddle emerging from the strong Fano coupling. Our measurements further reveal a transition at 14 K, pointing to a possible crossover of the dominant commensuration order of these puddles. These results highlight how the layered structure affects the CDW order, which is crucial for the design and understanding of novel vdW heterostructures.

TT 49.3 Wed 11:15 HSZ/0101

Electronic band gap tuning of interchain phonon transport in Ta₂Ni(S_xSe_{1-x})₅ — YUAN-SHAN ZHANG¹, MASAHIKO ISOBE¹, HIDENORI TAKAGI^{1,2,3}, and DENNIS HUANG¹ — ¹Max Planck Institute for Solid State Research, Stuttgart, Germany — ²Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Germany — ³National Institute for Materials Science, Tsukuba, Japan

The dual electronic and structural characters of the 326 K transition in the quasi-one-dimensional compound Ta₂NiSe₅ continues to inspire heated discussion as to the origin of its primary driving force. The current state of affairs may be best summarized as a three-party debate, in which electron-hole interactions (excitonic insulator), electron-lattice coupling (hybridization gap), and “intrinsic” lattice effects are all championed to play some role. The isostructural compound Ta₂NiS₅ should serve as a valuable foil for better understanding Ta₂NiSe₅, as substitution of Se for S enlarges the single-particle electronic band gap, which diminishes the role of electronic degrees of freedom and greatly reduces the transition temperature. Here, we report thermal transport measurements that probe the interchain phonon conductivity of Ta₂Ni(S_xSe_{1-x})₅. A soft-phonon anomaly observed in the Se-rich compounds is absent in the S-rich compounds, implying the crucial role of electronic (excitonic and hybridization-gap) fluctuations that couple to the lattice and boost the structural transition temperature.

TT 49.4 Wed 11:30 HSZ/0101

Doping tunable charge density waves in misfit layer compounds — HUGO LE DU¹, LUDOVICA ZULLO², JUSTINE CORDIEZ³, ROBIN SALVATORE¹, DANIEL SCHMIEG¹, GIOVANNI MARINI⁴, FRANÇOIS DEBBONTRIDDER¹, MARIE HERVÉ¹, SHUNSUKE SASAKI³, FLORENT PAWULA³, ETIENNE JANOD³, MATTEO CALANDRA⁴, LAURENT CARIO³, and TRISTAN CREN¹ — ¹Institut des Nanosciences de Paris, Sorbonne Université, Paris, France — ²Julius-Maximilians-Universität Würzburg, Würzburg, Germany — ³Institut des Matériaux de Nantes, Nantes, France — ⁴University of Trento,

Italy

Misfit layer compounds are van der Waals heterostructures formed by stacking transition metal dichalcogenide (TMD) and monochalcogenide layers. Theoretically, charge transfer from monochalcogenide to TMD layers results in significant doping. Adjusting the monochalcogenide composition enables precise control over TMD doping levels. We show via scanning tunneling microscopy (STM) that in $(\text{La}_x\text{Pb}_{1-x}\text{Se})_{1.14}(\text{NbSe}_2)_2$, the NbSe_2 Fermi level shifts from 0.0 eV to 0.3 eV by varying La content. Combining STM with DFT calculations, we demonstrate that NbSe_2 transitions from the conventional 3×3 CDW state to alternative configurations at higher doping. Superconducting properties also change, offering a novel platform to explore the interplay between superconductivity and charge density waves.

TT 49.5 Wed 11:45 HSZ/0101

Coherent amplitude response in the excitonic insulator $\text{Ta}_2\text{Pd}_3\text{Te}_5$ — ●ANJAN KUMAR NARALAPURA MANOHARA¹, SHUHAN WANG¹, SNEHASHISH CHATTERJEE², CHANDRA SHEKHAR², CLAUDIA FELSER², and STEFAN KAISER¹ — ¹Institute of Solid State and Materials Physics, TU dresden — ²Topological Quantum Chemistry Group, Max Planck Institute for Chemical Physics of Solids, Dresden

The excitonic insulator represents a fascinating electronic phase in which bound electron-hole pairs condense into a macroscopic quantum state. The layered compound $\text{Ta}_2\text{Pd}_3\text{Te}_5$ has recently emerged as a compelling platform for exploring this elusive phase. A hallmark of such condensate is the presence of collective excitations analogous to the Higgs (amplitude) and Goldstone (phase) modes in superconductors. In this work, we present the experimental fingerprint of a coherent amplitude response in the excitonic insulator phase of $\text{Ta}_2\text{Pd}_3\text{Te}_5$. Through non-degenerate pump-probe spectroscopy, we identify three low frequency A_{1g} phonons that show strong coupling to the excitonic condensate. We characterise these modes as a function of temperature and excitation fluence to reveal their link to the emergence and dynamics of the excitonic condensate.

TT 49.6 Wed 12:00 HSZ/0101

Doping-tunable charge ordering in semiconducting single-layer Cr_2Se_3 — ●SISHENG DUAN and MIGUEL UGEDA — Donostia International Physics Center, Paseo Manuel de Lardizábal 4, 20018 San Sebastián, Spain

The charge density wave (CDW), a charge ordering phase, offers a valuable framework for exploring electron-electron interactions, electron-phonon coupling, and quantum phase transitions. In CDW materials, carrier density substantially influences the ground state, typically altered through foreign ion doping and investigated at macro- or mesoscopic scales via photoemission or transport techniques. However, atomic-scale visualization, particularly in doped CDW systems without foreign ions, remains rare. Here, we present real-space observation of doping-tunable granular charge ordering using scanning tunneling microscopy in semiconducting single-layer Cr_2Se_3 , a group VIB transition metal chalcogenide. Observations of lattice distortion, bandgap modulation at the Fermi energy, and STM contrast inversion at low temperatures indicate a charge ordering origin. The semiconducting nature of Cr_2Se_3 enables charge ordering modulation through

doping: Hole doping suppresses it, whereas electron doping alters the pattern, yielding a periodic $3\sqrt{3} \times 3\sqrt{3}$ CDW phase. This tunable charge ordering in a group VIB TMC advances the understanding of charge doping and ordering interactions in two-dimensional materials.

TT 49.7 Wed 12:15 HSZ/0101

On the origin of charge density waves as an emergent phenomenon from the electron-phonon interactions in ZrTe_3 — ●RAGHOTTAM M SATTIGERI^{1,2}, NICCOLÒ MIGNANI¹, CLAUDIA DALLERA¹, ETTORRE CARPENE¹, SIMONA ACHILLI², and ALBERTO CREPALDI¹ — ¹Physics Department, Politecnico di Milano, Milan, Italy — ²Physics Department, University of Milan, Milan, Italy

Charge density ordering is not elusive in electronic structures which are highly anisotropic, thus indicating a strong electron-phonon (e-ph) interaction which drives such phenomenon. There has been an active debate on the origin of such ordering in two-dimensional transition metal dichalcogenides, however, similar investigations for bulk materials are scarce. It is evident from experiments that, quasi one-dimensional crystal structure ZrTe_3 exhibits stable modulations with long-range ordering which facilitates the system to host charge density waves (CDW). We address and investigate thoroughly the origin of CDW in bulk ZrTe_3 using density functional theory based first-principles calculations. We analyze the role of electronic instability and e-ph coupling, respectively, as possible mechanisms for the formation of CDW. From our calculations we were able to identify a peak in the the Lindhard response function and strong e-ph interactions suggesting that, both, the electronic and phononic contributions have a role in the process of CDW ordering in ZrTe_3 .

TT 49.8 Wed 12:30 HSZ/0101

Controlling metastable charge-ordered states in $\delta\text{-Ag}_{2/3}\text{V}_2\text{O}_5$ — ●MASAHIKO ISOBE¹, Taisei KUBO², NAOYUKI KATAYAMA², and ROBERT E. DINNEBIER¹ — ¹Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — ²Department of Applied Physics, Nagoya University, Nagoya 464-8603, Japan

Vanadium bronzes have attracted much interest as a playground of various quantum phenomena. They are essentially mixed valent oxides where metallic conductivity and novel phenomena with spin, charge and orbital degrees of freedom can be exhibited. Recently we have investigated the delta-phase of vanadium bronze, focusing on the phase transition in $\delta\text{-Ag}_{2/3}\text{V}_2\text{O}_5$ which shows characteristic supercooling effects. The structure consists of double trellis layer formed by edge/corner-shared VO_6 octahedra and Ag ions located between the layers. We have observed the phase transition at around 230 K accompanied by jumps of magnetic susceptibility and resistivity. Structural analysis of the low-temperature triclinic phase reveals that Ag ion order and Vanadium dimer formation. Below the transition temperature the magnetic susceptibility shows a broad maximum around 110 K followed by spin gap behavior. We conclude that the phase transition in $\delta\text{-Ag}_{2/3}\text{V}_2\text{O}_5$ is a charge order into V^{4+} and V^{5+} induced by Ag ion order. The V^{4+} ions form dimers with the spin-gapped ground state. Also it can be super-cooled down to the lowest temperature by rapid cooling.

TT 50: German-French Focus Session: Superconducting Junctions and Quantum Circuits

Superconducting junctions are important building blocks for various applications including qubits. The importance of superconductivity to probe macroscopic quantum physics has been underlined by the Nobel prize in physics 2025. Current research activities in the field of superconducting quantum circuits bridge from fundamental symmetry aspects of superconductivity to material science for improved performance of superconducting electronics. Beyond these activities, superconductivity has developed as a tool to probe also unconventional normal conducting properties. The scope of this focus session is to showcase recent activities in this field in France and Germany and to tighten the interaction between the very active research communities in both countries.

Coordinators: Clemens Winkelmann (CEA/UGA Grenoble), Guillaume Weick (University of Strasbourg), Elke Scheer (University of Konstanz).

Time: Wednesday 15:00–18:30

Location: HSZ/0003

Topical Talk TT 50.1 Wed 15:00 HSZ/0003
Josephson Quantum Tunneling at Odd Parity — MANUEL HOUZET¹, •JULIA S. MEYER¹, and YULI V. NAZAROV² — ¹Univ. Grenoble Alpes, France — ²Delft University of Technology, The Netherlands

When a Josephson junction is embedded in an electromagnetic circuit, the superconducting phase difference across the junction becomes a quantum-fluctuating variable. The resulting quantum mechanics of the Josephson effect is the core ingredient for quantum technologies with superconducting circuits. On a microscopic level, the Josephson effect is related to Andreev bound states in the junction and depends on their occupation. When a single quasiparticle is trapped in an Andreev bound state—a situation known as quasiparticle poisoning—the junction is in the odd-parity sector. Because of parity conservation, such a poisoned state may exhibit a long lifetime. Our work opens a new avenue in this field by showing that the Josephson quantum mechanics in the odd-parity sector differs fundamentally from the conventional behavior in the even-parity sector. We uncover a rich phenomenology that contrasts with the naïve expectation of a simple supercurrent quench, which prevailed so far. Covering several representative cases, we predict a variety of novel effects that can be probed in upcoming experiments. Hybrid superconductor-semiconductor-superconductor junctions, that have been intensively studied in recent years both with nanowires and two-dimensional electron gases, provide a promising platform for observing these phenomena.

Topical Talk TT 50.2 Wed 15:30 HSZ/0003
Superconducting qubits and amplifiers resilient to Tesla-scale magnetic fields — •IOAN POP — KIT, Karlsruhe, Germany

Superconducting qubits with quantum non-demolition readout and active feedback can act as information engines to probe and control microscopic degrees of freedom, both engineered and environmental. However, performing such experiments in magnetic fields above tens of mT poses a significant challenge for conventional superconducting qubits. We demonstrate a fluxonium qubit with a granular aluminum nanojunction (gralmonium) that maintains spectral stability and coherence above 1 T [1]. This robust performance enables exploration of spin environment dynamics and supports hybrid quantum architectures integrating superconducting qubits with spin systems [2].

[1] Günzler & Beck et al., Nature Comm. 16, 9564 (2025)

[2] Günzler et al., Phys. Rev. B 112, 115424 (2025)

Topical Talk TT 50.3 Wed 16:00 HSZ/0003
Josephson metamaterials as near-quantum-limited microwave amplifiers — •NICOLAS ROCH — Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Neel, 38000 Grenoble, France

Josephson meta-materials have recently emerged as a highly promising platform for superconducting quantum science and technology. Their unique potential lies in the ability to engineer these materials at sub-wavelength scales, allowing for complete control over wave dispersion and nonlinear interaction. In this seminar, I will demonstrate how Josephson meta-materials can be utilized as microwave amplifiers with added noise that approaches the quantum limit. These materials are already widely used in experiments ranging from quantum information processing with superconducting qubits to dark matter detection. In the second part, I will present a recent experiment demonstrating a microwave amplifier that exhibits intrinsic isolation and can be used to read out a superconducting qubit without the need for magnetic isolators.

This research is conducted in collaboration with the company Silent Waves.

15 min. break

Topical Talk TT 50.4 Wed 16:45 HSZ/0003
Second Order Topological Insulators probed with mesoscopic physics — •SOPHIE GUERON — Laboratoire de Physique des Solides Université Paris-Saclay France

Second Order Topological Insulators (SOTIs) are a new family of materials, predicted to be insulating in the bulk and surfaces, and perfectly conducting along dimensional crystal hinges. Similarly to Quantum Spin Hall edges states in 2D Topological Insulators, the hinge states are expected to carry current with no dissipation and no backscattering, due to their unique spin-momentum-locked configuration, also called helicity. I will present various mesoscopic physics experiments that have uncovered the special properties of SOTIs. Firstly, experiments with superconducting contacts have led to the discovery that Bismuth was a Second Order Topological Insulator, by providing evidence of hinge states and their topological character. We have also recently extended our experiments to new SOTI materials and to non-superconducting contacts, as well as to the investigation of the current-induced spin polarization due to spin-momentum locking in the hinge states. Finally, I will present a new detection scheme to explore orbital currents in 2D materials, that has the potential to reveal persistent currents circulating at the hinges of a mesoscopic SOTI crystal.

This work is a collaborative work conducted in the Mesoscopic Physics group at Laboratoire de Physique des Solides

Topical Talk TT 50.5 Wed 17:15 HSZ/0003
Proximity superconductivity in chiral Kagome antiferromagnets — •PIET BROUWER, ADAM CHAOU, GAL LEMUT, and FELIX VON OPPEN — Freie Universität Berlin, Dahlem Center for Complex Quantum Systems, Fachbereich Physik, and Halle-Berlin-Regensburg Cluster of Excellence CCE, Arnimallee 14, 14195 Berlin

Recent experiments on the chiral Kagome antiferromagnet Mn_3Ge have provided strong evidence of proximity-induced spin-polarized superconductivity. We introduce and explore a minimal model which exhibits a rich phase diagram as a function of chemical potential and spin canting. We find a valley-singlet superconducting phase for chemical potentials and canting consistent with the experimental system. This phase transitions into a Chern insulator at larger canting and gives way to topological superconducting phases with Chern numbers $C_{\text{BdG}} = \pm 1, \pm 3$ at other chemical potentials. Our results show that proximity-induced superconductivity in Kagome antiferromagnets is a promising route towards superconductivity with spin-polarized Cooper pairs.

TT 50.6 Wed 17:45 HSZ/0003
Spectroscopy of a nanowire fluxonium — •HUGUES POTHIER¹, JOAN CACERES¹, DIEGO SANZ¹, JON ORTUZAR¹, EMMANUEL FLURIN¹, JESPER NYGARD², CRISTIAN URBINA¹, and MARCELO GOFFMAN¹ — ¹Quantronics group, SPEC (CNRS UMR 3680), CEA-Paris Saclay, University Paris-Saclay, 91191 Gif-sur-Yvette, France — ²Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, Universitetsparken 5, 2100 Copenhagen, Denmark

We fabricated a fluxonium qubit [1] in which the Josephson junction is replaced with a semiconducting nanowire weak link. The Josephson

effect in the nanowire is associated with Andreev bound states, which themselves have been shown to behave as qubits [2-4]. Through precise analysis of the spectroscopy data, we searched for evidence of strongly transmitted channels [5] and for an hybridization of the two types of qubits.

- [1] V.E.Manucharyan, J.Koch, M.H.Devoret, Science 326, 113 (2009).
- [2] C. Janvier et al., Science 349, 1199 (2015).
- [3] M. Hays et al., Phys. Rev. Lett. 121, 047001 (2018).
- [4] M. Hays et al., Science 373, 430 (2021).
- [5] M. Pita-Vidal et al., Phys. Rev. Applied 14, 064038 (2020).

TT 50.7 Wed 18:00 HSZ/0003

Multiterminal Josephson Junctions: non-hermiticity, topology and reflectionless modes — ●DAVID CHRISTIAN OHNMACHT, WILHELM VALENTIN, WEISBRICH HANNES, and BELZIG WOLFGANG — Universität Konstanz, Konstanz, Germany

In multiterminal Josephson junctions (MTJJs), the Andreev bound state energies depend on multiple phase differences, enabling band structure engineering. MTJJs are predicted to host non-trivial topological phases and associated Weyl nodes in the synthetic Brillouin zone spanned by these superconducting phases [1]. In [2], spectroscopic measurements were performed on four-terminal Josephson junctions with phase control of all three superconducting phase differences, unveiling the presence of a tri-Andreev molecule, compatible with a topologically non-trivial model. We predict that such MTJJs, in the presence of additional normal leads, host non-trivial non-Hermitian topology, leading to spectral topology in the form of point gaps and Weyl disks [3]. Additionally, we predict that reflectionless scattering modes in MTJJs are a source of topological phase boundaries [4]. Our work provides an effective bulk boundary correspondence by demonstrating a relationship between unity transmission modes and boundaries between topologically trivial and non-trivial regions, like in quantum

Hall systems.

- [1] R.-P. Riwar et. al., Nature Commun. 7, 1 (2016)
- [2] T. Antonelli et. al., Phys. Rev. X 15, 031066 (2025)
- [3] D. C. Ohnmacht et. al., Phys. Rev. Lett. 134, 156601 (2025)
- [4] D. C. Ohnmacht et. al., arXiv:2503.10874 (2025)

TT 50.8 Wed 18:15 HSZ/0003

From Shapiro steps to photon-assisted tunneling in microwave-driven atomic-scale Josephson junctions with a single (magnetic) adatom — ●MARTINA TRAHMS^{1,2}, BHARTI MAHENDRU¹, CLEMENS B. WINKELMANN², and KATHARINA J. FRANKE^{1,3} — ¹Fachbereich Physik, Freie Universität Berlin, Berlin, Germany — ²Univ. Grenoble Alpes/CEA/Grenoble-INP/IRIG-Pheliqs, Grenoble, France — ³Fachbereich Physik and Halle-Berlin-Regensburg Cluster of Excellence CCE, Freie Universität Berlin, Berlin, Germany

Understanding Josephson junctions (JJs) on the atomic scale yields insights for the prospect of superconducting circuits in future technological applications. We form JJs between a superconducting tip and sample in a scanning tunneling microscope (STM). The phase dynamics of the JJ such as dissipation and coherence of the tunneling processes are investigated by high-frequency (HF) irradiation. Shapiro steps indicate coherent Cooper-pair tunneling while incoherent tunneling processes are described by photon-assisted tunneling. With increasing HF irradiation amplitude, the STM JJs transition from the coherent to the incoherent tunneling regime due to the increase of thermal fluctuations. Introducing a magnetic adatom into the junction reduces the Josephson coupling and increases the quasiparticle tunneling rate which leads to a suppression of coherence. We highlight the presence of phase coherence in atomic scale JJs and ascribe the transition from coherent to incoherent Cooper-pair tunneling processes to the interplay of thermal fluctuations and the Josephson coupling strength.

TT 51: Correlated Electrons: Method Development II

Time: Wednesday 15:00–18:15

Location: HSZ/0101

TT 51.1 Wed 15:00 HSZ/0101

Towards accurate low energy models — ●JONAS PROFE¹, JAKSA VUCICEVIC², P. PETER STAVROPOULOS¹, MALTE RÖSNER³, ROSER VALENTI¹, and LENNART KLEBL⁴ — ¹Institute for Theoretical Physics, Goethe University Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt a.M., Germany — ²Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia — ³Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands — ⁴Institut für Theoretische Physik und Astrophysik und Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany

Effective low-energy models are a central cornerstone for understanding emergent phenomena in quantum materials. These models, often containing only a small subset of the original degrees of freedom, capture the low temperature dynamics while being tractable to a variety of numerical and analytical techniques enabling quantitative results even in the strongly correlated limit. As such, a faithful method to derive such low-energy models is essential. In this talk, we will introduce an exact framework for deriving effective models and extract known approaches from it. We further introduce conditions under which an effective model is guaranteed to capture the effective dynamics of the material. Within this framework, we then discuss what material classes display relevant corrections beyond standard downfolding approaches and we explain the physical origin of these corrections.

TT 51.2 Wed 15:15 HSZ/0101

Study of a two-dimensional Rydberg array in a cavity with neural quantum states — ●NOE SALMERON¹, MARIN BUKOV², and MARKUS SCHMITT^{1,3} — ¹University of Regensburg, Germany — ²Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ³Institute of Quantum Control (PGI-8), Forschungszentrum Jülich, Germany

Recent advances in cold atom manipulation enable the study of many-body systems where both short-range interactions between neighboring atoms and long-range interactions mediated by photons coexist. Such a combination of interactions makes a theoretical approach challeng-

ing beyond mean-field methods. In this work, we develop numerical techniques to investigate one of the simplest model capturing these features: a two dimensional lattice of Rydberg atoms coupled to a single photon mode. We use neural quantum states coupled with stochastic reconfiguration to obtain the ground state on lattices with hundreds of sites. We adapt a neural network architecture commonly used for spin models, to incorporate the additional photon mode. This allows us to capture spin-spin and spin-photon correlations and we explore how the fully correlated ground states deviate from mean field theory. The resulting method provides a scalable approach for investigating the ground state properties of such systems.

TT 51.3 Wed 15:30 HSZ/0101

Understanding discrepancies in noncovalent interaction energies from wavefunction theories for large molecules — ●ANDREAS IRMLER, TOBIAS SCHAEFER, ALEJANDRO GALLO, and ANDREAS GRUENEIS — TU Wien, Vienna, Austria

Recent advances in combining quantum-mechanical methods with machine learning have generated excitement for large-scale molecular simulations. Yet the reliability of these approaches depends on the benchmark accuracy expected from high-level quantum reference methods. Discrepancies have been reported between two widely trusted references - diffusion quantum Monte Carlo and coupled-cluster theory - for large noncovalent complexes, posing a puzzle for the accuracy required to support QM/ML modeling. In this talk, I analyze these discrepancies, identify their origin, and present modifications to the coupled-cluster ansatz that restore reliable, high-accuracy interaction energies for molecules on the hundred-atom scale, paving the way toward more accurate predictive simulations.

TT 51.4 Wed 15:45 HSZ/0101

Embedded Impurity Models with Quantitative Predictive Accuracy: Beyond Mean Field Baths and cRPA — ●KEVIN ACKERMANN and MAURITS W. HAVERKORT — Institute for Theoretical Physics, Heidelberg, Germany

Ab-initio embedded impurity approaches, such as DFT+DMFT, are powerful tools for studying correlated materials. However, the interface between the mean-field bath and the many-body impurity presents

persistent challenges, particularly in the consistent determination of the screened Coulomb interaction, and the associated double-counting correction.

We address these challenges in the context of transition metal complexes, where an accurate description of the correlated d -electron physics is essential. We present a systematic investigation of electronic g -factors and d - d excitations – sensitive probes of the low-energy electronic structure. Our analysis reveals that achieving quantitative agreement with experimental data requires two components: (1) extending the correlated active space beyond the metal d -orbitals to include relevant ligand states, and (2) incorporating vertex corrections in the calculation of the screened interaction. Only the combination of both yields results consistent with experiment, establishing a clear path toward predictive accuracy in embedded impurity models for coordination complexes.

TT 51.5 Wed 16:00 HSZ/0101

SOLAX: An Open Source Python Package for Neural Network Configuration Interaction — PAVLO BILOUS², LOUIS THIRION¹, ●MAX KROESBERGEN¹, PAUL FADLER³, and PHILIPP HANSMANN¹ — ¹Friedrich-Alexander-Universität Erlangen-Nürnberg — ²Max Planck Institute for the Science of Light, Erlangen — ³Universität Bremen

We present a modular Python library, SOLAX [1], designed for configuration interaction (CI) calculations of fermionic quantum many-body systems in high dimensional Hilbert spaces. The provided classes allow convenient encoding of states and operators in second quantization. The JAX-based GPU-accelerated back-end efficiently performs the operations necessary to determine many-body eigenstates in finite-size Hilbert spaces. Along with its core functionalities, SOLAX integrates neural-network (NN) support for the CI calculation of otherwise prohibitively large expansions in Slater determinant basis sets. We show how a NN can be used in CI calculations to identify a priori unknown subsets of the most important Slater determinants and iteratively obtain high-quality approximate many-body eigenstates. Applications involve the paradigmatic Single Anderson Impurity Model in a solid-state physics context [2], as well as computation of molecular ground-[3,4] and excited states [5] in Quantum Chemistry.

- [1] L. Thirion, P. Hansmann, P. Bilous, 10.21468/SciPostPhysCodeb.51,
- [2] P. Bilous *et al.*, 10.1103/PhysRevB.111.035124
- [3] Y.L.A. Schmerwitz *et al.*, 10.1021/acs.jctc.4c01479
- [4] L. Thirion *et al.*, arXiv:2510.27665
- [5] G. Levi *et al.*, arXiv:2510.26751

TT 51.6 Wed 16:15 HSZ/0101

Finite Temperature Neural Quantum States — ●ATIYE ABEDINIA^{1,2,3}, ANKA VAN DE WALLE^{1,3,4}, and ANNABELLE BOHRDT^{1,2,3} — ¹Ludwig-Maximilians-University Munich, Theresienstr. 37, Munich D-80333, Germany — ²University of Regensburg, Universitätsstr. 31, Regensburg D-93053, Germany — ³Munich Center for Quantum Science and Technology, Schellingstr. 4, Munich D-80799, Germany — ⁴Department of Physics and Astronomy, Ghent University, 9000 Gent, Belgium

Finite-temperature effects play an important role in the design and optimization of quantum devices, as decoherence and noise often originate from thermal fluctuations. At finite temperatures, quantum systems are described by a statistical ensemble of states rather than a single pure state. Simulating such thermal states requires constructing the thermal density matrix, which suffers from significant computational challenges due to the exponential growth of the Hilbert space with system size. In this work, we propose using neural quantum states (NQS), leveraging the expressivity and scalability of transformer-based architectures to address the challenges of thermal equilibrium density matrix representation.

15 min. break

TT 51.7 Wed 16:45 HSZ/0101

Tensor Network Python (TeNPy) version 2: status and prospects — ●JOHANNES HAUSCHILD^{1,2}, JAKOB UNFRIED^{1,2}, NICO KIRCHNER^{1,2}, LUDWIG ZWENG^{1,2}, and FRANK POLLMANN^{1,2} — ¹Department of Physics, NAT school, Technical University Munich, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

TeNPy is an established python library for the simulation of strongly correlated quantum systems with tensor networks. We report on the

implementation of a new linear algebra package for the library to make it more versatile. On the one hand, it allows to switch between CPU and GPU devices, providing significant speedup in certain cases. On the other hand, one can toggle between different symmetry backends. Backends for none or abelian symmetries have been ported from TeNPy version 1 and available with a minimal overhead. Moreover, a new symmetry backend based on fusion trees has been implemented, which can handle general fusion categories. As such, it can be used to conserve non-abelian symmetries like $SU(2)$, $SU(n)$, but also to implement fermions in PEPS, or models based on anyons, e.g., the Fibonacci chain.

TT 51.8 Wed 17:00 HSZ/0101

Holographic Representation of One-Dimensional Many-Body Quantum States via Isometric Tensor Networks — KAITO KOBAYASHI¹, ●BENJAMIN SAPPLER^{2,3}, and FRANK POLLMANN^{2,3} — ¹Department of Applied Physics, the University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan — ²Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Isometric tensor network states (isoTNS) allow for efficient and accurate simulations of higher-dimensional quantum systems by enforcing an isometric structure. We bring this idea back to one dimension by introducing a holographic isoTNS ansatz: a $(1+1)$ -dimensional lattice of isometric tensors where the horizontal axis encodes physical space and an auxiliary "holographic" axis boosts expressivity. We investigate this ansatz and benchmark it in comparison to matrix product states (MPS). We show that randomly initialized holographic isoTNS typically display volume-law entanglement even at modest bond dimension. We further demonstrate that holographic isoTNS can faithfully represent arbitrary fermionic Gaussian states, Clifford states, and certain short-time-evolved states under local evolution. Finally, we implement a time-evolving block decimation (TEBD) algorithm on holographic isoTNS. While the method remains efficient, error accumulation suppresses entanglement and leads to rapid deviations from exact dynamics. Overall, holographic isoTNS broaden the reach of tensor-network methods, opening new avenues to study volume-law physics.

TT 51.9 Wed 17:15 HSZ/0101

A Quasiparticle Excitation Ansatz for 2D Isometric Tensor Network States — ●LUKAS WITTMANN^{1,2}, JOHANNES HAUSCHILD^{1,2}, and FRANK POLLMANN^{1,2} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Isometric tensor network states (isoTNS) in 2D were introduced as a subclass of projected entangled pair states (PEPS) with additional isometry conditions that allow for an efficient evaluation of local expectation values [1]. Based on a formulation in a finite 45° -rotated square lattice [2], we introduce an ansatz for quasiparticles in the tangent space of an isoTNS [3,4], generalizing the ideas from 1D matrix product states (MPS) [5,6] and infinite PEPS [7]. We show that this ansatz can faithfully represent low-energy excitations with standing waves of spin flips, crucial for the dynamical structure factor, and discuss an algorithm to variationally optimize them.

- [1] M.P. Zaletel, F. Pollmann, Phys. Rev. Lett. 124, 037201 (2020)
- [2] B. Sappeler *et al.*, arXiv:2507.08080
- [3] L. Wittmann, Master's Thesis, https://github.com/lukasjwittmann/iso_tns-public
- [4] L. Wittmann, J. Hauschild, F. Pollmann, in preparation
- [5] J. Haegeman *et al.*, Phys. Rev. B 88, 075133 (2013)
- [6] M. Van Damme *et al.*, Phys. Rev. B 104, 115142 (2021)
- [7] L. Vanderstraeten *et al.*, Phys. Rev. B 92, 201111 (2015)

TT 51.10 Wed 17:30 HSZ/0101

Finite-temperature DMRG calculations for big spin systems using matrix product states — ●LUKAS HORSTMANN and JÜRGEN SCHNACK — University of Bielefeld, Bielefeld, Germany

Nowadays DMRG is a well established method for calculating ground states. Over time and with the introduction of Matrix Product State (MPS) more and more applications were discovered. On of these is using imaginary time-evolution to calculate finite-temperature states. For this application there already exist a few different methods to achieve it: Time Evolution Block Decimation (TEBD), Time Dependent Variational Principle (TDVP) both with purification and Minimally Entangled Typical Thermal States (METTS) using a sampling

approach. These methods perform differently based on the model. Here we will discuss in which scenarios which method is performing best in a one-dimensional model. The focus will be on the aspects of runtime and accuracy for temperatures down to $T = 0.5$, with the prospect to use it to simulate magnetic observables in real quantum systems.

TT 51.11 Wed 17:45 HSZ/0101

Renormalised Interactions via Composite Fields — ●OLEKSANDR SULYMA¹, JAN VON DELFT², and BENEDIKT SCHNEIDER² — ¹Institute for Theoretical Physics, University of Cologne, Cologne, Germany — ²Arnold Sommerfeld Center for Theoretical Physics, Center for NanoScience, and Munich Center for Quantum Science and Technology, Ludwig-Maximilians-University of Munich, Munich, Germany

The renormalised interactions of particles in quantum many-body systems and general field theories are described by the one-particle-irreducible vertices. The numerical calculation and treatment of these objects have proven to be challenging because of their high dimensionality and complicated frequency and momentum structure. To address these problems, multiple solutions have been proposed: a frequency parametrisation using asymptotic classes; the single-boson exchange (SBE) formalism, which uses only physical correlation functions, thereby avoiding vertex divergencies in the parquet formalism; and symmetric estimators which avoid the amputation of Green's func-

tions, to name a few. We present a unified framework based on the inverse Legendre transform of the composite field effective action that generalises asymptotic classes, symmetric improved estimators, the SBE and the parquet formalism. We demonstrate that these representations of the four-point vertex correspond to different choices of composite fields and naturally extend to more general theories and any-order vertices via simple tree diagrams.

TT 51.12 Wed 18:00 HSZ/0101

The TRIQS arbitrary X-Crossing Approximation impurity solver (triqs_xca) — ●HUGO U. R. STRAND¹, PACO RILLORAZA², ZHEN HUANG³, NILS WENTZELL⁴, DENIS GOLEŽ⁵, and JASON KAYE⁴ — ¹Örebro University, Örebro, Sweden — ²New York University, New York, USA — ³University of California, Berkeley, USA — ⁴Flatiron Institute, Simons Foundation, New York, USA — ⁵Jozef Stefan Institute, Ljubljana, Slovenia

The triqs_xca solver is the latest quantum impurity solver addition to the Toolbox for Research on Interacting Quantum Systems (TRIQS) based on the bold hybridization expansion, a.k.a. the X:t order Crossing Approximation (XCA). Using the sum-of-exponentials trick we achieve parametrically better computational complexity compared to direct integration and the Discrete Lehmann Representation (DLR) is employed for fast convolutions as well as for representing response functions. The solver is open source and distributed as part of the TRIQS project, see github.com/TRIQS/xca.

TT 52: Heavy Fermions

Time: Wednesday 15:00–16:30

Location: HSZ/0103

TT 52.1 Wed 15:00 HSZ/0103

High-field muon spin resonance/rotation (μ SR) studies on CeRh_2As_2 — ●SEUNGHYUN KIM¹, OLIVER STOCKERT¹, ANDRIN DOLL², and ROBERT SCHEUERMANN² — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²Paul Scherrer Institute, Villigen, Switzerland

The heavy-fermion CeRh_2As_2 with $T_c = 0.35$ K exhibits unique two-phase superconductivity under a c -axis magnetic field. In the superconducting (SC) state, a field-induced transition at $H^* = 4$ T separates a low-field even-parity (SC1) phase from a high-field odd-parity (SC2) phase. In addition, an unusual ordering of the Ce-4f moments emerges below $T_0 = 0.55$ K, which is suppressed with increasing c -axis field. The T_0 phase boundary smoothly extends into the SC2 phase and persists to zero temperature at approximately 7 T. Previous zero-field μ SR studies have identified that an internal field develops spontaneously below T_0 and becomes nearly saturated below T_c , suggesting a possible correlation between the magnetic order and superconductivity. Here, we present following high-field μ SR measurements up to 7.5 T. Temperature-dependent measurements at 2 T show that the internal field is fully established below 0.3 K, coinciding with the onset of the SC1 phase. Furthermore, field-dependent measurements at 20 mK reveal that the internal field begins to be suppressed above 4 T and then vanishes entirely at around 7 T. These observations propose that the magnetic order in the T_0 phase is locked in exclusively within the SC1 phase, reflecting an intricate coupling between the magnetic and SC order parameters.

TT 52.2 Wed 15:15 HSZ/0103

Coupled magnetic and quadrupolar order in tetragonal CeRh_2As_2 evidenced by the basal-plane anisotropy — ●KONSTANTIN SEMENIUK^{1,2}, BURKHARD SCHMIDT², SEUNGHYUN KIM², and ELENA HASSINGER^{1,2} — ¹Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — ²Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Unconventional superconductivity in Ce-based Kondo-lattice materials has been known to emerge exclusively in the vicinity of weak dipolar magnetic orders, while higher-order multipolar orders are only known to occur in a few Pr-based unconventional superconductors and possibly URu_2Si_2 . Moreover, for tetragonal Ce-based compounds, quadrupolar orders are disfavoured by a two-fold degenerate ground state of the crystal electric field scheme, in contrast to a four-fold degenerate one in cubic systems. The multiphase superconductor CeRh_2As_2 appears to be a notable exception from both of these trends

by possibly hosting coupled magnetic and quadrupolar orders. In this talk, we explain how such a scenario can be realised [1,2] and show that the field-temperature phase diagram of CeRh_2As_2 has a pronounced basal-plane anisotropy, which effectively proves the existence of higher-order multipolar ordering and raises questions regarding its role in the superconducting pairing.

[1] D. Hafner et al., Phys. Rev. X, 12, 011023 (2022).

[2] B. Schmidt, P. Thalmeier, Phys. Rev. B 110, 075154 (2024).

TT 52.3 Wed 15:30 HSZ/0103

Pressure evolution of coplanar antiferromagnetism in heavy-fermion $\text{Ce}_2\text{CoAl}_7\text{Ge}_4$ — ●MUKKATTU O. AJEESH^{1,2}, ALLEN O. SCHEIE¹, YU LIU¹, LUCAS KELLER³, SEAN M. THOMAS¹, PRISCILA F. S. ROSA¹, and ERIC D. BAUER¹ — ¹Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA — ²Department of Physics, Indian Institute of Technology Palakkad, Kerala 678623, India — ³Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen CH-5232, Switzerland

$\text{Ce}_2\text{MAl}_7\text{Ge}_4$ ($M = \text{Co, Ir, Ni, or Pd}$) compounds are heavy-fermion materials that exhibit a variety of ground states ranging from magnetism to non-Fermi-liquid behavior. The Co, Ir, and Ni members undergo magnetic ordering with decreasing transition temperatures across the series. In contrast, the Pd compound shows no magnetic order down to 0.4 K and exhibits non-Fermi-liquid behavior, indicating proximity to a magnetic quantum critical point. Among these materials, $\text{Ce}_2\text{CoAl}_7\text{Ge}_4$ orders antiferromagnetically below $T_N = 1.9$ K and displays heavy-fermion behavior below 15 K. We investigated the magnetic structure of its antiferromagnetic phase along with the evolution of the magnetic transition under external pressure. Resistivity and calorimetry measurements under hydrostatic pressure reveal that T_N is suppressed to 1 K at $p \approx 1$ GPa, above which the transition abruptly disappears in a first order-like fashion. These results highlight that transition metal substitution is not merely a lattice volume effect akin to applied pressure; instead, carrier doping and anisotropic changes in lattice parameters likely play important role.

TT 52.4 Wed 15:45 HSZ/0103

Tuning the ground state of CePdAl by hydrogenation — HAILIANG XIA, JITONG SONG, HE SUN, ZHAOTONG ZHUANG, JUNSEN XIANG, SHUAI ZHANG, and ●PEIJIE SUN — Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

CePdAl is an antiferromagnetic heavy-fermion compound crystallizing in a geometrically frustrated Kagome lattice. We have succeeded in hydrogen doping the bulk single-crystalline CePdAl by an ionic liquid

gating technique, resulting in a large lattice expansion of the c axis by more than 20%. The hydrogen-doped sample CePdAlH_x is stable in air, and can be subject to various ex-situ transport, magnetic and thermodynamic measurements down to very low temperatures. Hydrogen distribution in CePdAl significantly alters the crystal electric field, reducing the Ising-like magnetic anisotropy, and the antiferromagnetic transition temperature T_N is reduced from 2.7 K to 1.1 K. Intriguingly, the Kondo effect remains almost intact. We discuss the results in view of a local and anisotropic negative pressure effect realized by hydrogenation.

TT 52.5 Wed 16:00 HSZ/0103

Intertwined magnetic and superconducting orders in $\text{Ce}_3\text{PtIn}_{11}$ — JAN FIKÁČEK¹, SARAH R. DUNSIGER², ANDREA D. BIANCHI³, MANUEL BRANDO⁴, LAURENT NICOLAI⁵, AKI PULKKINEN⁵, and ●JEROEN CUSTERS¹ — ¹Charles University, Faculty of Mathematics and Physics, Dept. Condensed Matter Physics, Prague, Czech Republic — ²Centre for Molecular and Materials Science, TRIUMF, Vancouver, Canada — ³Département de Physique, Université de Montréal, Montréal, Canada — ⁴Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ⁵New Technologies Research Centre, University of West Bohemia, Pilsen, Czech Republic

The heavy fermion compound $\text{Ce}_3\text{PtIn}_{11}$ exhibits intriguing low-temperature properties. At ambient pressure, it undergoes two successive antiferromagnetic (AFM) transitions at $T_{N1} = 2.2$ K and $T_N = 2.0$ K. Superconductivity (SC) emerges below $T_c = 0.32$ K (J. Prokleška *et al.*, Phys. Rev. B **92**, 161114(R) (2015)). The coexistence

of AFM and SC has been proposed, attributed to the presence of two inequivalent Ce sites whose distinct local environments may stabilize either magnetic or superconducting order. In this work, we focus on the superconducting state, presenting specific heat measurements and recent muon spin rotation experiments performed at ambient pressure down to 20 mK, complemented by band-structure calculations. Together, these results reveal signatures of an unconventional SC state coexisting with magnetism.

Work is supported by the Czech Ministry for Education, Youth and Sports program INTERCOST (Grant No. LUC24139).

TT 52.6 Wed 16:15 HSZ/0103

Coupling between Kondo effect and in-plane strain in YbRh_2Si_2 — ●SOURMENDRA NATH PANJA, JACQUES G. PONTANEL, JULIAN KAISER, ANTON JESCHE, and PHILIPP GEGENWART — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86159 Augsburg, Germany

We study symmetry-resolved elastoresistance in the tetragonal Kondo lattice YbRh_2Si_2 down to 2 K and in fields up to 14 T. By measuring longitudinal and transverse electrical transport response under applied in-plane uniaxial strain along [100] and [110], we extract the A_{1g} , B_{1g} , and B_{2g} elastoresistive responses. This is complemented by high-resolution in-plane thermal-expansion measurements utilizing a novel sample-mounting strategy for thin crystals in the capacitive dilatometer. Our results establish a thermodynamic link to the strain-dependent electronic behavior and highlight how Kondo hybridization couples to in-plane strain in this heavy-fermion system.

TT 53: Nonequilibrium Quantum Systems II (joint session TT/DY)

Time: Wednesday 15:00–17:30

Location: HSZ/0105

TT 53.1 Wed 15:00 HSZ/0105

Nonlocal Correlation Effects in the Relaxation Dynamics of the Photo-Excited Hubbard Model — ●GUSEIN BEDIRKHANOV¹, NAGAMALLESWARARAO DASARI², ALEXANDER I. LICHTENSTEIN², and EVGENY A. STEPANOV¹ — ¹CPHT, CNRS, École polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ²Institut für Theoretische Physik, Universität Hamburg, 22607 Hamburg, Germany

Experiments on ultrafast irradiation of correlated materials have revealed a variety of exotic nonequilibrium phenomena. A theoretical investigation of these phenomena requires methods capable of accurately describing a complex interplay between the non-perturbative local correlations and nonlocal collective electronic fluctuations throughout their relaxation pathway. A recently developed real-time nonequilibrium D - GW method allows for such a description by incorporating nonlocal charge and spin fluctuations diagrammatically, going beyond the dynamical mean-field theory solution. In this work, we apply D - GW to track the relaxation dynamics of a photo-excited Hubbard model across different interaction strengths, including the particularly challenging region near the Mott transition. To simulate the transfer of electronic energy to other degrees of freedom, we introduce controlled cooling by coupling the electronic system to various relaxation baths and compare their efficiency and physical implications. We analyze the emergent steady and metastable states, and investigate how interaction strength and nonlocal correlations shape the relaxation pathway.

TT 53.2 Wed 15:15 HSZ/0105

Optimizing energy conversion with nonthermal resources in steady-state quantum devices — ●ELSA DANIELSSON, HENNING KIRCHBERG, and JANINE SPLETTSTOESSER — Chalmers University of Technology, Sweden

In quantum transport, particle currents are investigated through quantum devices coupled to multiple contacts, which are defined by their electrochemical potentials and temperatures. However, when reaching the nanoscale, particles might no longer equilibrate with their thermal surroundings. Consequently, in the investigation of energy conversion processes, nonthermal distributions become highly relevant descriptors of the particles' environment. I will present how a nonthermal resource can be exploited to generate power or cool a contact and how to maximize the efficiency or precision for these processes. Utilizing coherent electron scattering, the optimization is made by adjusting the transmission probabilities of electrons at different energies. Importantly, we also address the issue of how to define an efficiency as

the energy current cannot be neatly divided into heat and work, due to the presence of a nonthermal resource. Based on this, we show that for a fixed output current the optimal transmission function is a series of band-passes in the energy spectrum, depending on the shape of the nonthermal distribution. When applying this result on example systems with nonthermal resources we find that all performance quantifiers improve compared to thermal counterparts. These findings highlight the importance of designing nanoelectronic devices according to the electron distributions their contacts.

TT 53.3 Wed 15:30 HSZ/0105

Excited State Phases of Matter in the SymTFT Paradigm — ●LUDWIG ZWENG^{1,2}, APOORV TIWARI³, and SANJAY MOUDGALYA^{1,2} — ¹Technical University of Munich, TUM School of Natural Sciences — ²Munich Center for Quantum Science and Technology (MCQST) — ³Southern Denmark University, Center for Quantum Mathematics at IMADA

Recent works have developed a unifying framework for classifying ground state phases of matter with a wide range of discrete symmetries—both group-like and non-invertible symmetries—via a holographic correspondence between symmetric operators in d dimensions and topological operators in a $d+1$ dimensional system often known as the SymTO or SymTFT. Its lattice formulation naturally yields fixed-point commuting Hamiltonians that realize these phases in their ground state. In this work, we extend this framework to nonequilibrium settings by analyzing excited states of these fixed-point models. Characterizing symmetry breaking patterns in the excited states requires new tools and diagnostic methods, which we develop to find that they can differ dramatically from their ground state counterparts, leading to a rich and sometimes surprising phenomenology. We illustrate these phenomena by constructing lattice models for a variety of invertible and non-invertible symmetries, classifying the distinct excited state phases that arise in each case. Finally, we propose a concrete definition of excited state phases of matter and argue that the SymTFTs that capture ground state phases do not fully capture the intricacies of the excited states.

TT 53.4 Wed 15:45 HSZ/0105

Improving the stability of the hierarchical equations of motion approach for generic bosonic spectral densities — ●SALVATORE GATTO, SAMUEL RUDGE, and MICHAEL THOSS — University of Freiburg

The hierarchical equations of motion (HEOM) constitute a numeri-

cally exact method for investigating the dynamics of open quantum systems across a wide range of environmental conditions [1]. In this contribution, we investigate the stability of HEOM for generic bosonic spectral densities and identify temperature- and coupling-dependent instabilities in the time evolution. We show that, upon increasing the system-bath coupling strength, the conventional HEOM formulation may become unstable, and that simply extending the hierarchy depth does not cure these long-time divergences [2]. Starting from the HEOM structure, we derive a multidimensional phase-space differential equation that generalizes the Quantum Fokker-Planck equation to arbitrary temperature [3]. We further demonstrate that expanding this new equation in an alternative basis removes the numerical instabilities inherent to the standard HEOM representation.

[1] J. Bätge, Y. Ke, C. Kaspar, M. Thoss, PRB 103, 235413 (2021)

[2] I. S. Dunn, R. Tempelaar, D. R. Reichman, J. Chem. Phys. 150, 184109 (2019)

[3] T. Li, Y. Yan, and Q. Shi, J. Chem. Phys. 156, 064107 (2022)

TT 53.5 Wed 16:00 HSZ/0105

Non-Local Correlation effects in DC and optical conductivity of the Hubbard model — NAGAMALLESWARARAO DASARI¹, HUGO STRAND², MARTIN ECKSTEIN¹, ALEXANDER LICHTENSTEIN¹, and ●EVGENY STEPANOV³ — ¹Universität Hamburg, Germany — ²Örebro University, Sweden — ³CPHT, CNRS, École polytechnique, France

Many-body effects in correlated materials can be explored through various response functions, with transport measurements being among the simplest and most direct probes. Accurately addressing the unconventional transport properties of materials requires accounting for spatial electronic correlations. These correlations can significantly influence transport characteristics by modifying the electronic spectral function and giving rise to complex multi-electron scattering processes, known as vertex corrections, which can both strongly impact the conductivity. In this talk, I will discuss the impact of non-local correlations on the conductivity of the single-band Hubbard model within the recently developed D-GW method [arXiv:2507.16673]. I will demonstrate that the impact of non-local correlations on the conductivity differs between the correlated metallic and Mott insulating phases. Incorporating non-local correlations in both the electronic spectral function and vertex corrections is crucial for accurately describing the optical conductivity at finite frequencies in both these regimes. The crossover between the metallic and Mott insulating phases can be identified by a vanishing contribution of vertex corrections to the DC conductivity.

15 min. break

TT 53.6 Wed 16:30 HSZ/0105

Conditioning Subsystem Magnetization into the Large-Deviation Regime in Quantum Spin Chains — ●KRITI BAWEJA¹, SAMUEL GARRATT², DAVID LUITZ¹, ALI ZAHRA^{3,4}, and JÉRÔME DUBAIL^{3,5} — ¹Institute of Physics, University of Bonn, Germany — ²Department of Physics, Princeton University, USA — ³Laboratoire de Physique et Chimie Théoriques, University of Lorraine, France — ⁴Centro de Análise Matemática, Departamento de Matemática, Universidade de Lisboa, Portugal — ⁵Centre Européen de Sciences Quantiques and ISIS, University of Strasbourg, France

We investigate the ground-state and finite-temperature properties of free-fermion and XXZ spin systems when a contiguous spatial region of the chain is conditioned to have a fixed value of its total S^z . We analyze how this conditioning operation reshapes the local magnetization profile and longitudinal spin-spin correlations both within the constrained region and in its surrounding environment. To access regimes beyond analytically tractable limits, we extend an existing post-measurement Quantum Monte Carlo (QMC) framework by introducing new update rules that enable efficient sampling of states with arbitrary subsystem magnetization. Using this post-measurement QMC approach, we probe the finite-temperature properties of these conditioned states and characterize how magnetization constraints modify local structure in both interacting and non-interacting spin models. Our results provide a computational tool for exploring measurement-induced constraints and conditioned ensembles in quantum many-body systems.

TT 53.7 Wed 16:45 HSZ/0105

Consistent quantum treatments of nonconvex kinetic energies

— CHRISTINA KOLIOFOTI, MOHAMMAD ATIF JAVED, and ●ROMAN-PASCAL RIWAR — Peter Grünberg Institut (PGI-2), Forschungszentrum Jülich, 52428 Jülich, Germany

The task of finding a consistent relationship between a quantum Hamiltonian and a classical Lagrangian is of utmost importance for basic, but ubiquitous techniques like canonical quantization and path integrals. Nonconvex kinetic energies (which appear, e.g., in nonlinear capacitors or classical time crystals) pose a fundamental problem: the Legendre transformation is ill-defined, and the more general Legendre-Fenchel transformation removes nonconvexity essentially by definition. Arguing that such anomalous theories follow from suitable low-energy approximations of well-defined, harmonic theories, we show that seemingly inconsistent Hamiltonian and Lagrangian descriptions can both be valid, depending on the coupling strength to a dissipative environment. There occurs a dissipative phase transition from a nonconvex Hamiltonian to a convex Lagrangian regime, involving exceptional points in imaginary time. Our approach thus resolves apparent inconsistencies and provides computationally efficient methods to treat anomalous, nonconvex kinetic energies.

TT 53.8 Wed 17:00 HSZ/0105

Lanczos-Pascal approach to correlation functions in chaotic quantum systems — ●MERLIN FÜLLGRAF, JIAOZI WANG, ROBIN STEINIGEWEG, and JOCHEN GEMMER — University of Osnabrück, Department of Mathematics/Computer Science/Physics, D-49076 Osnabrück, Germany

We suggest a method to compute approximations to temporal correlation functions of few-body observables in chaotic many-body systems in the thermodynamic limit based on the respective Lanczos coefficients. Given the knowledge of these Lanczos coefficients, the method is very cheap. Usually accuracy increases with more Lanczos coefficients taken into account, however, we numerically find and analytically argue that the convergence is rather quick, if the Lanczos coefficients exhibit a smoothly increasing structure. For pertinent examples we compare with data from dynamical typicality computations for large but finite systems and find good agreement if few Lanczos coefficients are taken into account. From the method it is evident that in these cases the correlation functions are well described by a low number of damped oscillations.

[1] Accepted in Phys. Rev. Lett.

TT 53.9 Wed 17:15 HSZ/0105

Many-body neural network wavefunction for a non-Hermitian Ising chain — ●LAVOISIER WAH — Max Planck Institute for the Science of Light, 91058 Erlangen, Germany

Non-Hermitian (NH) quantum systems have emerged as a powerful framework for describing open quantum systems, non-equilibrium dynamics, and engineered quantum optical materials. However, solving the ground-state properties of NH systems is challenging due to the exponential scaling of the Hilbert space, and exotic phenomena such as the emergence of exceptional points. Another challenge arises from the limitations of traditional methods like exact diagonalization (ED). For the past decade, neural networks (NN) have shown promise in approximating many-body wavefunctions, yet their application to NH systems remains largely unexplored. In this paper, we explore different NN architectures to investigate the ground-state properties of a parity-time-symmetric, one-dimensional NH, transverse field Ising model with a complex spectrum by employing a recurrent neural network (RNN), a restricted Boltzmann machine (RBM), and a multilayer perceptron (MLP). We construct the NN-based many-body wavefunctions and validate our approach by recovering the ground-state properties of the model for small system sizes, finding excellent agreement with ED. Then, for larger system sizes, we demonstrate that the RNN outperforms both the RBM and MLP. These results highlight the potential of neural network-based approaches - particularly for accurately capturing the low-energy physics of NH quantum systems both in case of weak and strong non-Hermiticity.

TT 54: Graphene: Electronic structure, excitations, etc. (joint session O/TT)

Time: Wednesday 15:00–17:45

Location: HSZ/0204

TT 54.1 Wed 15:00 HSZ/0204

Magneto-photoelectric effect in graphene via tailored potential landscapes — •FRIEDEMANN QUEISSER¹, JORIS JOSIEK^{1,2}, STEPHAN WINNERL¹, and RALF SCHÜTZHOLD^{1,2} — ¹Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — ²Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

We consider the propagation of charge carriers in planar graphene under the combined influence of a constant transversal magnetic field and an in-plane varying electric potential. By suitably designing the potential landscape, we may effectively steer charge carriers generated by photo-excitation, for example, in order to achieve an efficient charge separation. These findings may pave the way for transport schemes or photoelectric/photovoltaic applications. Funding by the DFG through the SFB 1242 is gratefully acknowledged.

TT 54.2 Wed 15:15 HSZ/0204

Topological obstruction in twisted bilayer graphene — FLO-RIE MESPLE¹, PIERRE MALLET², •GUY TRAMBLAY DE LAISSARDIÈRE³, CLEMENT DUTREIX⁴, GÉRARD LAPERTOT⁵, JEAN-YVES VEUILLEN², and VINCENT T. RENARD⁵ — ¹Dept. Physics, Univ. of Washington, Seattle, USA — ²CNRS, Univ. Grenoble Alpes, Inst. Néel, Grenoble, France — ³CY Cergy Paris Univ., CNRS, LPTM, Cergy-Pontoise, France — ⁴Univ. Bordeaux, CNRS, LOMA, Talence, France — ⁵Univ. Grenoble Alpes, CEA, IRIG, PHELIQS, Grenoble, France

The rich physics of magic angle twisted bilayer graphene (TBG) results from the Coulomb interactions of electrons in nearly flat bands of non-trivial topology [1]. Here [2], we perform STM/STS measurements on a moiré pattern generated in a TBG tilted by 4.3°, focusing on a point-like defect. We observe quasi-particle interferences (QPIs) resulting from intravalley backscattering between Dirac cones of graphene layers 1 and 2. Rationalized by tight binding calculations and T-matrix theory, our work shows that the QPIs are strongly impacted by the relative chirality of the Dirac cones of layer 1 and 2 in each valley. It establishes that, within a given moiré valley, the two Dirac cones have the same electronic chirality, as expected in the usual continuum model [3]. This peculiar topology leads to a topological obstruction.

[1] B. A. Bernevig, D. K. Efetov, *Physics Today* **77**, 38 (2024)

[2] F. Mesples, et al., arXiv:2506.08913 (2025)

[3] R. Bistritzer, A. H. MacDonald, *PNAS* **108**, 12233 (2011)

TT 54.3 Wed 15:30 HSZ/0204

Quasiparticle Interferences in 30°-twisted graphene quasicrystal — •JEAN-MAXIME SCHLACHTER¹, AHMED EL ALOUANI², VINCENT S. RENARD², ABHISHEK KARN¹, ILEANA FLOREA², STÉPHANE VÉZIAN², ADRIEN MICHON², CLEMENS B. WINKELMANN¹, and VINCENT T. RENARD¹ — ¹Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG, PHELIQS, 38000 Grenoble, France — ²CNRS-CRHEA, Université Côte d'Azur, rue B. Grégory, 06560 Valbonne, France

Quasicrystals are materials that have clean diffraction pattern but no translational symmetry. The advent of van der Waals stacking has opened the possibility to engineer quasicrystals. For example, the moiré pattern in 30°-twisted graphene bilayers has 12-fold rotational symmetry which is not compatible with translation symmetry in 2D, hence it is a quasicrystal (1). Studying this system gives insight into the behavior of Dirac fermions in 2D quasicrystals. ARPES experiments (2) demonstrated the existence of multiple Dirac cone replicas, originating from the incommensurate interlayer coupling. The goal of this study is to determine to what extent these Dirac cone replicas influence the electronic properties of the Dirac fermions. Our low temperature scanning tunneling microscope (STM) experiments evidence the replicated Dirac cones by specific patterns in the local density of states patterns associated with scattering between them, contrary to previous STM experiments (3).

(1) P. Moon et al., *Phys. Rev. B*, **99**, 16, :165430 (2019) ; (2) S. J. Ahn et al., *Science*, **361**, 6404, :782-786 (2018) ; (3) C. Yan et al., *2D Mater.*, **6**, 4, :045041 (2019)

TT 54.4 Wed 15:45 HSZ/0204

Machine Learning for Bandstructure-Structure Relationships in Doped Graphene — •BENEDICT SAUNDERS¹, LUKAS HÖRMANN^{1,2}, VALDAS VITARTAS¹, CHEN QIAN¹, and REINHARD J

MAURER^{1,2} — ¹University of Warwick, Coventry, United Kingdom — ²University of Vienna, Vienna, Austria

The introduction of topological defects or dopants to graphene's honeycomb lattice is a common approach to tuning the electronic and transport properties of the material to suit a specific application. Nitrogen is a widely investigated dopant, which can be introduced into the lattice in various configurations, each with a distinct effect on the material's bandstructure. However, due to the combinatorial explosion of possible dopant configurations, conventional first-principles screening of the electronic bandstructure for all possible configurations is not feasible. Here, we address this limitation by employing the recently developed MACE-H machine learning model to predict the electronic Hamiltonian of nitrogen-doped graphene configurations directly for a series of previously generated defect configurations. This allows us to rapidly generate accurate bandstructures and densities-of-states for large numbers of configurations, enabling the identification of structure-property relationships as a function of temperature and composition.

TT 54.5 Wed 16:00 HSZ/0204

Electronic structure of intercalated epitaxial graphene: A first principles study — •ANDRES UNIGARRO¹, FLORIAN GÜNTHER², and SIBYLLE GEMMING¹ — ¹Institute of physics, TU Chemnitz, Chemnitz, Germany — ²UNESP, Rio Claro, Brazil

Two-dimensional materials such as graphene are particularly intriguing due to their exceptional mechanical and electronic properties. A natural next step involves combining different 2D materials to form heterostructures with enhanced functionalities. In epitaxial graphene on silicon carbide (SiC), intercalation provides an effective means to tune the electronic, optical, and transport properties of graphene while preserving its honeycomb lattice. Moreover, intercalation enables the synthesis of otherwise unstable 2D layers. In particular, the intercalation of heavy elements such as Pb [1] and Bi [2] is especially promising, as these can introduce strong spin-orbit coupling (SOC) effects [3] (e.g. Rashba effect, gap opening) in graphene. In this work, we use first-principles calculations to investigate the electronic properties of heterostructures formed by Pb and Bi intercalation.

[1] Schölzel, Franziska, et al. *Small Structures* (2024), 2400338

[2] Tilgner, N., et al. *Nat Commun* **16**, (2025), 6171.

[3] Unigarro A., et al. *J. Phys. Chem. C* (2025), 129, 11, 5617-5624

TT 54.6 Wed 16:15 HSZ/0204

Domain-resolved electronic structure of AgTe-intercalated graphene on SiC(0001): From semiconducting Te-rich interlayer bands to metallic AgTe alloy states — •VIBHA REDDY¹, SAWANI DATTA¹, BHARTI MATTA¹, PHILIPP ROSENZWEIG², ULRICH STARKE¹, and KATHRIN KÜSTER¹ — ¹Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, — ²Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

Intercalation at the graphene/SiC(0001) interface provides a powerful route towards engineering the electronic properties of both the graphene and the intercalant. Here, we present the first realization of a transition-metal chalcogen alloy intercalated into the graphene/SiC(0001) interface via AgTe intercalation. The nominally AgTe-intercalated system segregates into multiple microscale intercalation phases, namely, Te-rich, Ag-rich and AgTe alloyed domains. Spatially-resolved and angle-resolved photoemission spectroscopy (ARPES) reveals that each domain exhibits distinct graphene doping levels and interlayer band dispersions, highlighting the strong interplay between local intercalation chemistry investigated by X-ray photoelectron spectroscopy (XPS) and electronic band structure. Given the intrinsic spin-orbit coupling and topologically non-trivial states associated with Te- and Ag-based 2D materials, the AgTe alloy-intercalated graphene represents a promising platform for realizing domain-specific emergent quantum phenomena, underscoring the chemical versatility and tunability of alloy-based heterostructures in interface engineering.

TT 54.7 Wed 16:30 HSZ/0204

Proximity-induced electronic states in epitaxial graphene/SiC (0001) via Sn intercalation — •HUU THOAI NGO¹, ZAMIN MAMIYEV¹, NIKLAS WITT^{2,3}, TIM WEHLING², and

CHRISTOPH TEGENKAMP¹ — ¹Solid Surface Analysis, Institute of Physics, Chemnitz University of Technology, Chemnitz, Germany — ²Institute of Theoretical Physics & Centre for Ultrafast Imaging, University of Hamburg, Hamburg, Germany — ³Institute for Theoretical Physics and Astrophysics, University of Würzburg, Würzburg, Germany

Intercalation of heavy elements at the buffer layer/SiC interface is an effective route to decouple it from the substrate while tailoring its electronic properties, for example, energy gap opening [1] and Mott insulating states [2]. In this work, we investigate the Sn-intercalated buffer layer using low-temperature STM/STS, supplemented by SPA-LEED, and DFT calculations. By precisely controlling the intercalation process, we obtain two distinct Sn phases beneath graphene: Sn(1×1) that induces Kekulé-O distortion, and honeycomb-Sn structure that gives rise to Moiré patterns. Remarkably, our STS results reveal a gap opening in Kekulé-O graphene due to Sn-induced sublattice symmetry breaking. In contrast, the honeycomb-Sn phase exhibits Mott insulating states. These findings demonstrate how Sn intercalants modify the structural and electronic properties of graphene at both nano- and microscale. [1] Ghosal, Tegenkamp, C. et al. Phys. Rev. Lett. 129, 116802 (2022). [2] Ghosal, Tegenkamp, C. et al. Phys. Rev. B 111, 235426 (2025).

TT 54.8 Wed 16:45 HSZ/0204

Doping monolayer graphene to the Van Hove singularity — •GUANGYAO MIAO¹, DANIEL JANSEN¹, BILAL HAWASHIN², JULIAN KLEESCHULTE², KATHARINA OFFERMANN¹, CHRISTIAN KRÄMER¹, AFFAN SAFEER¹, ABDALLAH KARAKA¹, JEISON FISCHER¹, THOMAS MICHELY¹, MICHAEL M. SCHERER², and WOUTER JOLIE¹ — ¹II. Physikalisches Institut, Universität zu Köln, Zùlpicher Straße 77, 50937 Cologne, Germany — ²Theoretische Physik III, Ruhr-Universität Bochum, D-44801 Bochum, Germany

Tuning correlated states in graphene is an intriguing topic, particularly since the experimental realization of superconductivity, correlated insulator states, and magnetic states in twisted-angle bilayer graphene near the magic angle, along with Van Hove singularities (VHSs) tuned to the Fermi level. Such correlated phenomena have also been predicted in monolayer graphene doped to its van Hove singularity. Motivated by this, we study the effect of Cs doping on a graphene monolayer on Ir(111) using MBE. A $\sqrt{3} \times \sqrt{3}$ superstructure is observed due to the Cs intercalations between graphene and Ir(111). Further deposition of Cs on top of graphene leads to the formation of several surface structures with varying Cs concentrations, including adatoms, stripes, and compact islands. Their morphology and electronic structures are revealed by scanning tunneling microscopy and spectroscopy at low temperature. By optimizing the dosage, we successfully tune the VHS to the vicinity of the Fermi level and observe a $2\sqrt{3} \times 2\sqrt{3}$ superstructure with respect to the graphene lattice. Possible origins of the superstructure related to many-body interactions will be discussed.

TT 54.9 Wed 17:00 HSZ/0204

Optimizing quantum transport in multi-barrier graphene systems using differential evolution — •LEON BROWNE and STEPHEN R. POWER — School of Physical Sciences, Dublin City University, Ireland

Potential and mass barriers in graphene introduce electron scattering, modulating transmission probabilities. Complex multi-barrier setups allow electron transmission to be controlled with high precision, but have a huge design space of possible barrier geometries. This work

presents a framework to optimize electronic transport in such systems using differential evolution algorithms. First, transfer matrix methods are employed to efficiently compute quantum transport through multi-barrier structures, before optimization is applied to find barrier configurations whose transmission profiles closely match a predefined target profile. To address the trade-off between the accuracy and complexity of resulting barrier configurations, regularization techniques are incorporated into the optimization process. Our approach demonstrates the potential for highly tunable electronic transport in graphene-based systems by exploiting evolution-inspired optimization techniques.

TT 54.10 Wed 17:15 HSZ/0204

Comparative study of plasmons in half-filled graphene via Quantum Monte Carlo and kinetic theory — MAKSIM ULYBYSHEV¹, •ADRIEN REINGRUBER¹, and KITINAN PONGSANGANGAN² — ¹Institut für Theoretische Physik und Astrophysik, Universität Würzburg — ²Department of Physics, Faculty of Science, Mahidol University, Bangkok

A quantitative description of hydrodynamic electronic transport in strongly correlated materials requires accurate knowledge of collective excitations such as plasmons, which can notably influence viscosity. In free-standing graphene, where long-range interactions are important, standard Dirac-cone perturbation theory misses important finite Brillouin-zone and strong-coupling effects. We investigate plasmons in half-filled free-standing graphene using unbiased Quantum Monte Carlo simulations. Our results reveal well-defined plasmon peaks near the Gamma-point, map their dispersion, and extract the momentum dependence of their quasiparticle residue. Comparing to perturbative predictions, we find substantial deviations arising from the interaction and lattice effects captured only beyond the Dirac approximation. These results underscore the need to incorporate such corrections in analytical theories of electronic transport in graphene.

TT 54.11 Wed 17:30 HSZ/0204

NanoARPES Facility in Shanghai Synchrotron Radiation Facility and Investigation of the Moiré bands in Graphene Devices — •ZHONGKAI LIU — ShanghaiTech University

Spatially resolved angle-resolved photoemission spectroscopy (NanoARPES) is an indispensable tool for probing the electronic structure of exfoliated sample flakes, fabricated devices, and more. In this presentation, we describe the construction, specifications, capabilities, and operation of BL07U-the NanoARPES endstation at the Shanghai Synchrotron Radiation Facility (SSRF) [1]. We will showcase our research on the electronic structure of emerging graphene devices, with a focus on moiré and flat bands. For example, our ARPES studies on magic-angle twisted trilayer graphene clearly reveal the coexistence of moiré flat bands and Dirac bands [2]. In aligned bilayer graphene/hBN heterostructures, we demonstrate that in-situ back gating enables precise tuning of the moiré electronic structure [3]. We directly observe the characteristic topological electronic structures of rhombohedral multilayer graphene, from a 3D generalization of the 1D Su-Schrieffer-Heeger (SSH) chain in thin layers to a topological Dirac nodal spiral semimetal in bulk rhombohedral graphite [4]. Finally, we present our work on the moiré band in bulk alternating twist graphene, which becomes flat at "magic momenta".

Reference: [1] H. Gao et al., Synchrotron Radiation News 37, 12-17 (2024) [2] Y. W. Li et al., Advanced Materials 202205996 (2022) [3] H. B. Xiao et al., Advanced Science 202412609 (2025) [4] H. B. Xiao et al., Science Bulletin 70, 1030-1033 (2025)

TT 55: Topology and symmetry protected materials & Topological insulators (joint session O/HL/TT)

Time: Wednesday 15:00–17:45

Location: HSZ/0401

TT 55.1 Wed 15:00 HSZ/0401

Majorana or Not? An Insight from Atomic-Scale Shot-Noise — ●ABHISHEK MAITI¹, GENDA GU², and FREEK MASSEE¹ — ¹Université Paris-Saclay, CNRS, Laboratoire de Physique des Solides, 91405, Orsay, France — ²Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory, Upton, NY, USA

The search for non-abelian states of matter has become a central theme of modern quantum material research. Notably, Majorana zero modes are of special interest, as they can serve as the foundation for topological qubits. A robust zero-bias conductance peak, observed in scanning tunneling spectra, is often regarded as the primary signature of a Majorana zero mode. Yet similar features can also arise from trivial bound states, raising a long-standing challenge of how to distinguish a genuine Majorana from imposters. In my talk, I will address this problem with a new approach, atomic-scale shot-noise spectroscopy, that goes beyond conductance measurements. Through a detailed investigation on multiple defect- and vortex-bound zero-bias states in the widely studied (putative) topological superconductor Fe(Se,Te), I will show that while differential conductance measurements might sometimes fail to detect an imposter Majorana state locally, noise measurements consistently provide a conclusive diagnostic, offering a powerful complementary probe. Looking ahead, this technique can be applied to other reported platforms to verify whether their Majorana-like signature in tunneling conductance can pass the shot-noise test.

TT 55.2 Wed 15:15 HSZ/0401

Intrinsic topological superconductivity revealed by surface-extended Andreev bound states in PtBi₂ — ●XIAOCHUN HUANG¹, LINGXIAO ZHAO², SEBASTIAN SCHIMMEL^{3,4}, JULIA BESPROSWANNY^{3,4}, PATRICK HÄRTL¹, CHRISTIAN HESS^{3,4}, BERND BÜCHNER^{4,5}, and MATTHIAS BODE¹ — ¹Experimentelle Physik 2, Physikalisches Institut, Universität Würzburg, Germany — ²Quantum Science Center of Guangdong, Shenzhen, China — ³Fakultät für Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, Germany — ⁴Leibniz-Institute for Solid State and Materials Research, Dresden, Germany — ⁵Technische Universität Dresden, Germany

Intrinsic topological superconductivity remains a central question in condensed-matter physics. The three-dimensional Weyl semimetal PtBi₂ was recently shown by angle-resolved photoemission spectroscopy to host a superconducting gap that opens exclusively on its Fermi-arc surface states with a nodal structure, establishing it as a prime candidate for intrinsic topological superconductivity [1]. Using scanning tunneling microscopy and spectroscopy, we directly visualize surface-extended Andreev bound states (ABSs) across atomically pristine terraces within a sizable superconducting gap ($\Delta > 10$ meV) in PtBi₂. Quantitative analysis of the tunneling spectra within an anisotropic chiral pairing framework identifies these ABSs as signatures of an emergent Majorana-cone dispersion. Our findings provide a definitive real-space spectroscopic fingerprint of intrinsic topological superconductivity in PtBi₂.

[1] A. Kuibarov *et al.*, *Nature* **626**, 294 (2024)

TT 55.3 Wed 15:30 HSZ/0401

Probing chiral symmetry with a topological domain wall sensor — ●ARTEM ODOBESKO¹, GLENN WAGNER², TITUS NEUPERT², RONNY THOMALE¹, and MATTHIAS BODE¹ — ¹Physikalisches Institut, Universität Würzburg, Würzburg, Germany — ²Department of Physics, University of Zurich, Zürich, Switzerland

Chiral symmetry is a fundamental property with profound implications for the properties of elementary particles, that implies a spectral symmetry (i.e. $E \rightarrow -E$) in their dispersion relation. In condensed matter physics, chiral symmetry is frequently associated with superconductors or materials hosting Dirac fermions such as graphene or topological insulators. There, chiral symmetry is an emergent low-energy property, accompanied by an emergent spectral symmetry. While the chiral symmetry can be broken by crystal distortion or external perturbations, the spectral symmetry frequently survives. As the presence of spectral symmetry does not necessarily imply chiral symmetry, the question arises how these two properties can be experimentally differentiated. Here, we demonstrate how a system with preserved spectral symme-

try can reveal underlying broken chiral symmetry using topological defects. Our study shows that these defects induce a spectral imbalance in the Landau level spectrum, providing direct evidence of symmetry alteration at topological domain walls. Using high-resolution STM/STS we demonstrate the intricate interplay between chiral and translational symmetry which is broken at step edges in topological crystalline insulator $\text{Pb}_{1-x}\text{Sn}_x\text{Se}$.

[1] G. Wagner *et al.*, *Newton* **1**, 100009 (2025)

TT 55.4 Wed 15:45 HSZ/0401

Quantifying quasiparticle chirality in a chiral topological semimetal — ●JIAJU WANG¹, AMIT KUMAR¹, MARKEL PARDO-ALMANZA¹, JAIME SANCHEZ-BARRIGA², JORGE CARDENAS-GAMBOA³, MAIA VERGNIORY³, VLADIMIR STROKOV⁴, MORITZ HOESCH⁵, CHANDRA SHEKHAR⁶, CLAUDIA FELSER⁶, STUART PARKIN¹, and NIELS SCHRÖTER¹ — ¹Max Planck Institute of Microstructure Physics, Halle (Saale), Germany — ²Helmholtz-Zentrum Berlin, Berlin, Germany — ³Donostia International Physics Center, San Sebastián, Spain — ⁴Paul Scherrer Institute, Villigen, Switzerland — ⁵Deutsches Elektronen-Synchrotron, Hamburg, Germany — ⁶Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Recently, electron chirality has been proposed as an order parameter to quantify chirality. In chiral topological semimetals with the B20 structure, electron chirality is linked to parallel spin-momentum locking (SML) and spin deviations from SML, which affects numerous physical properties. However, experimental quantification of spin deviation still remains a big challenge. To achieve this, we have used spin and angle-resolved photoemission spectroscopy to directly probe the spin texture of Weyl cones in RhSi, a chiral topological semimetal with strong spin-orbit coupling (SOC). The spin-resolved spectra at different azimuthal angles are intricately fitted to extract numerical values of spin deviation for Weyl cones, allowing us to calculate the normalized electron chirality density (NECD). It was found that deviations can decrease the NECD from 1 down to 0.8. This observation may help interpret physical phenomena in chiral topological semimetals.

TT 55.5 Wed 16:00 HSZ/0401

Topology and Real-Space Obstruction: The Phase Diagram of the Triangular p-Orbital Lattice — ●JONAS ERHARDT^{1,2}, SVEN SCHEMMELMANN³, FABIAN SCHÖTTKE³, JÖRG SCHÄFER^{1,2}, GIORGIO SANGIOVANNI^{2,4}, MARKUS DONATH³, and RALPH CLAESSEN^{1,2} — ¹Physikalisches Institut, Universität Würzburg — ²Würzburg-Dresden Cluster of Excellence ct.d.qmat — ³Physikalisches Institut, Universität Münster — ⁴Institut für Theoretische Physik und Astrophysik, Universität Würzburg

Triangular *p*-orbital monolayers (MLs) host a rich topological phase diagram governed by the competition between spin-orbit coupling (SOC) and substrate-induced inversion-symmetry breaking (ISB). The SOC-dominated quantum spin Hall insulator (QSHI) phase arises from a band inversion in the p_{\pm} manifold and was first realized in indenene, a triangular ML of In atoms on SiC [1]. Real-space interference shifts the associated Wannier centers away from the atoms to interstitial sites A/B, which for the QSHI phase produces an alternating ABAB energy sequence in the charge localization, as demonstrated by scanning tunneling microscopy (STM) [1]. Using the same STM approach, we identify the complementary ISB-dominated regime in a TI ML on Si(111), where strong adsorption-induced ISB exceeds TI's SOC. The charge likewise shifts off the atoms but evidences a non-alternating AABB sequence, characterizing TI/Si(111) as a trivial obstructed atomic insulator. These results complete the experimental validation of the topological phase diagram for triangular *p*-orbital MLs.

[1] *Nat. Commun.* **12**, 5396 (2021).

TT 55.6 Wed 16:15 HSZ/0401

Majorana-metal transition in a disordered superconductor: percolation in a landscape of topological domain walls — VLADIMIR A ZAKHAROV¹, ION COSMA FULGA^{2,3}, ●GAL LEMUT⁴, JAKUB TWORZYDŁO⁵, and CARLO W. J. BEENAKKER¹ — ¹Instituut-Lorentz, Universiteit Leiden, PO Box 9506, 2300 RA Leiden, The Netherlands — ²Institute for Theoretical Solid State Physics, IFW Dresden, Germany — ³Würzburg-Dresden Cluster of Excellence

ct.qmat, Dresden, Germany — ⁴Dahlem Center for Complex Quantum Systems and Physics Department, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — ⁵Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warszawa, Poland

Most superconductors are thermal insulators. A disordered chiral p-wave superconductor, however, can make a transition to a thermal metal phase. Because heat is then transported by Majorana fermions, this phase is referred to as a Majorana metal. Here we present numerical evidence that the mechanism for the phase transition with increasing electrostatic disorder is the percolation of boundaries separating domains of different Chern number. We construct the network of domain walls using the spectral localizer as a "topological landscape function", and obtain the thermal metal-insulator phase diagram from the percolation transition.

TT 55.7 Wed 16:30 HSZ/0401

fabrication and characterization of the Moiré surface state on a topological insulator — ●YI ZHANG — Shanghai Jiao Tong University, Shanghai, China

A Moiré* superlattice on the topological insulator surface is predicted to exhibit many novel properties but has not been experimentally realized. Here, we developed a two-step growth method to successfully fabricate a topological insulator Sb₂Te₃ thin film with a Moiré* superlattice, which is generated by a twist of the topmost layer via molecular beam epitaxy. The established Moiré* topological surface state is characterized by scanning tunneling microscopy and spectroscopy. By application of a magnetic field, new features in Landau levels arise on the Moiré* region compared to the pristine surface of Sb₂Te₃, which makes the system a promising platform for pursuing next-generation electronics. Notably, the growth method, which circumvents contamination and the induced interface defects in the manual fabrication method, can be widely applied to other van der Waals materials for fabricating Moiré* superlattices.

TT 55.8 Wed 16:45 HSZ/0401

Backscattering in topological edge states despite time-reversal symmetry — JONAS ERHARDT^{1,2}, ●MATTIA IANNETTI^{3,4}, FERNANDO DOMINGUEZ^{2,5}, EWELINA M. HANKIEWICZ^{2,5}, BJÖRN TRAUZETTEL^{2,5}, GIANNI PROFETA^{3,4}, DOMENICO DI SANTE⁶, GIORGIO SANGIOVANNI^{2,5}, SIMON MOSER^{1,2}, and RALPH CLAESSEN^{1,2} — ¹Physikalisches Institut, Universität Würzburg — ²Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg — ³Dipartimento di Scienze Fisiche e Chimiche, Università degli Studi dell'Aquila — ⁴CNR-SPIN C/o Dipartimento di Scienze Fisiche e Chimiche, Università degli Studi dell'Aquila — ⁵Institut für Theoretische Physik und Astrophysik, Universität Würzburg — ⁶Department of Physics and Astronomy, University of Bologna

Quantum Spin Hall Insulators (QSHI) are promising materials for many applications based on Dirac fermions and topologically-protected edge states. Indium adatoms on a silicon carbide surface, the so-called Indene, was the first material in which a topological classification solely based on an inspection of the bulk wave functions has been demonstrated. In this work, we present a combined experimental and theoretical study of finite-sized Indene systems, using STM/STS measurements and a quantitative tight-binding model revealing the rich physics of edge states. We find that a strongly non-linear edge dispersion leads to inter-Kramers pair backscattering, thereby extending the conventional understanding of backscattering protection in topological edge states.

TT 55.9 Wed 17:00 HSZ/0401

Quantized Subband Tunneling from Topological Insulator Nanowire Scanning Probe Tips — ●ABHISEK KOLE^{1,2}, FELIX MÜNNING^{3,4}, XIAOSHENG YANG^{1,5}, JIA G. LU⁶, OLIVER BREUNIG⁴, F. STEFAN TAUTZ^{1,2}, YOICHI ANDO⁴, and FELIX LÜPKE^{1,4} — ¹Peter Grünberg Institute (PGI-3), Forschungszentrum Jülich, 52425 Jülich, Germany — ²Institute for Experimental Physics IV A, RWTH

Aachen University, Otto-Blumenthal-Straße, 52074 Aachen, Germany — ³Institute of Physics I, Universität zu Köln, Zùlpicher Straße 77, 50937 Köln, Germany — ⁴Institute of Physics II, Universität zu Köln, Zùlpicher Straße 77, 50937 Köln, Germany — ⁵School of Optical and Electronic Information, Huazhong University of Science and Technology, Wuhan 430074, China — ⁶Department of Physics/Electrophysics, University of Southern California, Los Angeles, CA 90089, USA

In topological insulator nanowires, the interplay between size quantization and the surface states wrapping the nanowire circumference gives rise to a magnetic-flux-tunable band structure. We demonstrate the controlled fabrication of (Bi_{1-x}Sb_x)₂Te₃ (BST) topological insulator nanowires into scanning tunneling microscopy tips. Tunneling spectroscopy reveals a series of distinct peak-like features that exhibit a characteristic 1D DOS, indicating tunneling into the quantized 1D subbands of the BST nanowire tips. Furthermore, a magnetic-field-induced gap-closing and reopening transition is observed, consistent with the Dirac-like gap-closing transition expected for such wires. Moreover, we find indications of spin-selective helical tunneling between the nanowire tip and the Rashba surface states of Au(111).

TT 55.10 Wed 17:15 HSZ/0401

Simultaneous Characterization of Dispersion and Orbital Character of the Topological Surface State on the Topological Insulator Bi₂Te₃ — ●CHRISTOPH STEPHEN SETESCAK, ADRIAN WEINDL, and FRANZ JOSEF GIESSIBL — Universität Regensburg, D-93053 Regensburg

Scanning probe microscopy (STM and AFM) allows one to locally probe properties of topological insulators (TIs). On the compound Bi₂Te₃, atomic-scale electronic standing waves can be observed at crystalline step edges, which are associated with the hexagonal warping of the Dirac cone. These real-space oscillations provide a direct means to study the dispersion relation of the topological boundary mode. The interpretation relies on comparing the experimental data to calculations including not only the properties of the TI but also of the tip. In this framework, the tunneling current and differential conductance is modelled using Chen's derivative rule. Bending of the CO molecule at the tip apex due to lateral tip-sample forces is also included in the model. The relevant Bloch functions of the sample are obtained from Wannier-interpolated tight-binding Hamiltonians using maximally localized Wannier functions derived from first-principles DFT + GW computations. In combination with the high spatial resolution obtained with CO-terminated tips, not only the dispersion, but also the orbital character of the band structure can be probed.

TT 55.11 Wed 17:30 HSZ/0401

Defect-induced displacement of topological surface state in magnetic topological insulator MnBi₂Te₄ — ●FELIX LÜPKE^{1,2}, MAREK KOLMER^{3,4}, HENGXIN TAN⁵, ADAM KAMINSKI^{3,4}, and BINGHAI YAN^{5,6} — ¹Peter Grünberg Institute (PGI-3) and JARA-FIT, Forschungszentrum Jülich, 52425 Jülich, Germany — ²Universität zu Köln, Zùlpicher Straße 77, 50937 Köln, Germany — ³Ames National Laboratory, Ames, Iowa 50011, USA — ⁴Iowa State University, Ames, Iowa 50011, USA — ⁵Weizmann Institute of Science, Rehovot 7610001, Israel — ⁶The Pennsylvania State University, University Park, Pennsylvania 16802, USA

The gapped topological surface states of MnBi₂Te₄ (MBT) are an attractive platform for the realization of quantum anomalous Hall and Axion insulator states. However, experimentally observed surface state gaps fail to meet theoretical predictions, with the exact mechanism behind the gap suppression still being debated. We report on the effect of intrinsic anti-site defects on the MBT surface states, which we study using scanning tunneling microscopy (STM), angle-resolved photoemission (ARPES), and density functional theory (DFT). Our results show that high defect concentrations lead to a displacement of the surface states into the interior of the MBT crystal, consistent with theoretical predictions [PRL 130, 126702 (2023)].

TT 56: Superconductivity: Theory I

Time: Wednesday 15:00–18:30

Location: CHE/0089

TT 56.1 Wed 15:00 CHE/0089

Non-thermal pairing glue of electrons in the steady state — ●MICHELE PINI^{1,2}, CHRISTIAN H. JOHANSEN^{3,2}, and FRANCESCO PIAZZA^{1,2} — ¹University of Augsburg, Augsburg, Germany — ²MPI-PKS, Dresden, Germany — ³Pitaevskii BEC Center, CNR-INO and Department of Physics, Trento, Italy

The study of mechanisms for enhancing superconductivity has been a central topic in condensed matter physics due to the combination of fundamental and technological interests. One promising route is to exploit non-equilibrium effects in the steady state. Efforts in this direction have so far focused on enhancing the pairing mechanism known from thermal equilibrium through modified distributions for the electrons or the bosons mediating the electron-electron interaction. In this work, we identify an additional pairing mechanism that is active only outside thermal equilibrium. By generalizing Eliashberg theory to non-equilibrium steady states using the Keldysh formalism, we derive a set of Eliashberg equations that capture the effect of this genuinely non-thermal pairing glue even in the weak-coupling regime. We discuss two examples where this mechanism has a major impact. First, in a temperature-bias setup, we find that superconductivity is enhanced when the boson mediator is colder than the electrons. Second, we find that an incoherent drive of the boson mediator at energies much greater than the temperature pushes the system far from thermal equilibrium but leaves the critical coupling essentially unchanged, owing to a competition between electron heating and the enhancement of pairing by the non-thermal glue.

TT 56.2 Wed 15:15 CHE/0089

Critical behavior of the Superconducting Phase Transition in a Lattice Gauge Theory Approach — ●GRETA S. REESE^{1,2} and LUDWIG MATHEY^{1,2} — ¹The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — ²Center for Optical Quantum Technologies, University of Hamburg, 22761 Hamburg, Germany

We present a U(1) lattice gauge model to describe the superconducting phase transition of a type-II superconductor. Using the Landau Ginzburg free energy, we perform Monte Carlo simulations to investigate how the presence of a gauge field influences the nature of the phase transition. In particular, we study the effects of the gauge field on the Cooper pair density and the heat capacity.

TT 56.3 Wed 15:30 CHE/0089

Enhancing superconductivity using thermal bosons — ●EKATERINA VLASUK¹, EUGENE DEMLER², and RICHARD SCHMIDT¹ — ¹Institute for Theoretical Physics, Heidelberg University, Philosophenweg 16, 69120 Heidelberg, Germany — ²Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland

We investigate how the strong coupling of a superconductor to thermal bosons can enhance its superconducting critical temperature. To tackle this problem, we use a functional Renormalization Group (FRG) approach that allows us to describe the competition between the build-up of boson-induced attraction between fermions and diametral density fluctuations in the scattering channel between bosons and fermions. Thus self-consistently treating the mutual influence of bosonic and fermionic sectors allows us to uncover an increase of the critical temperature which is pronounced in the BCS limit but self-regulated as unitary fermion interactions are approached. Also, we find that the mutual influence leads to a nontrivial dependence of the critical temperature on the mass ratio between particles. We identify the regimes where our theory is applicable by investigating the phase diagram of enhanced/induced superconductivity for bosons being in either a condensed or thermal state. Moreover, we outline possible experimental realizations in cold atomic systems as well as discuss the implementation in an alternative solid-state platform - bilayer TMD materials - where excitons play the role of bosons.

TT 56.4 Wed 15:45 CHE/0089

Generalized condition for odd-frequency pairing in multiband materials — ●FLORIAN KAYATZ^{1,2}, ANNICA M. BLACK-SCHAFFER¹, and JORGE CAYAO¹ — ¹Department of Physics and Astronomy, Uppsala University, Box 516, SE-752 37 Uppsala, Sweden — ²WISE - allenberg Initiative Materials Science for Sustainability, Department of Physics and Astronomy, Uppsala University, Sweden

Odd-frequency superconductivity has been predicted to arise in various physical systems, including multiband materials, and is known to lead to phenomena such as the unusual Meissner response and long-range proximity effect [1]. The emergence of odd-frequency superconductivity is often explained in terms of a condition derived up to first order in the superconducting order parameter [2], leaving higher order corrections unaccounted. Here, we extend this analysis and derive the odd-frequency condition involving higher-order contributions of the order parameter, as well as a generalized expression valid to all orders. In addition, we explore the conditions for the emergence of odd-frequency correlations between individual bands. This allows us to identify cases where the structure of the Hamiltonian inherently forbids odd-frequency pairing. As an example, we apply our condition to a weakly coupled system consisting of a transition metal dichalcogenide monolayer proximitized by a conventional spin-singlet s-wave superconductor.

[1] J. Linder and A. V. Balatsky, *Rev. Mod. Phys.* **91**, 045005 (2019)[2] C. Triola, J. Cayao, A. M. Black-Schaffer *Ann. Phys.* **532**, 1900298 (2020)

TT 56.5 Wed 16:00 CHE/0089

Enhanced Superconductivity in Proximity to Peaks in Densities of States — ●JOSHUA ALTHÜSER¹, ILYA EREMIN², and GÖTZ S. UHRIG¹ — ¹TU Dortmund, Otto-Hahn-Straße 4, 44227 Dortmund, Germany — ²Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44801 Bochum, Germany

For the BCS theory of superconductivity, the electron-phonon interaction is transformed to an attractive electron-electron interaction in the vicinity of the Fermi energy only. An optimized transformation, however, reveals that the electrons attract one another whenever their energies do not differ more than the phonon energy ω_D . Consequently, the order parameter becomes finite even away from the Fermi energy. Intriguingly, an accumulation of density-of-states at an energy $\varepsilon_{\text{Peak}}$ in proximity to the Fermi energy induces a significant order parameter around $\varepsilon_{\text{Peak}}$, which easily exceeds the one at E_F for moderate coupling strengths. We predict measurable signatures in the thermodynamic and spectroscopic response of this unexpected phenomenon, guiding future experimental searches for it.

TT 56.6 Wed 16:15 CHE/0089

Fluctuation conductivity in multicomponent superconductors — ●SONDRE DUNA LUNDEMO and ASLE SUDBØ — Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

Multicomponent superconductors exhibit many properties that have no counterpart in single-component superconductors, ranging from Leggett modes to novel topological phase transitions. These features derive from the multiorbital character of the parent metallic state, and sometimes leave universal signatures in physical observables. In this talk, we scrutinize the electrodynamic response of such a metal as it approaches the superconducting critical point. In particular, we will elucidate whether the multicomponent character of the incipient superconducting order affects the electrical conductivity and highlight the importance of using a gauge-invariant approximation scheme for calculating it.

TT 56.7 Wed 16:30 CHE/0089

Constraints on the theoretical modeling of hole-doped La_2CuO_4 — ●QIWEI LI¹, HANIF HADIPOUR², XUE-JING ZHANG¹, and EVA PAVARINI¹ — ¹Peter Grünberg Institute, Forschungszentrum Jülich, 52428 Jülich, Germany — ²Department of Physics, University of Guilan, Rasht 41335-1914, Iran

The low-energy electronic properties of hole-doped La_2CuO_4 are believed to be well captured by the single-band Hubbard model describing x^2-y^2 electrons. This finds support, e.g., on Fermi surface and angle resolved photoemission experiments. Here we show [1] that this imposes constraints on the microscopic description of the system. Results are obtained via the LDA+DMFT method using a continuous time hybridization expansion Quantum Monte Carlo impurity solver, as implemented in [2].

[1] Q. Li, H. Hadipour, X.-J. Zhang, E. Pavarini, in preparation

[2] A. Flesch, G. Zhang, E. Koch, E. Pavarini, *PRB* **85**, 035124 (2012)

15 min. break

TT 56.8 Wed 17:00 CHE/0089

Superlinear Hall angle, magnetotransport, and superconductivity in solvable models for strange metals — ●DAVIDE VALENTINIS^{1,2}, AAVISHKAR A. PATEL^{3,4}, SUBIR SACHDEV⁵, and JOERG SCHMALIAN^{2,1} — ¹Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, Karlsruhe (DE) — ²Institute for Theoretical Condensed Matter physics, Karlsruhe (DE), Karlsruhe Institute of Technology — ³Center for Computational Quantum Physics, Flatiron Institute, New York (USA) — ⁴International Centre for Theoretical Sciences, Tata Institute of Fundamental Research, Bengaluru (IN) — ⁵Harvard University, Cambridge, MA (USA)

We provide exact numerical solutions from the Kubo formula for the DC magnetoconductivity tensor of the two-dimensional (2D) spatially disordered Yukawa-Sachdev-Ye-Kitaev (2D-YSYK) model on a square lattice, at first order in applied perpendicular magnetic field. This system describes fermions endowed with a Fermi surface and coupled to a bosonic scalar field through spatially random Yukawa interactions, which admit mean-field exact numerical solutions. From the interplay between YSYK interactions and square-lattice embedding, and the non-Boltzmann frequency dependent self energies, we find a superlinear evolution of the Hall-angle cotangent and the inverse carrier mobility with temperature, concomitant with linear-in-temperature resistivity, in an extended crossover regime above the low-temperature Marginal Fermi Liquid (MFL) ground state. In addition, a superconducting state with finite phase stiffness, mediated by the same YSYK interactions, emerges out of the MFL.

TT 56.9 Wed 17:15 CHE/0089

Achieving analogue states of high- T_c superconductivity with current quantum simulators — ●THOMAS KÖHLER and ADRIAN KANTIAN — SUPA, Institute of Photonics and Quantum Sciences, Heriot-Watt University, EH14 4AS Edinburgh, Scotland, United Kingdom

Employing the recently introduced matrix-product states plus mean-field method (MPS+MF) [Bollmark et al. 2020; 2023; 2025, Marten et al. 2023], we show how to realize the analogue of a high- T_c superconducting state in a t-J bi-plane lattice model with strongly enhanced inter-plane spin-spin coupling. Implementation of such systems using ultra cold atomic lattice gases has been demonstrated using metastable tilted Fermi-Hubbard systems [Hirthe et al. 2023]. We show that t-J bi-planes constructed in this way can achieve a critical temperature T_c for the onset of a correlated state analogous to high- T_c superconductivity that would be accessible within currently reachable entropy-per-particle. We further identify the optimal parameter regimes for such states to be realized, rule out the existence of any competing charge density wave-instabilities, and show how to unambiguously detect the onset of superconducting order.

TT 56.10 Wed 17:30 CHE/0089

Understanding and enhancing superconductivity in cuprates with low-energy Hamiltonians and explicit machine learning — ●JEAN-BAPTISTE MORÉE¹ and RYOTARO ARITA^{1,2} — ¹RIKEN Center for Emergent Matter Science, Wako, Saitama 351-0198, Japan — ²Department of Physics, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

Cuprate superconductors exhibit a wide range of transition temperatures $T_c \approx 6$ –166 K despite sharing a common electronic structure dominated by a Cu $3d_{x^2-y^2}$ -O $2p_\sigma$ antibonding orbital. Ab initio low-energy Hamiltonians combined with many-variable variational Monte Carlo have shown that T_c is primarily controlled by the nearest-neighbor hopping $|t_1|$ and the ratio $u = U/|t_1|$ (with U the onsite effective Coulomb repulsion), with only minor influence from longer-range terms. Applied pressure enhances T_c mainly by increasing $|t_1|$.

In this talk, I present recent progress [1] on the material dependence of these parameters using a new explicit, interpretable machine-learning approach. By analyzing structural and chemical descriptors across 36 cuprates, the algorithm reveals that $|t_1|$ increases when ionic radii in the block layer are reduced, while u can be tuned through the ionic charges. These results provide simple, physically transparent guidelines for designing cuprates with enhanced superconducting properties.

[1] J.-B. Morée and R. Arita, Phys. Rev. B **110**, 014502 (2024).

TT 56.11 Wed 17:45 CHE/0089

Strong-coupling superconductivity near Gross-Neveu quantum criticality in Dirac systems — ●VERONIKA STANGIER¹, DANIEL SHEEHY², and JÖRG SCHMALIAN¹ — ¹Karlsruhe Institute for Technology, Karlsruhe, Germany — ²Louisiana State University, Baton Rouge, USA

We investigate superconductivity in two-dimensional massless Dirac fermions at charge neutrality, coupled to bosonic collective modes via a Yukawa interaction. Despite the absence of carriers at zero temperature, we uncover the surprising possibility that such systems can become superconducting near a Gross-Neveu quantum critical point. Remarkably, superconductivity emerges precisely when the fermionic excitations lose coherence - once their anomalous dimension in the normal state becomes sufficiently large. In other words, well-defined quasiparticles fail to superconduct, whereas strongly incoherent ones can. To capture this behavior, we develop a general framework for four-component Dirac systems and derive explicit algebraic criteria for the onset of pairing. Within this description, different bosonic modes - classified by their transformation under time-reversal and internal symmetries - select distinct superconducting channels. We then apply this approach to Dirac models of spin-orbit-coupled systems with orbitals of opposite parity and extend it to analyze superconductivity in moiré Dirac materials such as double-bilayer WSe₂ and twisted bilayer graphene.

TT 56.12 Wed 18:00 CHE/0089

Chiral superconductivity in time-reversal symmetry broken honeycomb systems — ●LUCCA MARCHETTI¹, MATTHEW BUNNEY^{1,2}, and STEPHAN RACHEL¹ — ¹School of Physics, University of Melbourne, Melbourne, Australia — ²Institute for Theoretical Solid State Physics, RWTH Aachen University, Aachen, Germany

Rhombohedral graphene — stacked graphene layers in the ABC configuration — has emerged as an exciting playground for strongly correlated physics and superconductivity. Recent experiments on N-layer rhombohedral graphene reveal signatures of spin-valley polarised Fermi surfaces. Probes at low temperature exhibit several regions of superconductivity, with signs of chiral triplet pairing states.

To better discern how broken symmetries in the normal state affect underlying many-body states we focus on 2D single-layer honeycomb systems in the presence of various symmetry breaking terms. We employ the truncated-unity functional renormalization group technique to analyse the leading instabilities of the associated Hubbard model. We discuss how the different broken symmetries affect the resulting superconductivity, and the implications this has for chiral and/or triplet pairing states. We further characterise the superconducting states in a topological context through calculation of Chern number landscapes, where we find regions of topological superconductivity.

TT 56.13 Wed 18:15 CHE/0089

A universal route to chiral Ising superconductivity in monolayer TaS₂ and NbSe₂ — ●LUCIA GIBELLI¹, SIMON HÖCHERL¹, JULIAN SIEGL¹, VILIAM VANO², SOMESH C.GANGULI², MAGDALENA MARGANSKA³, and MILENA GRIFONI¹ — ¹University of Regensburg, Germany — ²University of Aalto, Finland — ³University of Science and Technology, Wroclaw

Ising superconductivity in two archetypal intrinsic superconductors, monolayer 1H-TaS₂ and 1H-NbSe₂, is investigated in a bottom-up approach [1]. Using ab initio-based tight-binding parameterizations for the relevant low-energy d -bands, the screened interaction is evaluated microscopically, in a scheme including Bloch overlaps. In direct space, the screened potential displays for both systems long-range Friedel oscillations alternating in sign. Upon scaling, the oscillation pattern becomes universal, with the location of minima and maxima locked to the lattice. Solving the momentum-resolved gap equations, a chiral ground state with p -like symmetry is generically found. Due to the larger Ising spin-orbit coupling, the chiral gap is more anisotropic in TaS₂ than in NbSe₂. This is reflected in tunneling spectra displaying V-shaped features for the former, in quantitative agreement with low-temperature scanning tunneling experiments on TaS₂. At the same time, our results reconcile the apparent discordance with hard gap tunneling spectra reported for the sibling NbSe₂ [2]. They also agree with recent top-down calculations on the same material.

[1] L. Gibelli et al., arXiv:2509.05784 (2025)

[2] J. Siegl et al., Nature Communications, 16(1):8228 (2025)

TT 57: Correlated Magnetism – Kagome Systems

Time: Wednesday 15:00–18:15

Location: CHE/0091

TT 57.1 Wed 15:00 CHE/0091

Probing Spin Dynamics and Hyperfine Coupling in the Frustrated Quantum Magnet Clinoatacamite: An NMR Study —

•RONI BOSE¹, HANS-JOACHIM GRAFE¹, BERND BÜCHNER¹, ANJA U. B. WOLTER¹, LEONIE STÖDTER³, CAROLINE KASTNER², and STEFAN SÜLLOW² — ¹IFW Dresden, Helmholtzstraße 20, 01069, Germany — ²IPKM, TU Braunschweig, Braunschweig, Germany — ³FZ Jülich, JCNS at MLZ, Garching, Germany

Recent work on Atacamite reveals a quantum critical point above 21.9 T with a dimensional reduction from 3D AFM ordering to 1D quantum spin liquid behavior. Clinoatacamite has same chemical formula as Atacamite, but displays distinct magnetic behaviour due to different crystal structure. Previous μ SR studies on polycrystals reveal coexistence of long range magnetic ordering and fluctuations below 18 K, which transforms into a metastable state below 6.5 K, while neutron-diffraction observes magnetic reflections only below 6.5 K, but not below 18 K.

To address the discrepancy in reported ordering temperatures and to investigate the magnetic behaviour below 18 K, we performed ¹H-NMR measurements with magnetic field orientations $B \parallel [201]$ (perpendicular to the Kagome plane) and $B \parallel [010]$. For both field directions, the NMR spectra show splittings near 18 K and again near 6 K, indicating magnetic transitions. Furthermore, the temperature dependence of the spin-lattice relaxation rate at different proton sites reveals a coexistence of partial spin freezing and strong fluctuations below 18 K, followed by a fully ordered state below 6 K.

TT 57.2 Wed 15:15 CHE/0091

Competing ordering modes in the distorted quantum Kagome material clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ —

•LEONIE STÖDTER^{1,2}, CAROLINE KASTNER¹, HARALD O. JESCHKE³, MANFRED REEHUIS⁴, KETTY BEAUVOIS⁵, BACHIR OULADDIAF⁵, EDMOND CHAN⁵, FABIANO YOKAICHIYA⁴, FABRICE BERT⁶, THOMAS J. HICKEN⁷, JONAS A. KRIEGER⁷, HUBERTUS LUETKENS⁷, JACKSON L. ALLEN⁸, RALF FEYERHERM⁴, MICHAEL TOVAR⁴, DIRK MENZEL¹, ANJA U. B. WOLTER⁹, KIRILY C. RULE¹⁰, F. JOCHEN LITTERST¹, ULRICH K. RÖSSLER⁹, and STEFAN SÜLLOW¹ — ¹IPKM, TU Braunschweig, Braunschweig, Germany — ²FZ Jülich, JCNS at MLZ, Garching, Germany — ³RIIS, Okayama University, Okayama, Japan — ⁴HZB, Berlin, Germany — ⁵ILL, Grenoble, France — ⁶SQM, Université Paris-Saclay, Orsay, France — ⁷PSI, Villigen, Switzerland — ⁸ISEM, University of Wollongong, Australia — ⁹Leibniz IFW Dresden, Dresden, Germany — ¹⁰ANSTO, Lucas Heights, Australia

Structurally, the mineral clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ is closely related to the Kagome material herbertsmithite $\text{ZnCu}_3\text{Cl}_2(\text{OH})_6$, however, its Kagome motif of Cu sites is embedded into a low-symmetry crystal structure. The magnetic ground states of clinoatacamite below an ordering temperature of 18.1 K have remained inconclusive to date. Here, we revisit the magnetic properties using single-crystalline material. We have characterized clinoatacamite by means of thermodynamic measurement techniques, μ SR as well as neutron diffraction. We reveal a complex zero-field sequence of phases and discuss our data within a scenario of competing antiferromagnetic ordering modes.

TT 57.3 Wed 15:30 CHE/0091

High-field μ SR on the frustrated quantum magnet clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ —

•CAROLINE KASTNER¹, FABRICE BERT², ANDRIN DOLL³, THOMAS J. HICKEN³, JONAS A. KRIEGER³, HUBERTUS LUETKENS³, DIRK MENZEL¹, F. JOCHEN LITTERST¹, LEONIE STÖDTER⁴, KIRILY C. RULE⁵, ANJA U. B. WOLTER⁶, and STEFAN SÜLLOW¹ — ¹IPKM, TU Braunschweig, Braunschweig, Germany — ²SQM, Université Paris-Saclay, Orsay, France — ³PSI, Villigen, Switzerland — ⁴FZ Jülich, JCNS at MLZ, Garching, Germany — ⁵ANSTO, Lucas Heights, Australia — ⁶Leibniz IFW Dresden, Dresden, Germany

The natural mineral clinoatacamite $\text{Cu}_2\text{Cl}(\text{OH})_3$ is a distorted Kagome system with antiferromagnetic in-plane couplings of the order of a few hundred K and ferromagnetic interplane couplings of the order of a few tens of K. This dominance of the antiferromagnetic couplings within the Kagome planes establishes clinoatacamite as a frustrated quantum magnet in its own right. In recent years, we have extensively characterized the complex magnetic phase diagram of clinoatacamite

which contains a sequence of magnetic transitions of unknown symmetry. In particular, we have performed a detailed μ SR study in zero magnetic field, thus characterizing the different magnetic regions below $T_N = 18.1$ K using this experimental technique.

To provide further insight into the microscopic details of the different magnetic regions we now have performed a μ SR study on single-crystalline clinoatacamite in high magnetic fields up to 6.5 T and will discuss the results in this presentation.

TT 57.4 Wed 15:45 CHE/0091

Pathway to the ground state in Kagome spin ice HoAgGe —

•PHILIPP GEGENWART — Lehrstuhl für Experimentalphysik VI, Universität Augsburg

HoAgGe represents the first crystalline realization of Kagome spin ice and displays striking fractionalized plateau states in magnetic and transport experiments [1,2]. We report single crystal neutron diffuse scattering to map the pathway from paramagnetism via partial order to the Kagome spin ice ground state [3]. The symmetry-broken nature of the latter is evidenced by the nonlinear magnetic susceptibility.

[1] K. Zhao, H. Deng, H. Chen, K.A. Ross, V. Petricek, G. Günther, M. Russina, V. Hutnanu, P. Gegenwart, Science 367, 1218 (2020)

[2] K. Zhao, Y. Tokiwa, H. Chen, P. Gegenwart, Nat. Phys. 20, 442 (2024)

[3] K. Zhao, H. Deng, H. Chen, N. Ma, N. Oefele, J. Guo, X. Cui, Ch. Tang, M. J. Gutmann, T. Mueller, Y. Su, V. Hutnanu, Ch. Jin, P. Gegenwart, arXiv:2505.22544

TT 57.5 Wed 16:00 CHE/0091

Pressure-tuned Kagome spin liquid in Herbertsmithite

$\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$ — •VICTORIA GINGA¹, RODOLFO A. RANGEL HERNANDEZ¹, BIN SHEN², LOUIS STEIN³, ECE UYKUR³, PHILIPP GEGENWART², and ALEXANDER A. TSIRLIN¹ — ¹Felix Bloch Institute, University of Leipzig, Germany — ²EP VI, EKM, University of Augsburg, Germany — ³Helmholtz-Zentrum Dresden-Rossendorf, Germany

Herbertsmithite is a benchmark $S = 1/2$ Kagome quantum spin-liquid candidate. At ambient pressure, our magnetization data confirm the absence of long-range order down to 2 K while revealing a low-field spin-freezing that is suppressed by moderate fields. High-pressure single-crystal diffraction shows that the trigonal structure remains stable up to 22 GPa, beyond which the material becomes amorphous. Whereas an earlier study [1] reported non-monotonic changes in Cu-O distances and Cu-O-Cu angles near 2.5 GPa concomitant with pressure-induced T_N around 6 K, our high-pressure structural data show no such behavior. Our pressure-dependent magnetization up to 4.2 GPa shows no transition, while spin freezing persists with an almost constant freezing temperature of 7 K. Using experimentally determined high-pressure structures, we quantify exchange couplings via DFT and map how the dominant interactions evolve with bond geometry. Our findings show that, to at least 4.2 GPa, Herbertsmithite preserves its quantum-disordered ground state and provides a reference framework for pressure tuning in Kagome spin-liquid candidates.

[1] Phys. Rev. Lett. 108, 187207

TT 57.6 Wed 16:15 CHE/0091

Anisotropic Transient Reflectivity Observed in Fe-Sn Kagome Binary Compounds —

•MARCOS VINICIUS GONCALVES FARIA^{1,2}, ALEXEJ PASHKIN¹, STEPHAN WINNERL¹, MANFRED HELM^{1,2}, HECHANG LEI³, QI WANG³, JURE DEMSAR⁴, CHANDRA KOTYADA⁴, LILIAN PRODAN⁵, ISTVÁN KÉZSMÁRKI⁵, and ECE UYKUR¹ — ¹Helmholtz-Zentrum Dresden-Rossendorf — ²Technische Universität Dresden — ³Renmin University of China — ⁴Johannes Gutenberg University Mainz — ⁵Universität Augsburg

In this work, we investigate the interlayer coupling in Fe-Sn Kagome binaries using ultrafast transient reflectivity. Previous pump-probe studies have revealed that many Kagome metals exhibit similar relaxation features when probing the Kagome plane. However, the ultrafast response changes significantly by moving the probe direction from in-plane to out-of-plane, which we ascribe to the confinement of localized carriers in the Kagome layers. Such anisotropic behavior is consistent with what has also been observed with resistivity and broadband optics. The strong coupling between the Kagome layers shows that the single-Kagome layer approximation is not sufficient to describe the

physics in this material family.

Beyond electronic anisotropy, the presence of magnetism, CDW and other lattice instabilities can strongly influence the nonequilibrium response of Kagome metals. Fe_3Sn and Fe_3Sn_2 are systems where there is an in-plane breathing mode and a coherent optical phonon can be excited. However, for FeSn , which has a pristine Kagome lattice, no coherent phonon could be observed.

15 min. break

TT 57.7 Wed 16:45 CHE/0091

Many-body interference in Kagome crystals — ●CHUNYU GUO¹, KAIZE WANG¹, LING ZHANG¹, CARSTEN PUTZKE¹, DONG CHEN², TAKASHI OKA³, RODERICH MOESSNER⁴, MARK FISCHER⁵, TITUS NEUPERT⁵, CLAUDIA FELSER², and PHILIP MOLL¹ — ¹Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — ²Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ³The Institute for Solid State Physics, The University of Tokyo, Kashiwa, Japan — ⁴Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ⁵Department of Physics, University of Zurich, Zurich, Switzerland

When electrons in metals act collectively, they create emergent phenomena that exceed the behavior of individual particles. We present experimental evidence of coherent charge transport in the normal state of the Kagome metal CsV_3Sb_5 . This is evidenced by magnetoresistance oscillations in mesoscopic crystalline pillars under in-plane magnetic fields, with periodicity determined by magnetic flux quanta, h/e , between adjacent Kagome layers, resembling an interlayer Aharonov-Bohm interferometer. The oscillation amplitude also correlates directly with other unusual electronic responses in CsV_3Sb_5 , suggesting an intrinsic coherence mechanism. These findings shed light on the debated nature of correlated order in Kagome metals, positioning CsV_3Sb_5 as a unique platform for long-range coherent charge transport outside of superconductivity, and opening new avenues for understanding coherence in correlated electron systems.

TT 57.8 Wed 17:00 CHE/0091

Correlation effects in extended Kagome Hubbard models — ●ALON STRUGATSKY and ROSER VALENTI — Goethe-Universität Frankfurt, Frankfurt am Main, Germany

Kagome materials display a rich interplay of topology, strong electronic correlations, and lattice dynamics. Recently, attention has focused on a class of Kagome metals whose nearly flat bands sit close to the Fermi level. Examples include FeGe , CsV_3Sb_5 , YbCr_6Ge_6 . Such systems are natural hosts for flat-band phenomena (for instance, flat-band ferromagnetism and unconventional superconductivity), but their large density of states makes perturbative diagrammatic approaches challenging. Here, we present a systematic study using dynamical mean-field theory (DMFT) and cluster DMFT on an extended Kagome Hubbard model, and map the phase diagram at various fillings.

TT 57.9 Wed 17:15 CHE/0091

Emergent Network of Josephson Junctions in a Kagome Superconductor — ●TYCHO BLOM¹, MATTHIJS ROG¹, MARIEKE ALTEA², ANDREA CAPA SALINAS³, STEPHEN WILSON³, MILAN ALLAN^{1,4}, CHUAN LI², and KAVEH LAHABI¹ — ¹Huygens-Kamerlingh Onnes Laboratory, Leiden University, 2300 RA Leiden, The Netherlands — ²MESA+ Institute for Nanotechnology, University of Twente, 7500 AE, Enschede, The Netherlands — ³Materials Department, University of California Santa Barbara, Santa Barbara, California 93106, USA — ⁴Munich Center for Quantum Science and Technology (MC-QST), Ludwig-Maximilians- University Munich, Munich 80799, Germany

Materials with a Kagome lattice are intensely studied because they host exotic states that combine strong correlations and topology. In this talk, I will describe several unique phenomena that are observed in the Kagome superconductor $\text{CsV}_3\text{Sb}_{5-x}\text{Sn}_x$ ($x = 0.03-0.04$), and show that a network of Josephson junctions spontaneously emerges below the transition temperature in thin, homogeneous flakes. Using magnetotransport experiments under both DC and radio frequency current bias, I will demonstrate that the junctions are localized and stable, and that supercurrent must flow in filaments. These results pave the way for determining the exact nature of superconductivity in the AV_3Sb_5 family.

TT 57.10 Wed 17:30 CHE/0091

Unconventional gap structure in Kagome superconductor

coupled to hybrid microwave resonators — ●YEJIN LEE, HAOLIN JIN, BERIT GOODGE, EDOUARD LESNE, SUSHMITA CHANDRA, and URI VOOL — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Kagome superconductors have been recently discovered, offering a rich platform to study strongly correlated systems, including superconductivity, charge density wave, and time reversal symmetry broken states, and their electronic properties, featuring flat bands and van Hove singularities. Finding a pairing symmetry is crucial to understand the quantum phases interplay. Despite numerous experimental efforts focused on bulk crystals, there is no consensus for microscopic origin so far. Additionally, van der Waals flakes show distinct phases that are hard to probe with conventional methods. Superconducting microwave resonator is highly sensitive to detect the kinetic inductance and allows for studying the microwave response when hybridized with vdW layered flakes. Using this technique we investigate the pairing symmetry of the Kagome superconductor. We fabricate the CVS flake-coupled circuits with cryogenic transfer method, which preserves the pristine property and atomically sharp interface. We find any disorder in the flake disrupts coupling in the circuits that hinders the investigation of the low temperature properties. The temperature dependent resonance frequency shows a linear behavior, which deviate from a conventional fully gapped structure. The linear dependence is a signature for a nodal structure, as a hallmark of unconventional superconductivity.

TT 57.11 Wed 17:45 CHE/0091

Superconductivity in Kagome metals due to soft loop-current fluctuations — ●DANIEL SCHULTZ¹, GRGUR PALLE², ASIMPUNYA MITRA³, YONG-BAEK KIM³, RAFAEL FERNANDES², and JÖRG SCHMALIAN¹ — ¹Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²Department of Physics, The Grainger College of Engineering, University of Illinois Urbana-Champaign, Urbana, Illinois 61801, USA — ³Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7, Canada

We demonstrate that soft fluctuations of translation symmetry-breaking loop currents provide a mechanism for unconventional superconductivity in Kagome metals that naturally addresses the multiple superconducting phases observed under pressure. Focusing on the rich multi-orbital character of these systems, we show that loop currents involving both vanadium and antimony orbitals generate low-energy collective modes that couple efficiently to electrons near the Fermi surface and mediate attractive interactions in two distinct unconventional pairing channels. While loop-current fluctuations confined to vanadium orbitals favor chiral $d+id$ superconductivity, which spontaneously breaks time-reversal symmetry, the inclusion of antimony orbitals stabilizes an s^\pm state that is robust against disorder. We argue that these two states are realized experimentally as pressure increases and the antimony-dominated Fermi surface sheet undergoes a Lifshitz transition.

TT 57.12 Wed 18:00 CHE/0091

Strain Tuning of the Kagome Metal GdV_6Sn_6 — ●FRANCISCO LIEBERICH^{1,2}, GANESH POKHAREL³, STEPHEN WILSON⁴, and ELENA GATI^{1,2,5} — ¹MPI-CPFS, Dresden, Germany — ²TUD, Dresden, Germany — ³UWG, Georgia, USA — ⁴UCSB, Santa Barbara, USA — ⁵Goethe Universität, Frankfurt, Germany

Kagome metals are a fertile ground for exotic states of matter, driven by the interplay of nontrivial band topology and strong correlation effects [1]. In the RV_6Sn_6 series, alternating rare-earth (R) triangular-lattice and V Kagome layers generate a unique environment for exploring the interaction of correlated topological behavior with magnetic frustration. GdV_6Sn_6 , in particular, exhibits strong coupling between Gd local magnetic moments and Kagome-plane itinerant electrons [2], giving rise to a fascinating interplay of commensurate and incommensurate spin modulations under applied magnetic field [3]. In this talk, we discuss the effects of uniaxial pressure, which lifts the inherent lattice frustration, on the thermodynamic properties of GdV_6Sn_6 . Using high-resolution elastocaloric effect [4] measurements we establish a rich phase diagram and show that the balance of commensurate and incommensurate spin modulations is highly tunable by uniaxial pressure. These findings highlight the exceptional sensitivity of magnetic Kagome metals to lattice tuning by uniaxial pressure.

[1] Sante *et al*, arXiv:2511.12731 (2025)

[2] Ishikawa *et al*, JPSC 90, 124704 (2021)

[3] Porter *et al*, PRB 108, 035134 (2023)

[4] Ikeda *et al*, RSI 90, 083902 (2019)

TT 58: Quantum Transport and Quantum Hall effects (joint session HL/TT)

Time: Wednesday 15:00–16:15

Location: POT/0006

TT 58.1 Wed 15:00 POT/0006

High Harmonic Hall Currents Driven by Curved Conducting Nanoarchitecture — •CHING-HAO CHANG^{1,2}, BOTSZ HUANG^{1,2}, WEI-XIANG YIN^{1,2}, and XIAO ZHANG³ — ¹Department of Physics, National Cheng Kung University Tainan, Taiwan — ²Center for Quantum Frontiers of Research and Technology (QFort), National Cheng Kung University Tainan 70101, Taiwan — ³Institute for Theoretical Solid State Physics Leibniz Institute for Solid State and Materials Research Dresden Helmholtzstr. 20, D-01069 Dresden, Germany

We theoretically establish a realizable non-perturbative mechanism for generating high harmonic ics (up to 6th order) in Hall currents within curved two-dimensional nanoarchitectures. Unlike previously explored perturbative mechanisms based on inversion symmetry breaking or Berry curvature, the high-harmonic generation demonstrated here is driven by magnetic-field dipoles induced purely by nanoscale curvature under an applied uniform magnetic field. We develop a theory showing that these harmonics originate from unique snake orbits induced by the interplay between an alternating electric field and curvature-induced magnetic-field dipole. Moreover, we establish quantitative control over harmonic suppression and enhancement by tuning the amplitude and orientation of the magnetic field, uncovering distinct symmetry-based even/odd harmonic selection rules. These findings provide a tunable platform for engineering nonlinear currents in curved electronics, with potential applications in developing high-frequency Hall sensors and THz devices.

TT 58.2 Wed 15:15 POT/0006

Gate-tunable isospin switching in graphene Mach-Zehnder electronic interferometers — •ANTONIO LACERDA-SANTOS, LILIAN SEYVE, YASSINE SETTI, BIKASH BARIK, LEO PUGLIESE, PREDEN ROULLEAU, and COSIMO GORINI — SPEC, CEA, CNRS, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

Graphene has become an exciting platform for electron (quantum) optics experiments [1]. Compact electronic interferometers can be realised via p-n interfaces, which in quantizing magnetic fields host counter-propagating chiral edge states. In a paradigmatic architecture with a single junction, such quantum Hall states form a Mach-Zehnder interferometer [2, 3]. The precise position of such edge states is set by the electrostatics of a given device [4], which can be determined to great accuracy with the self-consistent Schrödinger-Poisson solver Pescado [5].

We perform electrostatic and quantum transport simulations accompanying conductance measurements in a graphene Mach-Zehnder interferometer, and show that remote gates can be used to control the position of the p-n junction on sub-nanometer scales. Such a fine control does not meaningfully affect the edge state positions and lengths, but induces valley-isospin oscillations. The interferometer thus behaves as a tunable valley-isospin transistor.

[1] H. Chakraborti et al., J.Phys.:Condens.Matter 36 (2024) 393001
[2] D.S.Wei et al, Science Advances 3, e1700600 (2017) [3] M. Jo et al, PRL 126, 146803 (2021) [4] I.M. Flor et al, PRB 105, L241409 (2022)
[5] A. Lacerda-Santos, arXiv:2507.03131v1

TT 58.3 Wed 15:30 POT/0006

Phase-coherent autonomous nonequilibrium demon — •JOSÉ BALDUQUE^{1,2} and RAFAEL SÁNCHEZ^{1,2,3} — ¹Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain. — ²Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Madrid, Spain — ³Instituto Nicolás Cabrera (INC), Universidad Autónoma de Madrid, Madrid, Spain.

Mesoscopic conductors enable the efficient management and useful conversion of not only thermal resources but also nonequilibrium electron distributions. The latter scenario makes it possible to define demonic modes of operation, in which the entropy of a subsystem

is autonomously reduced without extracting net particles or energy from the subsystem that provides the nonequilibrium resource [1]. We propose an implementation of such a nonequilibrium demon, or N-demon, in a multiterminal system that exploits carrier coherence. This is achieved by directly coupling the demonic subsystem to an isothermal two-terminal conductor via a scanning tip, enabling the local injection of electrons in a nonthermal distribution that participates in the phase-coherent interference processes governing the system's transport response [2]. In this way, we uncover an extrinsic, nonlocal, and phase-tunable transport response induced by the demon [3].

[1] R. Sánchez, et al., Phys. Rev. Lett. 123, 216801 (2019).

[2] R. Sánchez, et al., Phys. Rev. B, 105, 239903 (2022).

[3] J. Balduque and R. Sánchez, in preparation.

TT 58.4 Wed 15:45 POT/0006

Exploring the Influence of Electron Density on the Giant Negative Magnetoresistance — •LINA BOCKHORN¹, CHRISTIAN REICHL², WERNER WEGSCHEIDER², and ROLF J. HAUG¹ — ¹Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — ²Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

Ultra-high mobility two-dimensional electron gases exhibit a robust negative magnetoresistance at zero magnetic fields, characterized by a temperature-independent peak around $B = 0$ T and a temperature-dependent giant negative magnetoresistance (GNMR) at higher fields [1-4]. By varying the electron density in situ, we gain valuable insights into the nature of GNMR. Our study shows a significant dependence of GNMR on electron density, suggesting that scattering potential variations [5] may not be fully addressed in current theoretical models. By examining these dependencies for different temperatures, we enhance the understanding of unresolved aspects of GNMR theory, potentially bridging the gap between experimental observations and theoretical predictions.

[1] L. Bockhorn et al., Phys. Rev. B 83, 113301 (2011).

[2] L. Bockhorn et al., Phys. Rev. B 90, 165434 (2014).

[3] L. Bockhorn et al., Appl. Phys. Lett. 108, 092103 (2016).

[4] L. Bockhorn et al., Phys. Rev. B 109, 205416 (2024).

[5] Y. Huang et al., Phys. Rev. Materials 6, L061001 (2022).

TT 58.5 Wed 16:00 POT/0006

A topological field-effect memristor — •FABIAN HARTMANN¹, MANUEL MEYER¹, SELENA BARRAGAN¹, SERGEY KRISHTOPENKO^{1,2}, JEAN-BAPTISTE RODRIGUEZ³, ERIC TOURNIE³, BENOIT JOUAULT², GERALD BASTARD¹, FREDERIC TEPPE², LUKAS WORSCHKE¹, VICTOR LOPEZ-RICHARD⁴, and SVEN HÖFLING¹ — ¹Lehrstuhl für Technische Physik, Julius-Maximilians-Universität Würzburg — ²L2C, CNRS-Université de Montpellier, France — ³IES, Université de Montpellier, France — ⁴Departamento de Física, Universidade Federal de São Carlos, Brazil

Quantum and neuromorphic computing rely on unconventional materials and device functionalities, yet achieving resilience to imperfections and reliable operation remains a major challenge. This has motivated growing interest in topological materials that provide robust and low-power operation while preserving coherence. However, integrating topological transport with memory functionality into a reconfigurable device has remained elusive. Here, we realize a topological field-effect memristor in which topological protection preserves edge state coherence, enabling the coexistence of coherent transport and non-volatile memory functionality. Utilizing inverted InAs/GaInSb/InAs trilayer quantum wells, we realize a quantum spin Hall insulator that exploits its intrinsic floating-gate behavior. This feature allows one to reconfigure the conventional field-effect transistor operation into memristive functionality with broad electric-field tunability. One resistance state is entirely governed by dissipationless, coherent transport.

TT 59: 2D Materials V – Magnetic, spintronic, and topological properties (joint session HL/TT)

Time: Wednesday 15:00–17:15

Location: POT/0081

Invited Talk

TT 59.1 Wed 15:00 POT/0081

Dual proximity engineering of spin-orbit and magnetic effects in graphene heterostructures — ●CHRISTOPH KASTL — Walter Schottky Institute, School of Natural Sciences, Technical University of Munich — Munich Center for Quantum and Technology (MCQST)

The coexistence of induced spin-orbit coupling (SOC) and magnetic exchange fields is predicted to drive graphene into topological phases, such as the quantum anomalous Hall state. Here, I will discuss the prospect of using monolayer graphene proximitized by WSe₂ (SOC) and Cr₂Ge₂Te₆ (magnetic exchange) for such dual proximity control. To determine the type and strength of the induced SOC, I will compare Landau fan analysis, where level anticrossings can serve as direct signatures of spin-orbit splittings, to optoelectronic measurements on graphene/WSe₂ heterostructures, where the photogalvanic effect can provide an indirect fingerprint of SOC. Low-temperature magnetotransport measurements of the heterostructures with combined magnetic and SOC proximity reveal a large and gate-tunable anomalous Hall effect persisting at zero magnetic field, signaling an intrinsic Berry curvature arising from the interplay of SOC and magnetism. These results highlight the coexistence of spin-orbit and magnetic proximity effects in graphene-based van der Waals heterostructures and establish a route toward topological graphene phases.

TT 59.2 Wed 15:30 POT/0081

Twist angle and pressure tuning of proximity-induced spin-orbit coupling in graphene/WSe₂ heterostructures — TOBIAS ROCKINGER¹, BALINT SZENTPÉTERI², SZABOLCS CSOKA², MARINA MAROCKO¹, JULIA AMANN¹, ZIYANG GAN³, ANTONY GEORGE³, ANDREY TURCHANIN³, KENJI WATANABE⁴, TAKASHI TANIGUCHI⁴, DIETER WEISS¹, PÉTER MAKK², and ●JONATHAN EROMS¹ — ¹Department of Physics, University of Regensburg, Regensburg, Germany — ²Department of Physics, Budapest University of Technology and Economics, Budapest, Hungary — ³Institute of Physical Chemistry, Friedrich Schiller University Jena, Jena, Germany — ⁴National Institute for Materials Science, Tsukuba, Japan

Proximity-induced spin-orbit interaction in heterostructures of graphene and transition metal dichalcogenides has been studied intensely in the past few years. However, present experiments still suffer from poor reproducibility, as one key parameter, the twist angle between the crystal axes of both materials, has not been systematically controlled during fabrication. Band structure calculations, on the other hand, have predicted a decisive influence of this parameter. In our experiments, we control the twist angle during fabrication by aligning fractured or CVD grown edges and resolving the ambiguity of zigzag and armchair directions using a crystallographic etching process. We employ weak antilocalization to extract the spin-orbit coupling parameters quantitatively, and report excellent reproducibility and a good match to theoretical predictions. We also confirm the influence of high pressure on the proximity effect.

TT 59.3 Wed 15:45 POT/0081

Nonlinear optical probing of local quantum geometry — ●NELE TORNOW¹, PAUL HERRMANN¹, CLEMENS SCHNEIDER², JAN WILHELM², and GIANCARLO SOAVI^{1,3} — ¹Institute of Solid State Physics, Friedrich Schiller University Jena, Jena, Germany — ²Institute of Theoretical Physics and Regensburg Center for Ultrafast Nanoscopy, Regensburg, Germany — ³Abbe Center of Photonics, Friedrich Schiller University Jena, Jena, Germany

With its direct relation to many phenomena in solid matter, quantum geometry has become a concept of increasing interest in solid state physics. However, measurements of the local quantum geometry, *e.g.*, Berry curvature, has been possible to date only *via* angle-resolved photoemission spectroscopy [1]. On the other hand, in one of our recent theoretical works [2] we have shown that there is a link between linear circular dichroism and derivatives of Berry curvature in 3D crystals with preserved time-reversal symmetry (TRS).

In this presentation I will further demonstrate both, experimentally and with analytical solutions of semiconductor Bloch equations, that in a 2D semiconductor with broken TRS, the emerging second-harmonic circular dichroism can be used as a direct probe of the Berry curvature at the opposite $\pm K$ valleys, providing a new all-optical approach to

access the local quantum geometry in 2D materials.

[1] Schüler, M. et al., *Sci. Adv.* 6, eaay2730 (2020)

[2] Soavi, G. and Wilhelm, J., *arXiv:2501.03684* (2025)

15 min. break

TT 59.4 Wed 16:15 POT/0081

Proposal for Resolving Quantized Landau Orbits via Elastic XUV Scattering — ●SABRINA MEYER¹, ANDREAS KNORR¹, STEPHEN HUGHES², and LARA GRETE^{1,2} — ¹Institut für Physik und Astronomie, Technische Universität Berlin, Germany — ²Department of Physics, Queen's University, Kingston, Canada

In a strong perpendicular magnetic field, a two-dimensional electron gas is quantized into discrete Landau levels. We propose a method to extract the spatial structure of Landau orbits via scattering with extreme ultraviolet radiation, whose wavelength naturally matches the Larmor radius. In a microscopic theory, we derive the far-field spectrum emitted by the optically induced current density. Contributions from Landau orbits within this spectrum are suppressed due to scattering effects imposed by the sample geometry. By normalizing against the zero-magnetic-field reference, however, we define a Landau level scattering spectrum that isolates Landau orbit information. This gives access to the probability density distributions of individual Landau level wave functions featuring radial maxima at the quantized Larmor radii.

TT 59.5 Wed 16:30 POT/0081

Berry Phase Shift in Folded Bilayer Graphene — ●HANNES KAKUSCHKE, LINA BOCKHORN, and ROLF J. HAUG — Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany

Mono- and bilayer systems of graphene have been extensively researched due to their unique magnetic and electronic transport properties. In more recent works, folded graphene [1-5] has gained interest as a platform for topological phenomena, such as zero-line modes [4]. However, these systems rely on self-assembled folded graphene, found by chance during exfoliation or induced by tearing [1-5]. Our dry-transfer approach allows us to fold graphene around hBN in a controllable manner, decoupling the overlapping graphene regions. In these samples, we observe a Berry phase shift from 2π to π near the edge of folded bilayer graphene, attributed to local strain fields and stacking shifts.

[1] J. C. Rode et al., *Ann. Phys.* 529, 1700025 (2017).

[2] J. C. Rode et al., *2D Mater.* 6, 015021 (2018).

[3] L. Bockhorn et al., *Appl. Phys. Lett.* 118, 173101 (2021).

[4] S. J. Hong et al., *2D Materials* 8, 045009 (2021).

[5] S. J. Hong et al., *Phys. Rev. B* 105, 205404 (2022).

TT 59.6 Wed 16:45 POT/0081

Probing spin-orbit coupling in graphene/WSe₂ heterostructures by the circular photogalvanic effect — ERNST KNÖCKL, ●MATTHIAS KLEIN, ALEXANDER HOLLEITNER, and CHRISTOPH KASTL — Walter Schottky Institute, School of Natural Sciences, Technical University of Munich

We investigate proximity-induced spin-orbit coupling (SOC) in graphene/WSe₂ heterostructures using the circular photogalvanic effect (CPGE) as a symmetry-selective and experimentally accessible probe of spin-valley-locked band textures [1]. By measuring helicity-dependent photocurrents as a function of gate voltage, excitation energy, and device geometry, we aim to disentangle Rashba and valley-Zeeman SOC contributions and to extract their magnitude and sign as a function of the graphene-WSe₂ twist angle. The observed trends in CPGE sign reversals and scaling behavior provide quantitative indications of interfacial symmetry breaking and moiré-enhanced spin-valley coupling, supported by comparison to microscopic transport models. These results are expected to establish CPGE as a promising metrological probe of proximity SOC in 2D heterostructures and to complement ongoing efforts in twist-angle-dependent spin-orbit engineering in graphene/TMD systems [2,3].

[1] Kiemle, J., et al. *ACS nano* 16.8, 12338-12344 (2022)

[2] Yang, H., et al. Nat. Mater. 23, 1502-1508 (2024)

[3] Zhang, Y., et al. Natur 641, 625-631 (2025)

TT 59.7 Wed 17:00 POT/0081

Study of the non-trivial spin texture in Tellurium and the consequences in charge-spin interconversion —

•ANDRÉS MARTÍNEZ-GARCÍA¹, DANIEL GOSÁLVEZ-MARTÍNEZ¹, CARLOS SABATER¹, and JUAN JOSÉ PALACIOS² — ¹Departamento de Física and Instituto Universitario de Materiales de Alicante (IUMA), Universidad de Alicante, Alicante, Spain. — ²Departamento de Física de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Madrid, Spain.

Tellurium is a chiral semiconducting material with a narrow band gap that can be synthesized with well-defined handedness in nanowires and

flakes, making it an excellent platform for studying chirality-related charge-spin interconversion in nanodevices. The coupling between charge and spin degrees of freedom is closely connected to the spin texture in momentum space. In this work, we demonstrate that tellurium exhibits a nontrivial radial spin texture at the top of the valence band, where the spin polarization aligns parallel to the HK direction of the Brillouin zone, while spins in the perpendicular ZHL plane display a nontrivial winding. We investigate the electronic transport and resulting spin polarization within the Landauer transport formalism using first-principles calculations. This approach allows us to map the transport properties along each crystallographic direction and to identify correlations between the spin polarization of the induced current and the underlying momentum-space spin texture. Our results provide microscopic insight into chirality-driven spin responses in tellurium and highlight its potential for spintronic applications.

TT 60: Spintronics (other effects) (joint session MA/TT)

Time: Wednesday 15:00–18:00

Location: POT/0112

Invited Talk

TT 60.1 Wed 15:00 POT/0112

Magneto-optic Kerr effects of higher order in magnetization in thin films of different crystal orientations —

•TIMO KUSCHEL — Johannes Gutenberg University Mainz, Germany

The magneto-optic Kerr effect (MOKE) is an important tool to study magnetic properties of thin films. While the MOKE contribution linear in magnetization (LinMOKE) is mainly used for Kerr imaging, Kerr spectroscopy, time-resolved MOKE, and vectorial magnetometry of ferromagnetic thin films [1], the MOKE contributions quadratic in magnetization (QMOKE) [2] have been used for investigations of antiferromagnetic materials, spin-orbit torques, and structural order of Heusler compounds [3]. Recently, we have identified MOKE contributions of third order in magnetization (cubic MOKE, CMOKE) [4] and studied its dependence on the structural domain twinning of Ni(111) thin films.

In this talk, I will introduce these MOKE effects of higher order and describe their angular dependencies with respect to the crystal orientations of the thin films. While it is quite simple to find CMOKE in (111)-oriented films, it is not straightforward to identify it in (001)-oriented samples. I will discuss the reasons. Furthermore, I will report on the material systems that have shown CMOKE so far and mention potential applications.

[1] T. Kuschel et al., J. Phys. D: Appl. Phys. 44, 265003 (2011)

[2] R. Silber, TK et al., Phys. Rev. B 100, 064403 (2019)

[3] R. Silber, TK et al., Appl. Phys. Lett. 116, 262401 (2020)

[4] M. Gaerner, TK et al., Phys. Rev. Applied 22, 024066 (2024)

TT 60.2 Wed 15:30 POT/0112

Ignition of spin-triplet supercurrent in a ballistic S/F/S Josephson junction with precessing magnetization —

•ELIZAVETA ANDRIYAKHINA, MIAD MANSOURI, MAXIM BREITKREIZ, and PIET BROUWER — Freie Universität Berlin, Germany

We develop a theory for a ballistic Josephson junction with a ferromagnetic (including half-metallic) interlayer whose uniformly precessing magnetization generates a controllable equal-spin (triplet) supercurrent. In a co-rotating frame, the driven junction maps to an effective static problem that can be treated with a scattering-matrix approach to obtain Andreev bound states and the dc Josephson current.

A key result is that steady precession produces a spin-dependent non-equilibrium occupation in the rotating frame, yielding a finite dc supercurrent. In the half-metal limit the junction is “off” without precession, but becomes “on” when a finite precession angle induces phase-sensitive Andreev levels and a triplet current.

For small precession angles, the induced current is approximately sinusoidal in phase and the critical current scales quadratically with the precession angle (and with drive parameters), enabling microwave-controlled switching via ferromagnetic resonance.

TT 60.3 Wed 15:45 POT/0112

Magnetic Domain Wall Motion under Microwave Excitation —

•LUKAS FISCHER¹, ROUVEN DREYER², JAE-CHUN JEON¹, GEORG WOLTERS DORF², and STUART PARKIN¹ — ¹Max-Planck Institute of Microstructure Physics, Halle (Saale), Germany — ²Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

Chiral domain walls (DWs) and their synchronous motion via current pulses in magnetic conduits (so-called magnetic racetracks) are of enormous interest due to their fast speed, non-volatility, and capability of creating high bit-density for advanced memory and logic technologies. Most experimental and numerical studies have focused on the motion of the DWs by spin-orbit torque using nanosecond-long current pulses which are not efficient in coupling to magnetization precessions of the magnetic material, typically occurring in the GHz regime.

Here we present that the microwave excitation of chiral Néel DWs in a magnetic microwire with perpendicular magnetic anisotropy significantly impacts the DW motion. We use either magnetic fields or electrical currents at RF-frequencies to explore the pronounced impact on the DW motion. Firstly, we directly visualize the high-frequency response of the DW by using the Super-Nyquist sampling magneto-optical Kerr effect. We then determine the effect of this excitation on the DW motion. When the DW is excited in the presence of a static, transverse magnetic field, it exhibits unidirectional self-propulsion. Moreover, the resonant excitation in a static, longitudinal field leads to a current-triggered, sustained DW motion over micrometer distances, which dramatically increases the effective DW displacement.

TT 60.4 Wed 16:00 POT/0112

Assembly of Magnetic Heterostructures with Chiral Nanographenes —

•CHI FANG, WENHUI NIU, JITUL DEKA, and STUART PARKIN — Max Planck Institute of Microstructure Physics, Halle(Saale) 06120, Germany

Chirality-induced spin selectivity (CISS) is an emergent phenomenon whereby chiral molecules act as efficient spin filters, selectively transmitting electrons of a particular spin orientation. A central challenge in advancing CISS-based spintronics lies in experimentally verifying spin filtering in structurally defined, laterally extended molecular systems, using standard solid-state device techniques that yield reproducible and robust spin-dependent transport signals. Here, we present direct experimental evidence of the CISS effect in helical nanographenes (NGs), using magnetoresistance (MR) measurements in magnetic heterostructures. The device architecture included a bottom electrode ferromagnetic contact, orthogonally patterned and electrically isolated by an AlOx layer to confine current to the junctions. NG, a synthetically tailored chiral molecule, was spin-coated to form a thin, uniform layer serving as a spin-filter interface. Different from previous works, the ferromagnet layer grown directly on the substrate offers a better performance of the magnetic properties. Both enantiomeric devices showed MR values around 1 % at room temperature, with minimal variation over the 10*400 K temperature range, indicating robust and reproducible spin selectivity. [1] B. Bloom et al. Chem. Rev. 124(4), 2014; [2] S. Ham et al. Micromachines 15(4), 528, 2024; [3] S. Yang et al., Nat. Rev. Phys. 3, 328, 2021.

TT 60.5 Wed 16:15 POT/0112

Alloying-Driven Modifications of the Magnetic Properties in Transition-Metal Iodides —

•PAULINA JURECZKO^{1,2} and MARTIN GMTIRA^{1,3} — ¹Institute of Experimental Physics, Slovak Academy of Sciences, 04001 Košice, Slovakia — ²Institute of Physics, University of Silesia in Katowice, 41-500 Chorzów, Poland — ³Institute of Physics, Pavol Jozef Šafárik University in Košice, 04001 Košice, Slovakia

Single-layer transition-metal dihalides have recently emerged as a platform for exploring two-dimensional magnetism and topology. Using density-functional theory, we investigate the electronic and magnetic properties of $M\text{I}_2$ monolayers and alloyed $M_{1-x}\text{N}_x\text{I}_2$ systems, where M and N represent Mn, Fe, Co, Ni. We analyze how chemical substitution modifies exchange interactions and spin-orbit-driven topological features by computing the Berry curvature and Chern numbers. The results reveal that alloying provides an efficient route for tuning magnetic anisotropy and topological phases in transition-metal iodides, underscoring their potential relevance for 2D spintronics.

This work has been funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I05-03-V02-00071.

15 min break

TT 60.6 Wed 16:45 POT/0112

Spintronic THz Frequency Conversion Mediated by Ferromagnetic/Oxide Interfaces — •KANG JIN¹, RUSLAN SALIKHOV¹, STEFAN KOBER², IGOR ILYAKOV¹, JAN-CHRISTOPH DEINERT¹, ALEKSANDRA LINDNER¹, JÜRGEN FASSBENDER^{1,3}, SEBASTIAN F. MAEHRLEIN^{1,3}, ZHE WANG², and JÜRGEN LINDNER¹ — ¹HZDR — ²TU Dortmund — ³TU Dresden

Frequency conversion is a key nonlinear phenomenon for communication and data processing technologies. Exploring this phenomenon at terahertz (THz) frequencies is of particular interest, as the high carrier frequency enables faster data transfer and higher operational speeds. Previous experiments have revealed that THz frequency conversion could serve as a distinctive probe for THz-light-induced ultrafast spin-transfer currents (STCs) at Ferromagnetic (FM)/Non-Magnetic (NM) interfaces. Building on these findings, we report THz frequency conversion using cost-effective NM materials (such as SiO_2 and Al_2O_3 films) and demonstrate their origin from the interfacial inverse Rashba-Edelstein effect. We compare conversion efficiencies and characteristics of different samples, revealing that FM interfaces, featuring off-stoichiometric SixOy and AlxOy , achieve conversion efficiencies comparable to heavy metal capping layers (i.e. Ta). The deposition sequence and the oxidation level of the samples were found to critically influence the sign of the spin-charge conversion. The observed THz second harmonic generation represents a spintronic foundation for developing THz frequency mixers and rectifying components.

TT 60.7 Wed 17:00 POT/0112

Magnetic hyperfine fields in solids without inversion symmetry induced by an external electric field — •ALBERTO MARMODORO^{1,2,3,4}, HUBERT EBERT¹, SERGIY MANKOVSKY¹, and JAN MINAR³ — ¹LMU Munich, Munich, DE — ²Inst. of Physics of the Czech Acad. of Sci., Prague, CZ — ³University of West Bohemia, Pilsen, CZ — ⁴Czech Technical University, Prague, CZ

An electric field induces in a solid without inversion symmetry spin and orbital magnetization - a phenomenon called Edelstein effect. This induced magnetization has to have its counterpart in an induced magnetic hyperfine field seen by nuclear magnetic moments. Corresponding NMR experiments have been performed recently on Te with success [1]. Using Kubo's linear response formalism implemented on the basis of the relativistic Korringa-Kohn-Rostoker Green function technique a description for the field induced hyperfine field (EFI-HFF) has been developed in analogy to that for the spin and orbital Edelstein effect [2]. The EFI-HFF drastically differs from that induced by an external magnetic field as the later one does not need missing inversion symmetry. Making use of a Gordon decomposition of the electronic current a splitting of the EFI-HFF into its spin and orbital parts is achieved [3]. This allows to discuss them in relation to their counterparts concerning the magnetization as well as the role of the spin-orbit coupling for them. Corresponding numerical results are presented for Te.

[1] T. Furukawa et al., Phys. Rev. Res., **3**, 023111 (2021). [2] S. Wimmer et al. Phys. Rev B, **103**, 024437 (2021). [3] M. Battocletti and H. Ebert, Phys. Rev. B, **64**, 094417 (2001).

TT 60.8 Wed 17:15 POT/0112

Theoretical description of the optical activity and directional dichroism of chiral solids — •HUBERT EBERT and SERGIY MANKOVSKY — Ludwig Maximilian University of Munich, Munich, DE

A scheme to deal with the optical activity and directional dichroism of solids on the basis of Kubo's linear response formalism is presented. Accounting for the \vec{q} -dependence of the radiation field implies that the corresponding optical transitions described in k -space are no more vertical. More important, one is led to corrections to the electric dipole matrix element due to the electric quadrupole and magnetic dipole interaction. The scheme is implemented making use of the relativistic Korringa-Kohn-Rostoker Green function (KKR-GF) formalism. Corresponding applications to chiral Te that has time reversal (\mathcal{T}) but no inversion (\mathcal{I}) symmetry led to a \vec{q} -dependent optical conductivity tensor with off-diagonal elements caused by the interference of the electric dipole and its correction terms giving rise to optical activity. In the case of anti-ferromagnetic Cr_2O_3 without \mathcal{T} -symmetry the correction terms lead to directional dichroism that strongly depends on whether a magnetic configuration with or without \mathcal{I} - but with combined \mathcal{IT} -symmetry is considered.

TT 60.9 Wed 17:30 POT/0112

Intrinsic and Proximity-Enhanced Spin-Orbit Torques in $\text{Fe}_3(\text{Ge,Ga})\text{Te}_2$ and WTe_2 Heterostructures — •GUSTAVO BRIZOLLA¹, STEPAN TSIRKIN², YAROSLAV ZHUMAGULOV², and JAROSLAV FABIAN¹ — ¹Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany — ²EPFL, Lausanne, Switzerland

Spin-orbit torques (SOTs) in 2D magnets and their heterostructures offer a route to ultra-thin, energy-efficient memories where currents can switch magnetization without external magnetic fields. Materials such as Fe_3GeTe_2 (FGT) and Fe_3GaTe_2 (FGaT), and their interfaces with low-symmetry WTe_2 , are especially promising, but the angular dependence and microscopic origin of their SOTs are still not fully understood. Here we compute SOTs in FGT, FGaT and WTe_2 -proximitized heterostructures using first-principles (DFT) calculations and compare two protocols for mapping the angular dependence: self-consistent magnetization rotation and rigid rotation of a fixed exchange field. They agree when spin-orbit mixing is weak, but differ strongly near in-plane alignment, where interband hot spots and evolving spin-orbit hybridization amplify the torques. In WTe_2 heterostructures, broken symmetry and Te-Te interfacial hybridization further boost torques with out-of-plane spin polarization. These results provide design rules for field-free current control in 2D magnets and show that the angle dependence of spin-orbit coupling must be treated explicitly to obtain reliable SOT angular maps.

TT 60.10 Wed 17:45 POT/0112

Spin vacuum switching — •EDDIE HARRIS-LEE^{1,2}, JOHN KAY DEWHURST², SAMUEL SHALLCROSS¹, and SANGEETA SHARMA^{1,3} — ¹Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Berlin, Germany. — ²Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany. — ³Institut für Theoretische Physik, Freie Universität Berlin, Berlin, Germany.

While physical mechanisms underpinning spin switching are established for nano- to pico-second time scales, here we present a physical route to magnetization toggle control at < 100 femtoseconds. A minority spin current injected into a ferromagnet is shown to create a minority "spin vacuum" that then drives rapid charge redistribution from the majority channel and spin switching. We demonstrate this mechanism reproduces many of the features of recent sub-picosecond switching of ferromagnetic Co/Pt multilayers, and provide simple practical rules for the design of materials to optimize "spin vacuum" control over magnetic order.

Harris-Lee *et al.*, Sci. Adv. **10**, eado6390 (2024). DOI:10.1126/sciadv.ado6390

TT 61: Topology – Poster

Time: Wednesday 15:00–17:00

Location: P4

TT 61.1 Wed 15:00 P4

Topological Surface States for the Implementation of a Landau Level Laser — •OLIVIER FAYET¹, JEAN-NOËL FUCHS², and PIÉCHON FRÉDÉRIC¹ — ¹Laboratoire de physique des solides, université Paris-Saclay et CNRS, Orsay, France — ²Laboratoire de physique théorique de la matière condensée, Sorbonne Université et CNRS, Paris

Landau levels have since long been proposed for the implementation of a tunable laser in the THz regime. However, rapid non-radiative relaxation processes (Auger processes, disorder) are preventing population inversion. The former may to some extent be circumvented by the choice of a material with a non-equidistant Landau levels spectrum, e.g. in bilayer graphene or in the surface states of a topological heterojunction, called Volkov-Pankratov states. Under a strong magnetic field, the latter are quantised into Landau levels, recently observed in transport and spectroscopic measurements at the LPENS (Paris), based on predictions from the LPS theory group. To study the possibility of obtaining laser emission with these states, a detailed study of the different life times of electrons in the associated Landau level is required.

TT 61.2 Wed 15:00 P4

Investigating Electrical and Thermal Hall Effect in Topological Insulators — •KARAN SINGH, ROHIT SHARMA, YONGJIAN WANG, YOICHI ANDO, ACHIM ROSCH, and THOMAS LORENZ — II. Physikalisches Institut, Universität zu Köln, Zùlpicher Strasse 77, D-50937 Köln, Germany

3D topological insulators are characterized by a bulk band gap and topologically protected gapless surface states formed by massless Dirac fermions. However, chemical disorder produces spatially fluctuating electric potentials, forming "charge puddles" that allow current to flow through the bulk [1]. With decreasing temperature, charge puddles localize, turning the sample electrically insulating. But these charge puddles remain thermally coupled via phonons and can be probed by the thermal Hall transport measurements [2]. In this work, we grew single crystals of $\text{TiBi}_{0.3}\text{Sb}_{0.7}\text{Te}_2$ and performed electrical and thermal transport measurements. The material shows a metal-semiconductor transition near 100 K and electron-like carriers at all temperatures. Notably, the thermal Hall conductivity (k_{xy}) measured on the same sample deviates from the Wiedemann-Franz law. After subtracting the electronic thermal contribution, the residual thermal Hall signal indicates that heat transport in this system involves contributions beyond conventional electronic carriers.

Work supported by the German Research Foundation via Project No. 277146847-CRC1238 (Subprojects A02 and B01).

[1] O. Breunig et al., Nat. Comm. 8, 15545 (2017).

[2] R. Sharma et al., Phys. Rev. B 109, 104304 (2024).

TT 61.3 Wed 15:00 P4

Synthesis and characterisation of Yb-doped TiBiSe_2 delafossite — •MANUEL SCHULZE¹, ISADORA NEME², JÖRG SICHELSCHMIDT², HELGE ROSNER², MICHAEL BAENITZ², and THOMAS DOERT¹ — ¹Faculty of Chemistry and Food Chemistry, TUD Dresden University of Technology, 01062 Dresden — ²Max Planck Institute for Chemical Physics of Solids, 01187 Dresden

TiBiSe_2 is a three-dimensional (3D) topological insulator with a unique single Dirac cone at the Brillouin-zone centre [1]. TiYbSe_2 represents a prototype 2D triangular-lattice quantum spin liquid candidate [2]. Combining the two materials through partial substitution of Bi and Yb provides an interesting platform to investigate the interplay between unconventional electronic and magnetic properties. Polycrystalline samples of the solid-solution series $\text{Ti}(\text{Bi},\text{Yb})\text{Se}_2$ were synthesised by melting the elements in a rotary setup to enhance homogenisation. Powder X-ray diffraction and Rietveld refinement reveal systematic shifts in the lattice parameters, confirming continuous substitution. First Electron Spin Resonance (ESR) measurements on $\text{Ti}(\text{Bi}_{0.95}\text{Yb}_{0.05})\text{Se}_2$ show metallic Yb^{3+} lines with hyperfine structure as expected for a magnetically diluted system. Future work will additionally focus on NMR spectroscopy together with magnetisation and specific-heat studies to analyze the evolution of magnetic and electronic correlations across the series.

[1] K. Kuroda et al., Phys. Rev. Lett. 105, 146801 (2010).

[2] T. Fujii et al., Phys. Rev. B 112, 024426 (2025).

TT 61.4 Wed 15:00 P4

Berry curvature induced giant anomalous and spin texture driven Hall responses in the layered Kagome antiferromagnet GdTi_3Bi_4 — •SHOBHA SINGH¹, SHIVAM RATHOD¹, RONG CHEN², LIPIKA LIPIKA¹, SNEH SNEH¹, RIE. Y. UMETSU^{3,4}, YAN SUN², and KAUSTUV MANNA¹ — ¹Department of Physics, Indian Institute of Technology Delhi, New Delhi 110016, India — ²Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences 72 Wenhua Road, Shenyang 110016, China. — ³Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan — ⁴Center for Science and Innovation in Spintronics, Tohoku University, Sendai 980-8577, Japan

Here, we present the single-crystal growth, magnetization, and electrical transport characterizations of the van der Waals-like layered antiferromagnet GdTi_3Bi_4 . The system exhibits pronounced field-induced first-order phase transitions. Comprehensive frequency, temperature, and field-dependent ac susceptibility measurements, and Hall analysis, reveal the formation of a spin-cluster-like glassy magnetic phase attributed to noncoplanar spin textures. Additionally, the system demonstrates a colossal anomalous Hall conductivity ($\sigma_{xy} = 8652 \Omega^{-1}\text{cm}^{-1}$ at 2 K). Detailed scaling analyses reveal the coexistence of skew scattering and intrinsic Berry-curvature contributions to the anomalous Hall effect. First-principles calculations highlight a flat band near the Fermi level, with f-electrons of the Gd ion contributing a large intrinsic Hall response.

TT 61.5 Wed 15:00 P4

Temperature and pressure dependant structural studies of PtBi_2 — •ESTEBAN AGUIRRE GARCÍA¹, SWARNAMAYEE MISHRA^{1,2}, and JOCHEN GECK^{1,2} — ¹Institute of Solid State and Materials Physics, Technical University Dresden, 01062 Dresden, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, Technical University Dresden, 01062 Dresden, Germany

Trigonal PtBi_2 is a non-centrosymmetric Weyl semimetal (space group $P31m$) in which strong spin-orbit coupling and broken inversion symmetry lift the degeneracy of linearly dispersing bands, providing a natural setting for topological superconductivity. While bulk PtBi_2 becomes superconducting only at very low temperatures of about 0.6 K, an enhanced and robust surface superconducting state with a critical temperature of 5 K or higher has been shown to emerge from the Fermi arc surface states, accompanied by a sizeable superconducting gap. In this work, high resolution single crystal X-Ray diffraction is employed as a function of temperature and pressure, which allows us to correlate structural features of the trigonal phase with the presence of surface superconductivity and to identify possible symmetry based mechanisms that can support topological pairing.

TT 61.6 Wed 15:00 P4

Nonlinear Hall effect in magnetic B_2O compounds — •MAXIMILIAN PHIELEPEIT¹, IVAN VOLKAU¹, YANNIS ULLRICH^{1,4}, MARC A. WILDE^{1,3}, ANDREAS BAUER^{1,3}, ANDREAS SCHNYDER⁴, and CHRISTIAN PFLEIDERER^{1,2,3} — ¹Technical University of Munich (TUM) — ²MCQST, Munich — ³TUM Zentrum für Quantum Engineering — ⁴Max Planck Institute for Solid State Research

A novel theoretical framework decomposes second-order nonlinear Hall conductivity into four quantum geometric contributions: the nonlinear Drude weight (NLD), the Berry curvature dipole (BCD), the interband quantum metric dipole (interQMD) and the intraband quantum metric dipole (intraQMD) [1]. In systems with C_3^z -symmetry, the BCD and interQMD terms are forbidden, which allows for the selective isolation of the NLD and intraQMD contributions [1]. We seek to investigate these contributions in magnetic B_2O systems, which host a C_3^z -rotational axis along the [111] crystallographic direction [2]. In this work, we perform nonlinear Hall measurements with two different magnetic field directions.

[1] Ulrich et al., arXiv:2506.17386 (2025)

[2] Hall et al., Phys. Rev. B 104 (2021)

TT 61.7 Wed 15:00 P4

Magnetic Properties of Single Crystal MnNb_2O_6 — •FLORIAN KÜBELBÄCK¹, LEO MAXIMOV¹, ANDREAS BAUER¹, and CHRISTIAN PFLEIDERER^{1,2,3} — ¹School of Natural Sciences, Technical Univer-

sity of Munich, Garching, Germany — ²Heinz Maier-Leibnitz-Zentrum (MLZ), Technische Universität München, Garching, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Technical University of Munich, Garching, Germany

CoNb₂O₆, with effective $S = \frac{1}{2}$ Ising chains, is a benchmark system for quasi-one-dimensional magnetism and field-induced quantum phenomena [1]. Its isostructural analogue columbite MnNb₂O₆ contains $S = \frac{5}{2}$ Mn²⁺ ions arranged in zig-zag chains and is expected to realise a more classical regime of low-dimensional magnetism [2, 3].

We have grown high-quality MnNb₂O₆ single crystals using the optical floating-zone technique. Magnetization measurements reproduce the antiferromagnetic transition at $T_N \approx 4.4$ K and reveal anisotropy with the *c*-axis acting as the hard direction, consistent with the recently refined phase diagram [4]. Field sweeps for $H \parallel c$ show a spin-flop transition near 1.8 T.

These results establish MnNb₂O₆ as a clean, anisotropic antiferromagnet and a promising classical counterpart to the quantum $S = \frac{1}{2}$ chain material CoNb₂O₆.

- [1] R. Coldea et al., Science 327, 5962 (2010)
- [2] L. M. Holmes et al., Solid State Communications 11, 409 (1972)
- [3] O. V. Nielsen et al., J. Phys. C 9 (1979)
- [4] R. Maruthi et al., J. Phys.: Condens. Matter 33, 345801 (2021)

TT 61.8 Wed 15:00 P4

Dirac Quantum Hall States on (Reciprocal) Curved Surfaces — ●MAXIMILIAN FÜRST — University of Regensburg, Regensburg, Germany

Three-dimensional topological insulator nanowires in an axial magnetic field B host peculiar Dirac-type quantum Hall surface states. Spatial variations in the wires' cross sections allow for shaping curved surfaces and hence for highlighting imprints of geometry and curvature, and their interplay, in the corresponding quantum Hall spectra [1, 2]. We discuss the peculiar spectral and magnetic properties of these systems. We show that these are composed of two classes, one asymptotically insensitive to the surface shape, scaling with B-field like regular quantum Hall states in the plane, and the other with an asymptotic B-field dependence intimately related to the wire geometry. Moreover, we demonstrate that a curved nanowire surface possesses a reciprocal partner nanowire surface such that the respective quantum Hall spectra are dual to each other upon exchanging angular momentum and magnetic flux. Notably, a cone-shaped nanowire, and the Corbino quantum Hall geometry as a limiting case, has a reciprocal partner wire with a dual quantum Hall spectrum that is B-field independent, with corresponding non-magnetic quantum Hall-type eigenstates. We support our analytical findings by numerical results for B-field ranges and wire geometries within reach of current experiment [3].

- [1] R. Kozlovsky et al., Phys. Rev. Lett. 124, 126804 (2020)
- [2] M. Fürst et al., Phys. Rev. B 109, 195433 (2024)
- [3] I. Dusa et al., arXiv:2503.17166 (2025)

TT 61.9 Wed 15:00 P4

Andreev reflection and interferometry of fractional quantum Hall edge states — ●TOM MENEI, MAXIME JAMOTTE, and THOMAS L. SCHMIDT — Department of Physics and Materials Science, University of Luxembourg, Luxembourg

Recent experimental work has demonstrated the possibility of coupling superconductors (SCs) to quantum Hall (QH) systems at both integer and fractional filling factors. However, the theoretical modelling of such QH/SC interfaces remains challenging due to the strong magnetic fields required and the presence of disorder. In this work, we develop a theoretical framework based on fractional QH edge state theory and incorporate realistic models of the superconductor to derive the effective coupling mechanisms at the interface. We analyse the resulting normal and Andreev reflection processes, as well as correlations probed through interference between multiple edge states across the QH/SC interface, and discuss their signatures in transport experiments.

TT 61.10 Wed 15:00 P4

Topologically nontrivial phase induced by disorder in a one-dimensional system — ●LARS EMMRICH and MICHAEL POTTHOFF — Department of Physics, University of Hamburg, Germany

The Su-Schrieffer-Heger model with additional local, uncorrelated, binary-alloy site disorder of strength W is a prototypical model for studying the phase diagrams of disordered topological band insulators. With the topological-Hamiltonian approach and with the twisted-boundary-conditions approach, we employ two complementary tech-

niques to compute the winding number ν , a topological invariant. Starting from the topologically nontrivial phase with $\nu = 1$ in the clean limit ($W = 0$), we find that, as W increases, the system undergoes a transition to a trivial phase with $\nu = 0$, followed by a second transition to a nontrivial phase with $\nu = 1$. Importantly, the latter phase cannot be connected continuously to the clean limit and thus represents a novel, disorder-induced phase, because the nontrivial topology is carried by the zeros of the single-electron Green's function.

TT 61.11 Wed 15:00 P4

Topological phases in the bosonic Haldane-Hubbard model — ●HANNAH CAROLINA DÜRSCHMIDT, AJESH KUMAR, and ACHIM ROSCH — Institute for Theoretical Physics, University of Cologne, Zùlpicher Straße 77, 50937, Köln, Deutschland

We study the interacting bosonic Haldane-Hubbard model at half filling, using a self-consistent parton mean-field approach. Within this framework, we map out the phase diagram and identify superfluid, Mott-insulating, and topological phases. The primary focus is on the effects of long-range interactions, which can cause spontaneous breaking of lattice translation symmetry. In addition to Mott insulating states, we investigate topological phases with a finite Hall conductivity.

TT 61.12 Wed 15:00 P4

Lattice defects in topological phases of matter — ●ALEXANDER GAVRISHEV^{1,2}, ALEXANDER WONG², HENRY DAVENPORT², ANDRES PEREZ FADON², and FRANK SCHINDLER² — ¹Max Planck Institute for the Physics of Complex Systems — ²Imperial College London

The defect response of topological materials offers a potential starting point for experimental probes of topology; while many comprehensive results exist for simple lattice defects in non-interacting topological matter, an analogue for interacting topological phases is missing. As a first step in this direction, we present exact diagonalisation results for lattice dislocations in a fractional Chern insulator.

TT 61.13 Wed 15:00 P4

The influence of fluctuations on the microwave response of multiterminal topological Josephson junctions — ●GLEB SELEZNEV and WOLFGANG BELZIG — Universität Konstanz, 78457 Konstanz, Germany

In recent years, it has been demonstrated that multiterminal Josephson junctions (MTJJs) can realize topological states of matter in synthetic dimensions defined by the superconducting phases. In this setting, topology is hosted by Weyl singularities in the spectrum of Andreev bound states (ABS) and is characterized by a nontrivial Chern number, which manifests itself in a quantized transconductance between two superconducting leads. Moreover, the Chern number leaves signatures in the dissipative part of the microwave response function, and can therefore be directly extracted using microwave spectroscopy.

In realistic experimental conditions, however, various types of fluctuations may obscure the observation of these topological properties. In this work, we investigate the role of thermal fluctuations and finite broadening of the ABS, which have a dominant effect in the large-gap limit, on the microwave response of MTJJs. We focus especially on the vicinity of the Weyl points, where the system is most sensitive to external perturbations. As a result, we demonstrate that the redefined Chern number is reduced, while other topological signatures become smeared by fluctuations.

TT 61.14 Wed 15:00 P4

Further Evidence of a Tomonaga-Luttinger Liquid in the Au/Ge(001) Surface Reconstruction — NICO KUBETSCHKE, ●ULRIKE KÜRPICK, JOHANN TONHÄUSER, TILL-JAKOB STEHLING, MARCEL SCHLESAG, and RENÉ MATZDORF — University of Kassel, Institute of Physics, Heinrich-Plett-Str. 40, Kassel D-34132, Germany

We investigated the Au/Ge(001) surface reconstruction using scanning tunneling microscopy (STM) and spectroscopy at 77 K and 5 K. Local density of states maps reveal quasi-one-dimensional channels, which are oriented almost perpendicular to the Au-induced nanowires visible in STM topographic images. Spectroscopic analysis shows a characteristic power-law dependence, indicative of Tomonaga-Luttinger liquid behavior [1,2]. An increased power-law exponent is measured when these channels are interrupted by embedded Co-Au-induced nanorods [3]. The results are consistent with the existence of a Tomonaga-Luttinger liquid in a deeper layer of the Au-induced surface reconstruction.

- [1] S.-I. Tomonaga, Prog. Theoret. Phys. 5, 544 (1950);
 [2] J. Luttinger, J. Math. Phys. 4, 1154(1963).

- [3] M. Schlesag et al., Phys. Rev. B 110, 195412 (2024).

TT 62: Correlated Electrons – Poster II

Time: Wednesday 15:00–17:00

Location: P4

TT 62.1 Wed 15:00 P4

Interplay of electronic and magnetic properties of single crystal Nd — ●MARKUS BRAUNER¹, IVAN VOLKAU¹, LUKAS BAUER¹, ANDREAS BAUER^{1,3}, CHRISTIAN PFLEIDERER^{1,2,3}, and MARC A. WILDE^{1,3} — ¹Technical University of Munich (TUM) — ²MCQST, Munich — ³TUM Zentrum für QuantumEngineering

The rare earth Neodymium hosts a wide range of multi-Q magnetic phases at temperatures below 20K and fields up to 4T [1]. Recently, Neodymium was found to exhibit a previously unknown spin glass behavior in bulk-like thick films [2]. We study the interplay of magnetism and the electronic structure of bulk single crystal samples grown with the Czochralski method and map the magnetic phase diagram of Nd using vibrating sample magnetometry. First results of Fermi surface study using Shubnikov-de Haas measurements and Density Functional Theory calculations will be presented.

- [1] S W Zochowski et al., J. Phys.: Condens. Matter 3, 8079 (1991)
 [2] U. Kamber et al. Science 368, eaay6757 (2020).

TT 62.2 Wed 15:00 P4

Magnetic polarons in antiferromagnetic EuCd₂P₂ with systematic impurities — ●DOMINIK HOFF, JULIAN BEU, SARAH KREBER, KRISTIN KLIEMT, CORNELIUS KRELLNER, and JENS MÜLLER — Goethe-University Frankfurt, Germany

Strong interactions between charge carriers and magnetism can give important insights on the physics of correlated electron systems. The colossal magnetoresistance (CMR) is one such effect, that is promising for applications. We are investigating EuCd₂P₂, which shows a strong CMR-effect above its antiferromagnetic transition [1]. In previous works, it was possible to link the CMR-effect to the existence and percolation of magnetic polarons resulting in a strong increase in low-frequency resistance fluctuations at the CMR-peak caused by the onset of polaron percolation. It was also found that the CMR-effect of EuCd₂P₂ is strongly sensitive to the sample's growth conditions [2]. To further examine these dependencies, we investigate systematic structural differences in the form of chemical substitutions. In this work we aim to investigate behavioural changes of magnetic polarons due to the substitution of Silicon in the growth process of EuCd₂P₂. We analyze the Hall effect, higher-harmonic resistance and resistance fluctuations as a function of temperature and magnetic field aiming to systematically determine the impact of structural impurities on polaron dynamics.

- [1] Phys. Rev. B 109 (2024) 104421
 [2] arXiv2503.24059

TT 62.3 Wed 15:00 P4

Noise spectroscopy on EuZn₂P₂ and Sm_{1-x}Eu_xB₆ — ●KRISTIJAN VERUSHESKI¹, JULIAN BEU¹, SARAH KREBER¹, KRISTIN KLIEMT¹, CORNELIUS KRELLNER¹, STEFFEN WIRTH², PRISCILA ROSA³, and JENS MÜLLER¹ — ¹Physikalisches Institut, Goethe Universität Frankfurt, Germany — ²Max Planck Institute for Chemical Physics of Solids Dresden, Germany — ³Los Alamos National Laboratory, Los Alamos, NM 87545, USA

The colossal magnetoresistance (CMR) effect is of great interest because it emerges in correlated electron systems, e.g. in Eu-based antiferromagnets such as EuZn₂P₂ and EuCd₂P₂. For these materials a set of dynamical measurements revealed that the CMR effect is most likely driven by formation and percolation of magnetic polarons [1,2,3]. While both systems exhibit a pronounced CMR effect, they differ considerably in their carrier density and resistivity behaviour, resulting in markedly different transport properties. In this work, EuZn₂P₂ is examined in detail where we aim to investigate how magnetic polarons form, evolve and dissolve through non-linear transport and resistance fluctuation spectroscopy measurements. Similarly, magnetic polarons can be studied in Sm_{1-x}Eu_xB₆. The antiferromagnetic composition Sm_{0.1}Eu_{0.9}B₆ shows a pronounced hysteresis in the MR curve [4], which likely indicates field-induced polaron stabilization.

- [1] Rev. B 108, 045116 (2023)

- [2] Phys. Rev. B 109, 104421 (2024)
 [3] arXiv:2503.24059
 [4] Condens. Matter 9, 55 (2024).

TT 62.4 Wed 15:00 P4

Growth and Structural Characterization of NdCo₂P₂ Single Crystals for Site-Resolved Magnetic Studies — ●FRANCESCA MARTINO^{1,2}, BENJAMIN HELMER¹, KRISTIN KLIEMT¹, KURT KUMMER², and CORNELIUS KRELLNER¹ — ¹Physikalisches Institut, Goethe-Universität Frankfurt, Frankfurt am Main, Germany — ²European Synchrotron Radiation Facility (ESRF), Grenoble, France

Rare-earth intermetallics with both 3d transition-metal and 4f rare-earth magnetic moments exhibit rich and often unexpected magnetic phenomena. Indeed, different intriguing properties have been found in the LnCo₂P₂ family [1][2]. As a first step towards exploring these interactions in NdCo₂P₂, high-quality single crystals have been successfully grown. In this study, we present an optimized growth procedure, confirmed by structural characterization via X-ray diffraction (XRD) and energy-dispersive X-ray spectroscopy (EDX), which demonstrates a well-ordered ThCr₂Si₂-type structure with high phase purity. Thermodynamic and transport measurements have also been performed to further assess the properties of the samples. These well-prepared single crystals provide a solid foundation for forthcoming site-specific X-ray magnetic spectroscopy studies, aiming to disentangle the contributions of the Nd and Co sublattices and to explore the complex magnetic behavior inherent to the LnCo₂P₂ series.

- [1] G. Poelchen et al., ACS Nano 16, 3573(2022).
 [2] C. Thompson et al., J. Mater. Chem. C2 (2014).

TT 62.5 Wed 15:00 P4

Locally non Centrosymmetric RRh₂Ga₂ (R=Ce, La) Systems: NMR/NQR as local probe for Magnetism and Superconductivity — ●I. NEME¹, A. M. STRYDOM², D. T. ADROJA³, V. K. ANAND^{3,4}, H. ROSNER¹, and M. BAENITZ¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²Physics Department, University of Johannesburg, South Africa — ³ISIS Facility, Rutherford Appleton Laboratory, Chilton, UK — ⁴Department of Physics, National Institute of Technology Agartala, Tripura, India

CeRh₂Ga₂ belongs to the class of locally non-centrosymmetric (LNC) correlated Ce Kondo systems [1] and is closely related to the recently discovered superconductor CeRh₂As₂ [2]. The non-magnetic reference LaRh₂Ga₂ is superconducting with relatively high T_c of 3.7 K, in contrast with 0.28 K for LaRh₂As₂. We have performed ^{69,71}Ga, ¹³⁹La NMR and ^{69,71}Ga NQR studies to probe the magnetism and the superconductivity. For characterization, we present magnetization and heat capacity measurements. Calculations of the band structure and the local electric field gradient at the Ga and La sites support our experimental results. We discuss the magnetic ground state of the Ce system and the occurrence of superconductivity in the La reference on basis of correlations and LNC properties.

- [1] V. K. Anand et al., J. Phys. Cond. Matt. 29 (2017)
 [2] S. Khim et al., Science 373 (2021)

TT 62.6 Wed 15:00 P4

Exploring the reciprocal space of CeRh₂As₂ at a high brilliance SwissFEL beamline — ●ALEXANDER MISTONOV¹, JAKUB VONKA², ALEXANDER STEPPKE², SWARNAMAYEE MISHRA¹, MAËL CLÉMENT², ADRIAN RUTSCHMANN², KARINA KAZARIAN², WENXIANG HU², BILL PEDRINI², SIMON GERBER², ELENA HASSINGER³, SEUNGHYUN KHAM⁴, and JOCHEN GECK¹ — ¹TU Dresden, Dresden, Germany — ²PSI, Villigen, Switzerland — ³KIT, Karlsruhe, Germany — ⁴MPI CPFS, Dresden, Germany

CeRh₂As₂ hosts two superconducting (SC) phases tuned by magnetic field [1] and undergoes an additional transition at T₀ = 0.55 K (with T_c = 0.35 K) [2]. The nearly non-magnetic and strongly anisotropic nature of the T₀ phase suggests an itinerant quadrupolar order of the Ce moments [3]. Since Ce-4f electrons couple to the lattice, a lowering of the tetragonal symmetry at T₀ is anticipated.

To test this, we performed single-crystal X-ray diffraction in non-resonant mode and at the Ce L_3 edge to search for symmetry reduction and signatures of multipolar order. We examined a possible splitting of the high- q (552) Bragg reflections and conducted energy-dependent rocking-curve scans near the $(\pi, \pi, 0)$ point.

These subtle effects were probed at ultralow temperatures using a high-brilliance SwissFEL beamline combined with a dilution refrigerator. The results are presented in this work.

[1] S. Khim et al., Science 373, 1012 (2021).

[2] K. Semeniuk et al., Phys. Rev. B 107, L220504 (2023).

[3] D. Hafner et al., Phys. Rev. X 12, 011023 (2022).

TT 62.7 Wed 15:00 P4

Pressure evolution of magnetic and electronic states in CeAgSb_2 — ●RILEY MANN, OLIVER BUSBY, CHRISTIAN DE PODESTA, OLIVER SQUIRES, and MALTE GROSCHE — Cavendish Laboratory, University of Cambridge, Cambridge CB3 0US, United Kingdom

CeAgSb_2 is a Kondo lattice material which hosts a weak ferromagnetic ground state at ambient pressure. Through the application of pressure, ferromagnetism can be suppressed, suggesting a quantum critical point at a critical pressure $p_c \sim 34$ kbar. Previous measurements have shown the emergence of new phases near this quantum critical region, two of which have been interpreted as antiferromagnetic, whereas the nature of the third phase remains unclear. Our quantum oscillation measurements at ambient pressure indicate strong quasiparticle mass enhancement, with effective masses up to $34 m_e$.

We present preliminary high-pressure measurements in the vicinity of the quantum critical region and extending up to about 70 kbar. Resistivity, magnetic susceptibility, and radio-frequency tunnel diode oscillator measurements were performed in high pressure anvil cells to track phase transition signatures, clarify the structure of the high pressure phase diagram, and investigate non-Fermi liquid signatures in transport properties. Measurements at $T < 1$ K near p_c give insight into the order of the ferromagnetic transition near the critical point and into the nature of the unknown phase.

TT 62.8 Wed 15:00 P4

Electron-phonon coupling for impurity models with flat bands in the bath — ●MAX FISCHER¹, EMIN MOGHADAS², NIKLAS WITT¹, ALESSANDRO TOSCHI², and GIORGIO SANGIOVANNI¹ — ¹Institut für Theoretische Physik und Astrophysik and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany — ²Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria

In Anderson impurity models the hybridization is typically assumed to be constant close to the Fermi level. Extensions including local vibrations coupled to the impurity site have been extensively studied. In this respect, the impact of Holstein phonons on the Kondo effect is particularly interesting, due to the subtle interplay between the exchange coupling and the phonon dynamics. Retardation effects can become particularly relevant since in addition to the bare phonon frequency and the bare kinetic energy, the correlation-induced renormalized bandwidth enters into the game. We add yet another knob, which is the flatness of the fermionic bath and study with analytical, quantum Monte Carlo and renormalization group approaches the effect of a singularity in the hybridization function, following our previous study without phonons [1].

[1] M. Fischer, A. Poli, L. Crippa, D. Călugăru, S. Ciuchi, M. Vojta, A. Toschi, and G. Sangiovanni, arXiv:2503.14326 (2025).

TT 62.9 Wed 15:00 P4

The Fate of Kondo Correlations in Superconducting Magnetic Impurities beyond Mean Field — ●KILIAN MÜNZ¹, BJÖRN KUBALA^{1,2}, CHRISTIAN AST³, JOACHIM ANKERHOLD¹, and CIPRIAN PADURARIU¹ — ¹Institute for Complex Quantum Systems and IQST, Ulm University, Ulm, Germany — ²German Aerospace Center (DLR), Institute for Quantum Technologies, Ulm, Germany — ³Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

The interplay between strong electronic correlations (Kondo effect) and superconductivity is of fundamental interest in mesoscopic physics. We investigate the superconducting single-impurity Anderson model (SIAM) with Numerical Renormalization Group methods using the NRG Ljubljana code [1]. Calculations confirm the expected emergence of Yu-Shiba-Rusinov (YSR) states within the superconducting gap.

Simulations also yield the tails of the renormalized Kondo density of states extending above the gap. We demonstrate that these above-gap features translate directly into additional contributions in the tunneling current measured by scanning tunneling microscopy. Crucially, these Kondo-rooted spectral signatures exhibit a discontinuous change across the quantum phase transition of the superconducting SIAM. These NRG predictions show excellent qualitative agreement with recent experimental results from MPI-FKF Stuttgart.

[1] Žitko, Rok: NRG Ljubljana. DOI: 10.5281/ZENODO.4841076.

TT 62.10 Wed 15:00 P4

Using $1/N$ graph expansions to explore the mesoscopic regime of strongly correlated systems — ●ANDREAS SCHELLENBERGER¹, LIDIA STOCKER², and KAI PHILLIP SCHMIDT¹ — ¹Friedrich-Alexander-Universität Erlangen-Nürnberg — ²Max Planck Institute for the Physics of Complex Systems, Dresden

Finite-size effects in strongly correlated systems can generate nontrivial low-energy behavior in the mesoscopic regime, yet this regime is difficult to access with standard many-body techniques [1–3]. We present a novel graph-expansion method to systematically explore strongly correlated systems with one-to-all couplings. This approach enables controlled exploration of the corrections to the thermodynamic limit in terms of a $1/N$ expansion for light-matter systems or systems with collective bath modes.

We apply our approach to the open Kondo box model at zero temperature [4], where an Anderson impurity is coupled to a bath with finite level spacing. By computing energies, correlation functions, and entanglement measures, we investigate how the Kondo effect emerges as a function of the systems parameters, benchmarking our results against exact diagonalization and DMRG.

[1] K. Lenk, J. Li, P. Werner, M. Eckstein, arXiv:2205.05559 (2022)

[2] A. Kudlis, D. Novokreschenov, I. Iorsh, I. Tokatly, arXiv:2304.00805 (2023)

[3] P. Simon, I. Affleck, PRL 89.206602 (2002)

[4] C. Rössler et al., PRL 155.166603 (2015)

TT 62.11 Wed 15:00 P4

Low-dimensional critical behavior of correlated electrons, Mermin-Wagner theorem, and local self-energy — ●ŠIMON KOS¹, SUNIL D'SOUZA¹, JAN GEBEL¹, JÁN MINÁR¹, and VÁCLAV JANÍŠ² — ¹University of West Bohemia, Univerzitní 8, CZ-301 00 Plzeň, Czech Republic — ²Institute of Physics, The Czech Academy of Sciences, Na Slovance 2, CZ-182 00 Praha 8, Czech Republic

We present a theoretical treatment of low-dimensional critical behavior coming from electron correlations. The treatment is based on the Baym-Kadanoff approach, which involves one-particle self-consistency between the propagator and the self-energy, along with the bare two-particle interaction. In low dimensions, self-consistency prevents ordering in agreement with the Mermin-Wagner theorem and exhibits critical behavior as the temperature is lowered towards zero. The critical behavior enables the use of the polar approximation, which reduces the convolutive Schwinger-Dyson equation to an algebraic equation for the local propagator and self-energy, amenable to solution. We demonstrate the treatment using the example of a 1d Hubbard model with an attractive interaction, which describes the tendency toward superconductivity, in the FLEX approximation. We present various features of the algebraic Schwinger-Dyson equation and the quantities that enter it.

TT 62.12 Wed 15:00 P4

Emergent relativity and topology of interacting quadratic fermions — ●LUKAS BERGER and THOMAS C. LANG — Institute for Theoretical Physics, University of Innsbruck, Austria

We investigate the lattice realization of perfect quadratic band touching of fermions augmented by local Coulomb interactions via quantum Monte Carlo simulations. We show that due to the C_4 rotational symmetry of the lattice, interactions trigger an instability towards quantum anomalous Hall order. In contrast, once the rotational symmetry of the lattice is reduced to C_2 , infinitesimally small interactions dynamically induce a topological transition from quadratic band touching to multiple Dirac cones before undergoing a Gross-Neveu transition where lattice symmetry is spontaneously broken via charge order. We directly monitor the separation of the Berry flux and the simultaneous emergence of Dirac-like excitation spectra.

TT 63: Quantum Dynamics and Many-body Systems – Poster (joint session DY/TT)

Time: Wednesday 15:00–18:00

Location: P5

TT 63.1 Wed 15:00 P5

Operator spreading through the lens of the information lattice — •LUCA GAWALLECK^{1,2}, MAXIME DEBERTOLIS¹, JENS H. BARDARSON³, and DAVID J. LUITZ¹ — ¹Institut of Physics, University of Bonn, Nüßallee 12, 53115 Bonn, Germany — ²Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — ³Department of Physics, KTH Royal Institute of Technology, Stockholm, 106 91 Sweden

We study the entanglement growth during Heisenberg time evolution by extending the framework of the information lattice to operators using the operator entanglement entropy. We focus on one-dimensional quantum spin chains and work in the tensor network formalism. The generalization of the information lattice to matrix product operators allows us to observe the spreading of initially local operators in a way that is not biased by the choice of a probing operator. We demonstrate that the operator information lattice we introduce contains all information typically provided by the out-of-time-order correlator with the additional ability to resolve the correlations on different scales. This method provides a good way to analyze systematically the time dependence of entanglement and can seamlessly be integrated into existing information-lattice-based algorithms.

TT 63.2 Wed 15:00 P5

Non-Perturbative Out-Of-Equilibrium Dynamics with Initial Four-Point-Correlations — JÜRGEN BERGES, LOUIS JUSSIOS, and •COSIMA SCHMITT — ITP Heidelberg

We investigate how initial correlations affect the equilibration dynamics of closed systems in quantum field theory. For interacting scalar fields with N components, we derive nonequilibrium evolution equations from a self-consistent large- N expansion to next-to-leading-order. By going beyond conventional Gaussian initial conditions, we point out the role of initial four-point correlations for the propagator evolution at early times and in the late-time approach to thermal equilibrium.

TT 63.3 Wed 15:00 P5

Nonequilibrium Green Function Simulations for Large Systems — •ERIK SCHROEDTER, JAN-PHILIP JOOST, and MICHAEL BONITZ — Christian-Albrechts-Universität zu Kiel, Kiel, Germany

Nonequilibrium Green Functions (NEGF) provide a powerful framework for accurately simulating the dynamics of correlated many-body systems. A major limitation of standard NEGF approaches is the cubic scaling of computational cost with the number of time steps. Recently, the G1-G2 scheme [1] overcame this limitation, achieving linear scaling. However, it introduces its own challenges, such as numerical instabilities at strong coupling and large memory requirements, which have so far restricted simulations to small systems with fewer than 150 basis states. Here, we introduce a NEGF-based quantum fluctuations approach (NEGF-QF)[2] that builds on earlier works [3] to efficiently factorize the two-particle Green function. This method drastically reduces computational costs for advanced self-energy approximations, including GW and T-matrix, while enabling straightforward parallelization. As a result, NEGF-QF allows simulations of systems with up to ten thousand basis states. We demonstrate the approach for large Hubbard clusters and graphene nanoribbons, illustrating its effectiveness for large, strongly correlated systems.

This work was funded by the Deutsche Forschungsgemeinschaft (DFG), Project No. 464370560.

[1] Schlünzen et al., Phys. Rev. Lett. 124, 076601 (2020)

[2] Schroedter et al., to be published (2026)

[3] Schroedter et al., Cond. Matt. Phys. 25, 23401 (2022)

TT 63.4 Wed 15:00 P5

Quantum Chaos in a Classical Counterpart to the Fermi-Hubbard model through an exact Path-Integral Formalism — •LOUIS RENCK¹, WOLFGANG HOGGER², JUAN DIEGO URBINA², and PETER SCHLAGHECK¹ — ¹IPNAS, CESAM research unit, Université de Liège, Belgium — ²Institut für Theoretische Physik, Universität Regensburg, Germany

Understanding quantum chaos in interacting many-fermion systems remains challenging: unlike many-bosons systems - where quantum-classical correspondence can be established using semiclassical tools

such as the van Vleck-Gutzwiller propagator [1] -, most interacting fermions models still lack a sensible classical limit where Hamiltonian chaos can be defined.

We propose a candidate to the first classical Hamiltonian for the Fermi-Hubbard model with integrability broken by a random onsite potential. Starting from the fermionic Hamiltonian, we apply a Jordan-Wigner transformation and switch to the Schwinger-boson representation to obtain a bosonic form. A recently developed exact bosonic path-integral formalism [2] then provides a classical Hamiltonian symbol defined over a symplectic phase space. We investigate the resulting quantum-classical correspondence by comparing the effective dynamics with the quantum evolution, and we present quantitative checks of chaos based on spectral properties and out-of-time ordered correlators.

[1]. T. Engl, J. Dujardin, A. Argüelles, P. Schlagheck, K. Richter, and J. D. Urbina, Phys. Rev. Lett. 112, 140403 (2014).

[2]. F. Bruckmann and J. D. Urbina (2018)

TT 63.5 Wed 15:00 P5

Adaptive Fermion Circuits with chiral transport — •MARKUS SIEGL and MICHAEL BUCHHOLD — Department of Theoretical Physics, Universität Innsbruck, Austria

Nonequilibrium quantum transport, where coherent many-body dynamics coexist with directional motion remains a central challenge in modern quantum physics. This project investigates transport phenomena in two coupled fermionic chains designed to break chiral symmetry. Using fermionic adaptive circuits and measurement-feedback protocols, we aim to control nonequilibrium dynamics and induce directional motion in an otherwise symmetric quantum system. By linking classical universality, quantum many-body effects, and information transport, the research seeks to uncover new mechanisms for controlled, symmetry-broken quantum transport, establishing a model system for genuinely nonequilibrium quantum matter.

TT 63.6 Wed 15:00 P5

Absorbing-State Dynamics and Feedback Control in Quantum Many-Body Scar Systems — •LARA SCHORR — University of Innsbruck

We look at quantum many-body scar states, which are special excited states in non-integrable systems that do not thermalize. To better understand their non-equilibrium dynamics, we translate the problem to a measurement-based quantum circuit equipped with feedback control. Focusing on a spin-1/2 chain with SU(2) symmetry, we show that local unitary feedback enables controlled manipulation of non-local charges, allowing the system to relax into highly entangled dark states. By analyzing the convergence towards the target state, we find that the dynamics resembles an emergent absorbing-state process, in which non-local charges diffuse and annihilate over time. Studying the scaling of convergence times allows us to identify conditions under which the dynamics may exhibit an absorbing-state phase transition.

TT 63.7 Wed 15:00 P5

Floquet-Magnus expansion for driven quantum systems and spin dynamic mean-field theory in NMR — •ANTONIA JOËLLE BOCK — TU Dortmund University, Germany

An accurate and reliable theoretical description of periodically driven quantum systems is highly relevant to many applications, such as for magic-angle spinning (MAS) in nuclear magnetic resonance (NMR) and ultracold atoms in driven optical lattices. Typically, the first step in capturing the dynamics is to determine an effective time-independent Hamiltonian, for which one can choose from a broad range of slightly different, hence often confusing, theories. Thus, I specifically investigated two widely used theories: Average Hamiltonian theory (AHT) and the Floquet-van Vleck approach (secular averaging). I was able to quantify the importance of the kick operator for the equivalence between perturbative and numerically exact approaches. This was achieved through analytical calculations and numerical evaluations of exemplary spin systems. These crucial insights then build the foundation for the second step of my project: a dynamic mean-field theory for dense spin ensembles applicable to complex couplings between three or more spins (MAS-DMFT). The recently developed spinDMFT (cp., e.g., Gräßer et al., 2024) has proven to be efficient, accurate and applicable to large spin systems yielding 2-particle inter-

actions.

TT 63.8 Wed 15:00 P5

Phonon mediated indirect spin interaction — ●PABLO REISER and HABIB ROSTAMI — University of Bath, Bath, United Kingdom

Due to the lack of inversion symmetry in the hBN monolayer, circular polarized vibration in solids, or chiral phonons, with nonzero angular momentum are allowed. These chiral phonons can couple to spins of different nature through their angular momentum. Within this context, we explored the coupling of chiral phonons with non-zero angular momentum to two impurity spins in hBN. Using field theory methods, we obtained the spin susceptibility and studied its properties like the mass dependence of the coupling, frequency of oscillation and rate of decay. The momentum transfer due to this coupling may open the door for non-trivial thermal or spin transport effects.

TT 63.9 Wed 15:00 P5

Dynamical Phases and Instabilities in Periodically Driven Bogoliubov-de Gennes Superconductors — ●SUBHADIP CHAKRABORTY, ANIMESH PANDA, and FERDINAND EVERS — Institute of Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

We investigate the nonequilibrium dynamics of a superconductor subjected to a periodic modulation of the interaction strength starting with Bogoliubov-de Gennes (BdG) mean field Hamiltonian. Using numerical solutions of the time-dependent Bogoliubov-de Gennes equations, we first explore several dynamical superconducting regimes. Our analysis reveals a rich variety of phases, including Rabi-Higgs oscillations, synchronized Higgs dynamics, and time-crystalline responses, and shows how their stability varies across driving parameters. In some regions of parameter space, infinitesimal initial seeds of finite momentum pairing grow exponentially during our driving protocol. By computing the momentum-resolved pairing response, we identify the instability bands associated with these finite-momentum modes, quantify their growth rates, and determine their dependence on driving frequency and drive amplitude. These results provide a comprehensive numerical characterization of the dynamical phases and instabilities that arise in periodically driven superconductors before the final steady state is reached.

TT 63.10 Wed 15:00 P5

Higher order Magnus expansion for two-level quantum dynamics — ●CHEN WEI and FRANK GROSSMANN — Institut für Theoretische Physik, 01062 Dresden, Germany

This study investigates the Magnus expansion [1] for a generic time-dependent two-level system. By using its convergence condition [2], we find that elementary unitary transformations significantly extend the validity of the Magnus expansion. Furthermore, higher order terms admit particular physical interpretations. By virtue of $su(2)$ Lie algebra, the expansion is decomposed into a commutator-free form. To illustrate its usefulness, we study the Landau-Zener [3] model, which displays a special case of non-adiabatic transitions. Using again the Magnus expansion, Hermitian and non-Hermitian versions of the semiclassical Rabi model are systematically treated by determining the Floquet quasienergy [4] and Bloch-Siegert shift [5]. As a noteworthy by-product, the Magnus expansion provides a quantitative characterization of the adiabatic theorem [6].

[1] W. Magnus, *Commun. Pure Appl. Math.* 7, 649-673 (1954). [2] M. M. Maricq, *J. Chem. Phys.* 86, 5647-5651 (1987). [3] C. Zener and R. H. Fowler, *Proc. R. Soc. Lond. A* 137, 696-702 (1932). [4] J. H. Shirley, *Phys. Rev.* 138, B979-B987 (1965). [5] F. Bloch and A. Siegert, *Phys. Rev.* 57, 522-527 (1940). [6] M. Born and V. Fock, *Z. Phys.* 51, 165-180 (1928).

TT 63.11 Wed 15:00 P5

Distribution of complex amplitudes of chaotic resonance states — ●JAN MÖSERITZ-SCHMIDT and ROLAND KETZMERICK — TU Dresden, Institut für Theoretische Physik, Dresden, Germany

Resonance states of chaotic scattering systems have complex amplitudes in the position representation. Naively, one would expect that the phase of the complex amplitude is uniformly distributed, however, we observe significant deviations. We find that part of this is a finite-size effect which is already present in the random wave model. It is enhanced by the multifractal structure of chaotic resonance states, which follows from the factorization conjecture. We quantify these deviations using the phase rigidity and analyze its scaling behavior

in the semiclassical limit. Numerically, this is demonstrated for the paradigmatic three-disk scattering system.

TT 63.12 Wed 15:00 P5

Complex dynamics and particle-wave correspondence in anisotropic mesoscopic cavities — ●SILVAN STOPP, SAMUEL SCHLÖTZER, LUKAS SEEMANN, and MARTINA HENTSCHEL — Technische Universität Chemnitz, 09107 Chemnitz, Germany

Mesoscopic billiard systems with different geometries are well-known model systems for investigating complex dynamics and quantum chaos. While the breaking of spatial cavity symmetries is typically considered to be the origin of chaotic dynamics, we show that anisotropies, i.e., broken symmetries in momentum space, can also cause chaotic particle dynamics. To this end, we investigate bilayer graphene systems (BLG) [1] and birefringent optical microcavities [2], both of which have preferred propagation directions. Anisotropy prevents angular momentum to be a conserved quantity, and consequently, the angles of incidence and of reflection of a particle trajectory deviate. Therefore, we implement an advanced ray tracing algorithm that we apply to BLG and birefringent cavities. We show that the presence of anisotropies induces chaotic dynamics even in circular cavities. We investigate the interplay of the cavity shape and the Fermi line geometry and illustrate how it affects the cavity dynamics. In particular, we find that certain trajectories can be stabilized by matching the symmetry in real and momentum space. In addition, we use Kwant and transformation optics to demonstrate ray/particle-wave correspondence in real space as well as in phase space using the Husimi function.

- [1] L. Seemann, A. Knothe, M. Hentschel, *PRB* 107, 205404 (2023)
- [2] M. Hentschel, S. Schlötzer, L. Seemann, *Entropy* 27(2):132 (2025)

TT 63.13 Wed 15:00 P5

Periodic orbit theory approach for a non-Hermitian Riemann operator — ●SEBASTIAN HÖRHOOLD, ANDREAS HÖTZINGER, JUAN DIEGO URBINA, and KLAUS RICHTER — Institut für Theoretische Physik, Universität Regensburg, Germany

The Riemann Hypothesis (RH) is one of the most important open problems in mathematics. Among the various approaches toward its proof is the Hilbert-Pólya (HP) conjecture, stating that there should exist a Hermitian operator whose eigenvalues t_n are given by the zeros of the Riemann zeta function $\zeta(1/2 + it_n)$. The RH would then follow from the reality of these eigenvalues.

In a recent contribution toward a proof of the RH, a non-Hermitian Hamiltonian has been introduced, referred to as a Riemann operator, whose spectrum contains the t_n , and from which one can construct an HP operator [1]. Our work focuses on a similar Hamiltonian, and we intend to make use of semiclassical tools to support earlier work by Berry and Keating, who obtained a formal asymptotic expression for the counting function of the nontrivial Riemann zeros [2]. Their results suggest a strong connection between the spectral statistics of these zeros and classically chaotic systems.

In this poster contribution, we show the emergence of the Riemann zeros within the spectrum of our non-Hermitian Hamiltonian and discuss how periodic orbit theory can be applied.

- [1] E. Yakaboylu, *arXiv:2408.15135*
- [2] M. V. Berry and J. P. Keating, *SIAM Review* 41.2 pp. 236-266

TT 63.14 Wed 15:00 P5

Echo state network prediction of billiard dynamics — ●ANNA SKOPNIK, LUKAS SEEMANN, and MARTINA HENTSCHEL — Institut für Physik, TU Chemnitz, Germany

Machine Learning has attracted a lot of interest recently. Here, we apply an Echo State Network (ESN) algorithm to two mesoscopic billiard systems in order to explore its usability in the prediction of the internal dynamics of ballistic cavities. First, we study the well-known Limaçon system with chaotic dynamics. Second, we study the more complex dynamics in an anisotropic system inspired by bilayer graphene (BLG) representing a mixed space dynamics with regular and chaotic trajectories. Here, we present preliminary results on the training and hyperparameter optimization for both systems, Limaçon and BLG.

TT 63.15 Wed 15:00 P5

Anomalous Dynamics in Complex Quantum Systems — ●IRINA PETRESKA¹, PECE TRAJANOVSKI^{1,2}, ERVIN KAMINSKI LENZI³, and TRIFCE SANDEV^{1,2,4} — ¹Ss. Cyril and Methodius University in Skopje, Macedonia — ²Macedonian Academy of Sciences and Arts, Skopje, Macedonia — ³Universidade Estadual de Maringá, Maringá, Brazil — ⁴Korea University, Seoul, Korea

We will give an overview of our recent works related to some generalizations of the Schrödinger equation. Special attention will be paid to the fractional Schrödinger equation, pointing out physical examples where the time-fractional Schrödinger equation naturally emerges under certain geometric constraints. Additionally, we include a long-range interaction term, modeled by an integral operator, which cap-

tures spatial nonlocalities. Using the Green's function approach, we derive analytical solutions and explore their implications in the time-space domain. Our findings reveal anomalous behavior arising from the interplay of fractional dynamics, nonlocal potentials and memory effects.

TT 64: BKT Physics

Time: Wednesday 16:45–18:15

Location: HSZ/0103

TT 64.1 Wed 16:45 HSZ/0103

Berezinskii-Kosterlitz-Thouless renormalization group flow at a quantum phase transition — ●MATTHIAS THAMM¹, HARINI RADHAKRISHNAN², HATEM BARGHATHI², CHRIS HERDMAN³, ARPAN BISWAS², BERND ROSENOW¹, and ADRIAN DEL MAESTRO² — ¹Leipzig University — ²University of Tennessee, Knoxville — ³Middlebury College, Vermont

We present a controlled numerical study of the Berezinskii-Kosterlitz-Thouless (BKT) transition in the one-dimensional Bose-Hubbard model at unit filling, providing evidence of the characteristic logarithmic finite-size scaling of the BKT transition. Employing density matrix renormalization group and quantum Monte Carlo simulations under periodic boundary conditions, together with a systematic finite-size scaling analysis of bipartite particle number fluctuations, we resolve boundary-induced complications that previously obscured critical scaling. We demonstrate that a suitably chosen central region under open boundaries reproduces universal renormalization group signatures, reconciling earlier discrepancies. Finally, leveraging a nonparametric Bayesian analysis, we determine the critical interaction strength with high precision, establishing a benchmark for BKT physics in one-dimensional quantum models.

TT 64.2 Wed 17:00 HSZ/0103

Finite-size effects in the vicinity of the BKT transition in superconducting NbN thin films — ●LEA PFAFFINGER¹, ALEXANDER WEITZEL¹, SVEN LINZEN², EVGENII IL'ICHEV², ILARIA MACCARI³, and CHRISTOPH STRUNK¹ — ¹Department of Experimental Physics, University Regensburg, Regensburg, Germany — ²Leibniz Institute of Photonic Technology, Jena, Germany — ³ETH, Zurich, Switzerland

For 2D superconducting thin films, Halperin and Nelson predicted a finite resistance between the Berezinskii-Kosterlitz-Thouless temperature T_{BKT} and the mean-field critical temperature T_{c0} due to the unbinding of thermally excited vortex-antivortex pairs. Recently, we observed a sharp BKT-transition in homogeneously disordered 3nm NbN films grown by ALD, which is in very good agreement with these theoretical predictions [1]. Although the sample width was much smaller the Pearl length $\Lambda_p \approx 2mm \gg w = 10\mu m$, we did not observe a size induced smearing of the transition. When further reducing the width to $w \leq 1\mu m$, we do observe a finite resistance for $T < T_{BKT}$ as expected from the cut-off of the divergence of the correlation length by the finite size. This resistance is thermally activated with an activation energy that depends logarithmically on the width. We present a systematic study of the resistance in this regime combined with an analysis based on the work of [2] and [3].

[1] A. Weitzel et al., Phys. Rev. Lett. 131, 186002 (2023).

[2] L. Benfatto et al., Phys. Rev. B 80, 214506 (2009).

[3] V.G. Kogan et al., Phys. Rev. B 83, 144526 (2011).

TT 64.3 Wed 17:15 HSZ/0103

Quasi-two-dimensional superconductivity in $1T\text{-Ti}_{1-x}\text{Ta}_x\text{Se}_2$ — ●POULAMI MANNA, SUHANI SHARMA, TARUSHI AGARWAL, SHASHANK SRIVASTAVA, PRIYA MISHRA, and RAVI PRAKASH SINGH — Indian Institute of Science Education and Research, Bhopal

The emergence of two-dimensional (2D) superconductivity in bulk transition metal dichalcogenides (TMDs) has sparked crucial research interest for hosting exotic quantum states. Intercalation, doping, or inserting insulating layers can significantly weaken the interlayer coupling, thereby achieving 2D behavior in bulk materials. While doped bulk crystals of TaS_2 and NbSe_2 show 2D superconductivity, Ti-based TMDs remain largely unexplored. Among them, non-superconducting TiSe_2 has been extensively studied due to its controversial electronic nature and semimetallic/semiconducting behavior.

Here, we discuss the superconducting properties of single-crystalline $1T\text{-Ti}_{1-x}\text{Ta}_x\text{Se}_2$ for $x = 0.2$, using magnetization, resistivity, and specific heat measurements. The results reveal anisotropic bulk superconductivity with a transition temperature of 2.32(1) K. Specific heat measurements show weakly coupled, isotropic s-wave superconductivity in $\text{Ti}_{0.8}\text{Ta}_{0.2}\text{Se}_2$. Notably, the first evidence of quasi-2D superconductivity in Ti-based TMD is confirmed by angle-dependent magneto-transport measurements and observation of a BKT transition. These findings offer an opportunity to explore numerous low-dimensional quantum phases in bulk materials and effectively broaden the new pathway for realizing 2D superconductivity.

TT 64.4 Wed 17:30 HSZ/0103

Two-dimensional multiband superconductivity in $1T\text{-MoS}_2$ — ●CHITHRA H. SHARMA^{1,2} and MADHU THALAKULAM² — ¹Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²IISER Thiruvananthapuram, 695551 Thiruvananthapuram, India

van der Waals materials provide ultra-clean platforms to realise superconductivity in 2D, which is decorated by features such as Berezinskii-Kosterlitz-Thouless (BKT) phase transition and Bose metal phase owing to the vortex dynamics in the system. One interesting yet seldom-studied material is $1T\text{-MoS}_2$, the metallic phase. Stable $1T\text{-MoS}_2$ prepared using Ar/H_2 microwave plasma exposure shows 2D superconductivity with a critical temperature of ~ 920 mK. BKT phase transition, Bose metal phase and enhanced parallel critical field above the Pauli limit have been observed in the system. The low-noise differential I - V characteristics of the sample show features corresponding to multiband superconductivity.

TT 64.5 Wed 17:45 HSZ/0103

Phases of Quasi-One-Dimensional Fractional Quantum (Anomalous) Hall Superconductor Heterostructures — STEFFEN BOLLMANN¹, ANDREAS HALLER², JUKKA I. VÄYRYNEN³, ●THOMAS L. SCHMIDT², and ELIO J. KÖNIG^{4,1} — ¹Max-Planck Institute for Solid State Research, 70569 Stuttgart, Germany — ²University of Luxembourg, L-1511 Luxembourg, Luxembourg — ³Purdue University, West Lafayette, Indiana 47907, USA — ⁴University of Wisconsin-Madison, Madison, Wisconsin 53706, USA

We study fractional quantum (anomalous) Hall-superconductor heterostructures in the presence of $U(1)$ order-parameter fluctuations and focus on the case of $\nu = 2/3$ quantum Hall states leading to \mathbb{Z}_3 parafermions. For an alternating pattern of superconductor and tunneling regions, coupled to fractional quantum Hall edge states, we use a map onto a topological Josephson junction chain involving lattice parafermions. Using DMRG simulations, we establish a phase diagram composed of Mott insulating phases and two different Luttinger liquids carrying excitations with charges $2e$ and $2e/3$. In agreement with analytical considerations using conformal field theory, we numerically find transitions of Berezinskii-Kosterlitz-Thouless (BKT) type as well as a continuous $\mathbb{Z}_3 \times U(1)$ second-order phase transition characterized by central charge $c = 9/5$. We finally extract information about a possible ground state degeneracy and comment on the stability of parafermionic edge states in the presence of order parameter fluctuations.

TT 64.6 Wed 18:00 HSZ/0103

Persistence of the Berezinskii-Kosterlitz-Thouless transition with long-range couplings — ●LUIS WALTHER^{1,2}, JOSEF WILLISHER^{1,3,2}, and JOHANNES KNOLLE^{1,3,4} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — ³Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ⁴Blackett Laboratory, Imperial College Lon-

don, London SW7 2AZ, United Kingdom

The Berezinskii–Kosterlitz–Thouless (BKT) transition is an archetypal example of a topological phase transition, which is driven by the proliferation of vortices. In this Letter, we analyze the persistence of the BKT transition in the XY model under the influence of long-range algebraically decaying interactions of the form $\sim 1/r^{2+\sigma}$. The model hosts a magnetized low temperature phase for sufficiently small σ . Crucially, in the presence of long-range interactions, spin waves renormalize the

interaction between vortices, which stabilizes the BKT transition. As a result, we find that there is no direct transition from the magnetized to the disordered phase and that the BKT transition persists for arbitrary long-range exponents, which is distinct from previous results. We use both Landau–Peierls-type arguments and renormalization group calculations—including a coupling between spin wave and topological excitations—and obtain similar results. We discuss the relevance of our findings for current Rydberg atom experiments, and highlight the importance of long-range couplings for other spin models.

TT 65: 2D materials: Stacking and heterostructures – Poster (joint session O/TT)

Time: Wednesday 18:00–20:00

Location: P2

TT 65.1 Wed 18:00 P2

Unexpected Ordered Interfaces in WSe₂-MoSe₂ Lateral Interfaces Observed by STEM — ●MATVEI KISLITSYN¹, MAX BERGMANN¹, JULIAN PICKER², JÜRGEN BELZ¹, ROBIN GÜNKEL¹, BADROSADAT OJAGHI DOGAHE¹, SHAMAIL AHMED¹, ANDREY TURCHANIN², and KERSTIN VOLZ¹ — ¹mar.quest | Marburg Center for Quantum Materials and Sustainable Technologies, Philipps-Universität Marburg, 35032 Marburg, Germany — ²Faculty of Chemistry and Earth Sciences, Friedrich-Schiller-Universität, 07743 Jena, Germany

Two-dimensional WSe₂-MoSe₂ lateral heterostructures offer a platform for engineering band alignment and excitonic behavior through atomic-scale control of composition, making this material attractive for use in 2D optoelectronic devices. In this contribution, we present a systematic scanning transmission electron microscopy (STEM) study of monolayer WSe₂-MoSe₂ heterostructures synthesized by chemical vapor deposition (CVD) directly on SiO₂ TEM grids. While some investigated 2D flakes show atomically sharp interfaces with minimal intermixing, we also observe a highly ordered and unexpected interface configuration consisting of alternating Mo and W atomic rows. By comparing experimental observations with STEM image simulations and theoretical predictions, we analyze the structural origins of both interface types and discuss the mechanisms that may give rise to this unusual ordering. These results provide insight into interface formation mechanisms in lateral transition-metal dichalcogenide heterostructures and their potential impact on material properties.

TT 65.2 Wed 18:00 P2

Superdomains and Strain Localization in Twisted Two Dimensional Transition Metal Dichalcogenides — ●RIYA PATEL¹, DANIEL WOLF¹, KRISTINA WEINEL^{1,2}, SILKE HAMPEL¹, and AXEL LUBK^{1,2} — ¹IFF, IFW Dresden, 01069 Dresden — ²Faculty of Physics, Technical University Dresden, 01069 Dresden

Bilayers of 2D transition metal dichalcogenides (TMDCs) exhibit special structural and electronic phenomena when stacked with a low-twist-angle. Particularly, they undergo lattice reconstruction, forming large triangular stacking domains, separated by domain walls that concentrate strain (soliton regime), which was shown in simulations. However, direct experimental quantification of these strain features and their correlation with electronic properties remains limited. Here we investigate low-twist-angle TMDCs using high-resolution transmission electron microscopy to visualize the reconstructed super lattice and identify the resulting superdomains structure. We employ geometric phase analysis to quantitatively map the strain distribution at the domain walls with nanometer resolution, revealing spatial maps of different strain components. We use Electron Energy Loss Spectroscopy to further probe the electronic properties of the reconstructed system. The understanding of strain localization in superdomain structures and the related electronic properties in such systems facilitate strain-engineered electronic properties in twisted TMDCs.

TT 65.3 Wed 18:00 P2

Pseudomonolayer TMDCs via organic intercalation — ●KATHARINA STEINKIRCHNER^{1,2}, JAKOB DILLING^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, TIM RIEDEL^{1,2}, MARKUS SCHOLZ⁴, and KAI ROSSNAGEL^{1,2,3,4} — ¹Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — ³Kiel Nano, Surface and Interface Science KiNSIS, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ⁴Deutsches Elektronen-Synchrotron DESY, 22607

Hamburg, Germany

Transition metal dichalcogenides (TMDCs) are a versatile class of layered materials with tuneable electronic properties. One approach to tailoring these properties is to manipulate the material's effective dimensionality. Specifically, intercalating cationic organic molecules with different alkane carbon chain into the van der Waals gaps between the layers increases the interlayer distance of the TMDC host material. This transforms the crystal from a bulk state to a monolayer-like state, thereby altering the electronic structure [1]. Here, we present a comprehensive study of the geometric and electronic structures of intercalated and non-intercalated TMDCs, such as NbSe₂, using SEM, EDS, and 11eV laser-based ARPES.

[1] H. Zhang *et al.*, Nat. Phys. **18**, 1425 (2022).

TT 65.4 Wed 18:00 P2

Preparation of quasi-freestanding few-layer samples of 2D materials — ●SEYEDEH HELYA ALAEI, HANNA SHIRIN PULIKKAL HAMZA, MASHOOD TARIQ MIR, LUKAS NÖDING, AHMED HASSANIEN, ARNE SENFTLEBEN, JOCHEN MIKOSCH, and THOMAS BAUMERT — University of Kassel, Institute of Physics, 34132 Kassel, Germany

Two-dimensional (2D) materials have garnered significant attention in the last two decades and have been analyzed using various methods in the fields of materials science and physics. To study the dynamic behavior of 2D materials upon irradiation with femtosecond laser pulses using ultrafast electron diffraction, it is necessary to isolate few-layer structures from bulk crystals and prepare them in a quasi-freestanding manner. Due to the weak van-der-Waals forces between the layers relative to the in-plane forces of the structure, mechanical exfoliation is a commonly used method. However, the transfer is challenging, due to the thinness of the flake and the adhesive force between the flake and the surface. Our preparation involves three major steps: (1) exfoliation using adhesive tape and viscoelastic gel, (2) isolation of 2D material nanosheets with thicknesses ranging from 3 to 50 nm, and (3) transfer onto a standard sample mesh of transmission electron microscopy with a high success rate. The transfer exploits liquid-solid phase transitions of a soluble wax-like material. In this ongoing study, the 2D ferromagnetic material Fe₅GeTe₂ has been of interest. We will discuss the different steps in detail and the challenges associated with the preparation of this material, including the fragility of the crystals due to oxidation and the partially covalent out-of-plane forces.

TT 65.5 Wed 18:00 P2

Ordering Phenomena in MoS₂ Nanocrystals on Graphite — ●LUKAS NÖDING¹, AHMED HASSANIEN¹, MASHOOD TARIQ MIR¹, HANNA SHIRIN PULIKKAL HAMZA¹, SEYEDEH HELYA ALAEI¹, THOMAS BAUMERT¹, JOCHEN MIKOSCH¹, FLORIAN GRASSME², CLAUDIA BACKES², and ARNE SENFTLEBEN¹ — ¹University of Kassel, Institute of Physics, Kassel, Germany — ²University of Kassel, Institute of Chemistry, Kassel, Germany

Two-dimensional transition-metal dichalcogenides (TMDCs) such as MoS₂ offer a platform for tailoring electronic and optical properties through controlled stacking and orientation. Achieving ordered assemblies of MoS₂ nanocrystals on crystalline substrates is, therefore, of considerable interest. In this work, we study the crystallographic alignment of MoS₂ nanocrystals on a graphite substrate. The samples were prepared using the Langmuir-Schäfer technique, enabling the reproducible deposition of nanocrystals with controlled density. To probe the crystallographic alignment of the deposited nanocrystals with respect to the graphite lattice, we performed wide field static electron diffraction measurements at an acceleration voltage of 35 kV,

complemented by selected area electron diffraction at 200 kV.

Our preliminary analysis reveals a pronounced localized and short-range ordered crystallographic alignment of the MoS₂ nanocrystals, extending over at least a few micrometers. A quantitative evaluation of the global ordering behavior, as well as its dependence on crystal size and deposition parameters, is currently underway and will be discussed.

TT 65.6 Wed 18:00 P2

Multiferroic Two-Dimensional Cu(CrX₂)₂ (X = S, Se, and Te) as Anode Materials for Lithium-Ion Batteries: A First-Principles Study — •MUHAMMAD FAYAZ¹ and ZIJING LIN² — ¹Department of Physics, University of Science and Technology of China, Hefei 230026, China — ²Department of Physics, University of Science and Technology of China, Hefei 230026, China

Identifying two-dimensional (2D) materials with the desired electrochemical performance for lithium-ion batteries is of great interest in developing next-generation energy devices. Motivated by the successful synthesis of multiferroic 2D materials, Cu(CrX₂)₂ (X = S, Se, and Te), which exhibit simultaneous ferroelectricity and ferromagnetism, we performed first-principles calculations to investigate their potential as anodes for lithium-ion batteries. We comprehensively investigate the electrochemical properties of the predicted systems and demonstrate that lithium exhibits sufficient mobility on their surface, with appreciable stability. For instance, the binding energy (Eb) of the

lithium adatom on Cu(CrS₂)₂ is -4.034 eV, with a diffusion barrier as low as 0.212 eV. As a consequence, the maximum theoretical specific capacity for lithium adatoms reaches as high as 1089 and 666 mAhg⁻¹, respectively, for Cu(CrS₂)₂ and Cu(CrSe₂)₂, which can be attributed to a much higher storage capacity of lithium adatoms compared to previously identified 2D anode materials. All of these remarkable properties, including high binding energy (Eb), low diffusion barrier, high specific capacity, and good electrical conductivity.

TT 65.7 Wed 18:00 P2

Valence-Band Renormalization and Spin Splitting in a Monolayer WTe₂/WSe₂ Heterostructure — •DAIYU GENG, NATALIE LEHMANN, JIABAO YANG, and NIELS SCHRÖTER — Max Planck Institute of Microstructure Physics, Weinberg 2, Halle (Saale), Germany

Monolayer WTe₂ (1L-WTe₂) hosts a variety of broken-symmetry phases, including a quantum spin Hall insulator, a topological excitonic insulator, and several intriguing spin-ordered states. The dielectric environment and charge-carrier density play crucial roles in the competition among these electronic phases. In this work, we investigate the band structure of 1L-WTe₂ interfaced with semiconducting WSe₂ using laser- and synchrotron-based micro-ARPES. We observe strong valence-band renormalization accompanied by pronounced spin splitting in 1L-WTe₂. Additionally, multiple replica pockets emerging in the Fermi surface indicate a substantial moiré effect in this heterostructure.

TT 66: 2D Materials: Electronic structure, excitations, etc. – Poster (joint session O/TT)

Time: Wednesday 18:00–20:00

Location: P2

TT 66.1 Wed 18:00 P2

Observation of many-body-localization in substituted 1T-TaS₂ — •JESUMONY JAYABALAN¹, GAELE REECHT¹, RICARDS KRISTERS KNIPŠIS², FLORIAN K DIEKMANN³, FRIEDEMANN QUEISSER², WALTER SCHNELLE⁴, PING ZHOU¹, KAI ROSSNAGEL³, RALF SCHÜTZHOLD², MANUEL GRUBER¹, and UWE BOVENSIEPEN¹ — ¹Uni. of Duisburg-Essen, Fakultät für Physik und CENIDE — ²HZ Dresden-Rossendorf, — ³CAU of Kiel and DESY — ⁴MPI for Chemical Physics of Solids, Dresden

Random modulations in the potential landscape are known to localize a single quantum particle, the Anderson localization leads, to stable non-thermalizing states. Adding interaction is expected to cause delocalization and a quick thermalization of such single particles, but in a strongly disordered system, the many-body quantum state itself becomes localized, known as the Many-Body Localization (MBL). Using time-resolved photoelectron spectroscopic measurements, we show that it is possible to realize MBL states in a Tungsten substituted 1T-TaS₂ material. Electrons are excited by using a 1.51 eV, 50 fs pulses and a 6 eV probe pulse was used to photoemit electrons. In contrast to ultrafast (<20 fs) decay of doublons in pristine 1T-TaS₂[1], we observe that some of the doublons decay in hundreds of femtosecond time scale, while the rest lasts for more than few microseconds. This observation is supported by scanning tunneling microscopic measurements and Fermi-Hubbard model calculations. Funding by DFG through QUAST-FOR5249 and SFB 1242 is acknowledged. [1] M. Ligges et al., Phys. Rev. Lett., 120, 166401 (2018).

TT 66.2 Wed 18:00 P2

Exciton Transport in Monolayer TMDs — •LIFENG OU, ALEJANDRO MOLINA-SÁNCHEZ, and ALBERTO GARCÍA-CRISTÓBAL — IC-MUV, University of Valencia, Valencia, Spain

Atomically thin transition metal dichalcogenides semiconductor emerges as promising candidates for novel optoelectronic application, displaying weak dielectric screening due to its truly two-dimension character. The optical properties are mostly related to inter-band transitions between valence and conduction bands, also called the strongly binding electron hole pair, exciton. Strain is expected to impact spatiotemporal distribution of excitons, e.g. spatially inhomogeneous strain acts as a driving force for exciton/carrier funneling, similarly to bias fields for charged particles. In this work we demonstrate the capability to manipulate exciton motion via spatially modulated strain fields, where excitonic energy especially its bandgap is largely tunable and the effective mass of electronic valleys is modified resulting in a qualitative change of the excitonic landscape and efficiency

of exciton-phonon scattering channels. These transport properties are represented by the coupled two equations, continuity equation and drift-diffusion equation, which derive from zero-order and first-order moment of Boltzmann equation, respectively. In addition, the simulation diffusion coefficient and mobility in latter equation are evaluated by first-principle and experiment qualitatively, as the function of strain fields.

TT 66.3 Wed 18:00 P2

trARPES investigation electron-phonon coupling in CrSBr — •MAURITS HOUMES, KARL SCHILLER, LASSE STERNEMANN, JONAH NITSCHKE, and MIRKO CINCHETTI — Departement of Physics, TU Dortmund University, 44227 Dortmund, Germany

CrSBr is a magnetic, semiconducting van der Waals material that has recently attracted significant interest. It hosts both localized Frenkel excitons and delocalized Wannier-Mott-like excitons, and its excitonic properties are strongly influenced by magnetic ordering and lattice distortions. [1,2,3] These features make CrSBr a compelling platform for exploring correlated phenomena in condensed matter systems.

To advance our understanding of the interplay between excitons, magnetism, and lattice dynamics in this material, a more complete characterization is essential. In this work, we present time- and angle-resolved photoemission spectroscopy (trARPES) measurements performed on CrSBr, with particular emphasis on quantifying the electron-phonon coupling. Aiming to provide a previously missing component needed to build a comprehensive picture of the interactions in CrSBr, offering a foundation for future studies and potential technological applications of this promising material.

1. Smiertka, M. et al. Preprint at ArXiv:2506.16426 (2025). 2. Lin, K. et al. ACS Nano 18, 2898-2905 (2024). 3. Bork, S. et al. Preprint at ArXiv:2511.20268v1 (2025).

TT 66.4 Wed 18:00 P2

Probing defect-induced wave patterns and superconductivity in 2H-NbS₂ — WERNER M.J. VAN WEERDENBURG, •MARGARETE HUISINGA, CONSTANTIN FLOMMERSFELD, LISA M. RÜTTEN, and KATHARINA J. FRANKE — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Transition metal dichalcogenides (TMDCs) host a variety of electronic phases, including superconductivity and charge-density-wave (CDW) order. Recent reports on 2H-NbS₂ have added a coexisting pair-density-wave (PDW) order to this set, inspiring new questions about the coexistence and driving mechanisms of these phases [1]. In contrast, the closely-related superconducting compound 2H-NbS₂ lacks a CDW phase, but has been suggested to be close to a CDW instability

and sensitive to the presence of defects [2,3].

Using low-temperature scanning tunneling microscopy and spectroscopy, we probe the electronic, phononic and superconducting properties of 2H-NbS₂. We observe wave-like modulations around intrinsic defects in differential-conductance maps and compare them to band-structure calculations. To assess the nature of these modulations, we probe the modulated regions and characterize the superconductivity spatially. These observations add to the ongoing exploration of superconducting, CDW, and PDW phases in TMDC materials.

[1] Liu et al., Science 372,1447-1452 (2021); [2] Heil et al., PRL 119, 087003 (2017); [3] Wen et al., PRB 101:241404, 6 (2020)

TT 66.5 Wed 18:00 P2

Theory of few- and many-body excitations in carbon nanotubes — ●MAURICE BERINGUIER^{1,2} and RICHARD SCHMIDT^{1,2} — ¹Institut für Theoretische Physik, Philosophenweg 16, 69120 Heidelberg — ²Universität Heidelberg, Grabengasse 1, 69117 Heidelberg

Even decades after their discovery, some properties of Carbon Nanotubes (CNTs) are still not fully understood. One of the phenomena still lacking a satisfying explanation is the behaviour of the absorption spectrum of semiconducting CNTs under doping. A resonance in these spectra appears only in the presence of additional charge carriers.

This has in the past been described with phenomenological models or few body physics (using trions and excitons), but experimental data (e.g. time resolved measurements of the spectra) hint at potential signatures of many-body physics. Inspired by their abundance in 2D or 3D semiconductors and cold quantum gases, we investigate whether quasiparticles like Fermi polarons could be responsible for the observations in CNTs, which due to their interesting geometry exhibit aspects of both 1D and 2D materials.

We tackle these questions by modeling charge carriers and excitons on CNTs interacting using a combination of exact diagonalization and variational techniques to gain insight into the interplay of few- and many-body physics in these systems.

TT 66.6 Wed 18:00 P2

Spin-orbit coupling in non-van der Waals 2D materials — ●MANI LOKAMANI¹, GUSTAV BIHLMAYER², GREGOR MICHALICEK², DANIEL WORTMANN², STEFAN BLÜGEL², and RICO FRIEDRICH^{1,3} — ¹Helmholtz-Zentrum Dresden-Rossendorf, Dresden — ²Forschungszentrum Jülich — ³TU Dresden

In recent years, the rising class of non-van der Waals 2D materials [1] has garnered substantial attention for their distinctive electronic and magnetic properties. In this contribution, we explore the impact of spin-orbit coupling (SOC) on the properties of these non-van der Waals 2D systems and its potential to induce topological properties. Given the presence of heavy elements like Bi and Tl in several 2D candidates, SOC effects notably influence the electronic structure. In our approach, we utilize AFLOW's standardized workflows [2] for initial screening. Subsequently, we extract metadata using AFLOW and tailor the parameters with an AiiDA-plugin [3] for precise electronic structure calculations employing the full-potential all-electron program FLEUR [4] within AiiDA. We analyze the influence of SOC on band structures and densities of states, with a particular focus on topologically protected 1D conduction edge channels.

[1] R. Friedrich *et al.*, Nano Lett. **22**, 989 (2022).

[2] Divilov *et al.*, High Entropy Alloys Mater. **3**, 178 (2025).

[3] G. Pizzi *et al.*, Comput. Mater. Sci. **111**, 218 (2016).

[4] The FLEUR project: <https://www.flapw.de>.

TT 66.7 Wed 18:00 P2

Strain Engineering Single Photon Emission in hBN and MoS₂ Monolayers using First Principles — ●PAULINA CHODYRA, CHENGCHENG XIAO, JOHANNES LISCHNER, and ARASH MOSTOFI — Departments of Physics and Materials and the Thomas Young Center for Theory and Simulation of Materials, Imperial College London, London SW7 2AZ, U.K

Point defects in monolayer hexagonal boron nitride (hBN) and molybdenum disulphide (MoS₂) are promising single-photon emitters (SPEs) for quantum technologies due to their potential for room-temperature operation and high photon emission efficiency. In this work we use density-functional theory calculations to investigate the nitrogen antisite-vacancy complex (N_BV_N) and boron vacancy (V_B) in hBN, and the sulphur vacancy (V_S) in MoS₂. We calculate the defect formation energy of different charge states of these defects as a function of biaxial strain and electronic chemical potential. For the charge states that are likely candidates for SPE, we find that their stability

can be enhanced via application of biaxial strain. Furthermore, the range of electronic chemical potential over which these charge states are stable can also be increased. These findings can provide predictive design rules for strain-engineered SPEs with improved resilience against electrostatic fluctuations. It also establishes our first steps toward an accelerated discovery of stable SPEs across 2D materials, where DFT-derived stability criteria combined with optical absorption and emission spectra could enable a deeper understanding of SPE operation under realistic conditions.

TT 66.8 Wed 18:00 P2

Beyond the Gamma point: Scanning tunneling spectroscopy on MoS₂/graphene/Ir(111) — BORNA PIELIĆ^{1,2}, DINO NOVKO², NINA GIROTTI ERHARDT², VITO DESPOJA², ALICE BREMERICH¹, SUMANASA BEGUR PRAKASH¹, ●ROBIN OHMANN¹, and CARSTEN BUSSE¹ — ¹Universität Siegen, Walter-Flex-Str. 3, 57068 Siegen, Germany — ²Institute of Physics, Bijenička cesta 46, 10000 Zagreb, Croatia

Scanning tunneling spectroscopy (STS) reveals information about the band structure of surfaces by measuring the local density of states, and it also allows detection of quasiparticles. For semiconducting transition-metal dichalcogenides the conduction- and valence-band edges have been readily explored with this method. However, STS studies at higher energies than the Γ -point are limited. Here, we investigate epitaxially grown monolayer islands of MoS₂ on graphene/Ir(111) using STS at low-temperature ($T=10$ K). Specifically, we employ the constant-current STS method, which enables easier access to spectroscopic features with higher energies, than the more commonly used constant-height STS. We find several peaks a few hundred meV above the Γ -point. We do not see them on graphene, allowing us to exclude substrate- or tip-related effects. When measured near the step edge of an island, these peaks bend closer to the Fermi level, similar to the peak at the Γ -point. Their appearance also varies depending on tip condition and intercalation. Our observations cannot be explained in a single-particle picture. Possible many-body models, such as phonon assisted inelastic tunneling or plasmarons are discussed.

TT 66.9 Wed 18:00 P2

Band structure and Work Function in Ultrathin HfSe₂ — ●YOUNG JUN CHANG — University of Seoul, Seoul, Republic of Korea

Two-dimensional (2D) transition metal dichalcogenides (TMDs) exhibit significant modifications in their electronic structures when reduced from bulk to monolayer thickness. In this study, we investigated the thickness-dependent electronic properties of epitaxial 1T-HfSe₂ thin films. The films were grown via molecular beam epitaxy (MBE) and monitored in situ by reflection high-energy electron diffraction (RHEED). Scanning tunneling microscopy (STM) revealed atomically flat surfaces with well-defined 1T hexagonal lattices, while scanning tunneling spectroscopy (STS) measured a bandgap of ~ 1.1 eV for the monolayer. Angle-resolved photoemission spectroscopy (ARPES) revealed thickness-induced band splitting in the valence band, while the valence band maximum (VBM) remained pinned regardless of thickness. In contrast, the work function increased monotonically with film thickness. Density functional theory (DFT) calculations reproduced the observed band structures and attributed the thickness-dependent work function to the screening effect of the underlying graphene substrate. These findings provide key insights into band alignment and interface engineering in 2D semiconductor-based electronic and optoelectronic devices. (RS-2023-00220471, RS-2023-00284081, RS-2024-00334854)

TT 66.10 Wed 18:00 P2

Exciton and trion dynamics of 2D transition metal dichalcogenides — ●SEAWOO MOON¹, ALESSANDRO DE VITA¹, LAWSON T. LLOYD², TANIA MUKHERJEE¹, ANH T. NGUYEN³, DONG-WOOK KIM³, MARTIN WOLF², RALPH ERNSTORFER^{1,2}, and TOMMASO PINCELLI¹ — ¹Institute for Physics and Astronomy, TU Berlin, Germany — ²Fritz Haber Institute of the Max Planck Society, Germany — ³Department of Physics, Ewha Womans University, South Korea

Key functionalities of transition metal dichalcogenides (TMDs) are determined by excitons whose behaviour can be tweaked by interface-induced external perturbation such as proximity effects, charge transfer and local electromagnetic fields. Excitonic behaviors and band alignment of TMDs with interfacing materials are explored. We studied the band alignment of monolayer WS₂ on nanostructured Ag by Kelvin probe force microscope, a tool that can map electrical potential of sample surface. By this method, the exciton-to-trion conversion mecha-

nisms in WS₂ could be explained, including the role of the localized surface plasmons. For a more direct approach, time and angle-resolved photoemission spectroscopy (TrARPES) with pump-probe technique is employed to directly map the equilibrium and non-equilibrium electronic structure of TMD-metal and TMD/TMD interfaces. In-situ and ex-situ techniques are required to achieve pristine TMD surfaces and interfaces, since TrARPES is a highly surface sensitive technique.

TT 66.11 Wed 18:00 P2

Ultrafast Photocurrent-Induced Ionic Rearrangement in Monolayer ReS₂ Probed with Femtosecond Electron Diffraction — •VICTORIA C. A. TAYLOR¹, YOAV W. WINDSOR^{1,2}, SAMUEL LAI³, HYEIN JUNG^{1,2}, MARTIN WOLF¹, FANG LUI³, and RALPH ERNSTORFER^{1,2} — ¹Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin, Germany — ²Technische Universität Berlin, 10623 Berlin, Germany — ³Stanford University, Stanford, CA 94305, USA

Rhenium disulphide (ReS₂) exhibits a distorted crystal structure compared to prototypical hexagonal transition metal dichalcogenides. This Peierls-like distortion results in quasi-1D chains of Re ions running in plane through each layer of ReS₂, which give rise to prominent anisotropic properties, such as polarization dependent optical absorption and anisotropic effective carrier masses.

We investigate the ultrafast lattice dynamics of monolayer ReS₂ with femtosecond electron diffraction (FED). Leveraging the strength of FED as a direct and quantitative measurement of the crystal lattice, we fit the intensities of many hundreds of Bragg peaks at each time delay to extract time resolved crystallographic information.

With this method, we not only resolve the increase in the incoherent phonon population (Debye-Waller), but also reveal a concerted atomic rearrangement within the lattice, with the ions rapidly (< 1 ps) moving away from their equilibrium atomic coordinates and returning on timescales of a few picoseconds. We associate this response with the aforementioned distortion, and discuss the physical origin.

TT 66.12 Wed 18:00 P2

Exploring Zincblende (100) Semiconductor Surfaces as Platforms for Correlated Adatom Lattices — •OLGA KASHIRINA, NIKLAS ENDERLEIN, and PHILIPP HANSMANN — Friedrich-Alexander-Universität Erlangen-Nürnberg

Adatom lattices on (111) surfaces of zincblende structured semiconductors have proven to be versatile, experimentally realizable platforms for hosting strong electronic correlations and associated emergent behavior near the Fermi energy (see [1] and references therein). Our recent study [2] reveals transition metals adatom lattices on 3C-SiC(111) surfaces to be intriguing candidates for strongly correlated material design. In the present contribution we continue this strategy by leaving the hexagonal/triangular lattices. Specifically, we explore the (100) surfaces of silicon, diamond, and 3C-SiC which in the infinite bulk exhibit a fourfold rotoinversion symmetry enabling square/rectangular adatom lattices. As the (100) surface is prone to dimerization, an additional complication arises from dimer-derived electronic states inside the bulk gap, which - depending on the chosen adatom and substrate combination - may or may not hybridize with the adatom states. In this context, the adatom coverage is another crucial parameter as it directly influences the nature of surface reconstructions and dimerizations. To assess the structural stability of our candidate systems, we employ phonon calculations based on density-functional perturbation theory as well as molecular-dynamics simulations. [1] X. Cao, et al., PRB 97, 155145 (2018). [2] H. Menke, N. Enderlein, et al., arXiv:2410.17165.

TT 66.13 Wed 18:00 P2

Engineering correlated electrons in adatom lattices on semiconductors — •TIM KULLICK¹, NIKLAS ENDERLEIN¹, HENRI MENKE^{1,2}, GIORGIO SANGIOVANNI³, and PHILIPP HANSMANN¹ — ¹Friedrich-Alexander-Universität Erlangen-Nürnberg — ²Max Planck Institute for Solid State Research, Stuttgart — ³Julius-Maximilians-Universität of Würzburg

Adatom lattices on (111) surfaces of zinc-blende structured semiconductors have proven to be versatile, experimentally realizable platforms for hosting flat bands with strong electronic correlations near the Fermi energy. A recent study [1] revealed transition metals on 3C-SiC(111) surfaces to be intriguing adatom systems, showcasing the diverse nature of strongly correlated systems. Together with earlier theoretical and experimental studies on adatom lattices on the Si(111) surfaces, this recent work underlines the great potential of this material family. In the present project, we explore promising adatom lattices on semi-

conducting/insulating substrates such as SiC and cubic BN in order to realize one-, two-, and three-band Hubbard models at different fillings. Combined with estimates of the quasiparticle interaction via cRPA, we point out new material directions in this increasingly vivid field. [1] H.Menke, N.Enderlein, et al., arXiv:2410.17165.

TT 66.14 Wed 18:00 P2

Investigation of the atomic and electronic structures of WSe₂-xTex — •GANBAT DUVJIR¹, NGUYEN-HOANG DANG², YOUNGHUN HWANG¹, and JUNGDAE KIM¹ — ¹Department of Semiconductor Physics and Engineering, University of Ulsan, Ulsan 44610, Republic of Korea — ²Electricity and Electronics and Semiconductor Applications, Ulsan College, Ulsan 44610, Republic of Korea

Ternary transition metal dichalcogenides (TMDs) exhibit diverse crystal structures and electronic properties depending on their composition. In this study, we systematically investigate the atomic and electronic structure of ternary WSe₂-xTex as a function of Te concentration using scanning tunneling microscopy/spectroscopy (STM/S). Notably, STM topography indicates that increasing the Te content induces structural deformation of the hexagonal lattice of WSe₂-xTex. This deformation manifests as the stretching of 2H structure along the zigzag direction and compression along the armchair direction. STS measurements reveal a significant reduction in the band gap of WSe₂-xTex with increasing Te concentration. While the valence band maximum shifts toward the Fermi level, the conduction band minimum remains relatively unchanged.

TT 66.15 Wed 18:00 P2

STM study on tuning the Fermi level of transition metal dichalcogenides — •NGUYEN-HOANG DANG¹, MINCHEOL KIM², GANBAT DUVJIR¹, YOUNG JUN CHANG^{2,3}, and JUNGDAE KIM¹ — ¹Department of Semiconductor Physics and Engineering, University of Ulsan, Ulsan 44610, Republic of Korea — ²Department of Physics, University of Seoul, Seoul 02504, Republic of Korea — ³Department of Smart Cities, University of Seoul, Seoul 02504, Republic of Korea

Controlling the Fermi level is essential for tailoring the electronic properties of semiconductors. Here, we investigate two routes of chemical doping and defect control using scanning tunneling microscopy and spectroscopy. For V-doped MoSe₂, we study how substitutional V atoms influence its electronic structure. Although STM primarily probes the top Se layer and the dopants are not directly imaged, the topography exhibits defect-like features whose contrast reverses with the bias polarity: dark at positive sample bias and bright at negative bias. This is characteristic of negatively charged acceptor states, consistent with V substituting Mo. STS spectra show a Fermi-level shift toward the valence band, indicating that V doping drives MoSe₂ from intrinsic n-type toward p-type. For HfSe₂, we study defect control via thermal annealing. STS measurements under different annealing conditions show Fermi level shifts toward the conduction band, suggesting that prolonged annealing enhances Se-vacancy formation, which acts as an electron donor. These results highlight how STM/STS links local defects with electronic properties, offering microscopic insight into Fermi level tuning through doping and defect engineering.

TT 66.16 Wed 18:00 P2

Impact of Mo doping on the charge density wave in 1T-TaS₂ studied by laser-ARPES and LEED — •ADINA TIMM^{1,2}, FINJA SCHILLMÖLLER^{1,2}, FLORIAN K. DIEKMANN^{1,2}, JANA KÄHLER^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, TIM RIEDEL^{1,2}, and KAI ROSSNAGEL^{1,2,3} — ¹Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — ³Kiel Nano, Surface and Interface Science KiN-SIS, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany

Controlling charge density waves (CDWs) in quantum materials enables the fine-tuning of their electronic properties, paving the way for future electronic and optoelectronic devices. The layered compound 1T-TaS₂ exhibits various temperature-dependent CDW phases that we aim to modify through doping. We introduced the dopant molybdenum during crystal growth via the chemical vapor transport method. Using 11-eV laser-based angle-resolved photoelectron spectroscopy (ARPES), we comparatively measured the electronic band structures of pristine and Mo-doped 1T-TaS₂ crystals. Complementary low-energy electron diffraction (LEED) measurements revealed the structural rearrangements during the CDW transitions and partial CDW suppression at specific doping levels. Our results suggest that modest Mo doping allows for subtle adjustments to the CDW

landscape of 1T-TaS₂, yielding different transition temperatures while preserving the underlying electronic-structural order.

TT 66.17 Wed 18:00 P2

Probing Electronic Structure Modulation in WSe₂ and MoTe₂ under Out-of-Plane Electric Fields via ARPES and XPS — ●SONJA REINHEIMER^{1,2}, LUKAS BRUCKMEIER^{1,2}, JAKOB DILLING^{1,2}, JENS BUCK^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, CHITHRA SHARMA^{1,2,4}, MARKUS SCHOLZ⁵, and KAI ROSSNAGEL^{1,2,3} — ¹IEAP, CAU Kiel, 24098 Kiel, Germany — ²RHL, DESY, 22607 Hamburg, Germany — ³KiNSIS, CAU Kiel, 24098 Kiel, Germany — ⁴Universität Hamburg, 22761 Hamburg, Germany — ⁵DESY, 22607 Hamburg, Germany

Transition metal dichalcogenides (TMDCs) are quantum materials that exhibit a broad spectrum of emergent electronic phenomena, arising from layer-dependent band structures. Owing to their tunable (opto-)electronic properties, TMDCs are promising candidates for next-generation photovoltaic devices and highly integrated electronic components. A key challenge is to systematically control charge transport and band alignment in these layered systems. Here, we investigate vertically stacked 2H-WSe₂/2H-MoTe₂ heterostructures using angle-resolved photoemission spectroscopy (ARPES) and X-ray photoelectron spectroscopy. By performing in-operando ARPES on a sample with an applied out-of-plane electric field during the measurements, we can directly probe field-induced modifications to the electronic band structure and the density of states. This approach enables us to identify electric-field-driven changes in the electronic and lattice structure and contribute to a deeper understanding of electric control mechanisms in TMDC heterostructures.

TT 66.18 Wed 18:00 P2

Many-body localisation in the Fermi-Hubbard model? — ●RICARDO KRISTERS KNIPSIS¹, JESUMONY JAYABALAN², GAEL REECHT², VIVEK MONDAL², FLORIAN KONSTANTIN DIEKMANN³, FRIEDEMANN QUEISSER¹, PING ZHOU², WALTER SCHNELLE⁴, KAI ROSSNAGEL^{3,5}, RALF SCHÜTZHOLD^{1,6}, MANUEL GRUBER², and UWE BOVENSIEPEN² — ¹Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — ²Faculty of Physics and CENIDE, University of Duisburg-Essen, Duisburg, Germany — ³Institute of Experimental and Applied Physics, Christian-Albrechts-University of Kiel, Kiel, Germany — ⁴MPI for Chemical Physics of Solids, Dresden, Germany — ⁵Ruprecht-Haensel-Laboratory, DESY, Hamburg, Germany — ⁶Institute of Theoretical Physics, Dresden University of Technology, Dresden, Germany

Motivated by recent experimental results, we study the 2D Fermi-Hubbard model in the Mott insulator state under the influence of a disorder potential. Special emphasis is placed on signatures of many-body localisation.

Using the hierarchy of correlations, we find that the disorder potential can localise the effective quasi-particle wavefunctions, resulting in their spatial separation. This, in turn, can be used to explain the drastic increase in the quasi-particle lifetimes observed in experiment.

Funding by the DFG through the SFB 1242 is gratefully acknowledged.

TT 66.19 Wed 18:00 P2

Magnetic properties of V-doped WSe₂ — ●JULES M. KNEBUSCH^{1,2}, JANA KÄHLER^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, ROBERT ZIEROLD⁴, TIM RIEDEL^{1,2}, ADINA TIMM^{1,2}, ROBERT H. BLICK⁴, and KAI ROSSNAGEL^{1,2,3} — ¹IEAP, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²RHL, Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — ³KiNSIS, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ⁴CHyN, Universität Hamburg, 22761 Hamburg, Germany

Spintronics holds promise for highly efficient classical and quantum computing and is therefore considered a key technology for future innovation. Pristine tungsten diselenide (WSe₂), known as a semiconductor with a quasi-two-dimensional hexagonal 2H structure, is expected to transform into a room-temperature dilute ferromagnetic semiconductor upon vanadium doping. This makes it a highly attractive candidate for spintronic applications. Density functional theory calculations and scanning transmission electron microscopy studies support this assumption, and RKKY interactions are predicted to be the driving mechanism. Pristine WSe₂ and vanadium-doped WSe₂ crystals were synthesized in separate in-house batches using the chemical vapor transport (CVT) method. The doped samples were grown with varying nominal concentrations of V intended to induce substitutional doping at the tungsten sites. The samples were investigated using

a vibrating-sample magnetometer (VSM). The results provide insight into the magnetic characteristics of the doped material compared to the pristine reference crystal.

TT 66.20 Wed 18:00 P2

Coexistence of a fully metallic antiphase boundary and the semiconducting charge density wave phase in 1T-TaS₂ — ●GEORG A. TRAEGER¹, KAI ROSSNAGEL^{2,3}, and MARTIN WENDEROTH¹ — ¹IV. Institute of Physics, University of Göttingen, Göttingen, Germany — ²Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — ³Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Transition metal dichalcogenides are an ideal platform for studying the interplay between charge density waves (CDWs), electronic correlations, and defect states. Using scanning tunneling microscopy and spectroscopy, we investigate a new type of intrinsic antiphase boundary (APB) in the commensurate CDW phase of 1T-TaS₂. In contrast to previous studies, we find a metallic APB extending laterally across several nanometers. We observe evanescent states spilling out from the defect into the metallic region and find that the fingerprint of the semiconducting system gradually disappears within the APB, without signs of strong interactions, suggesting the orthogonality of the two systems wave functions. Our findings highlight the crucial role of domain boundaries in the interpretation of other, especially conductivity-based, measurements. Furthermore, we propose this new type of metallic APB as a model system to study interlayer coupling in correlated layered materials.

TT 66.21 Wed 18:00 P2

Temperature-dependent VUV-ARPES of 1T-Mo_xTa_{1-x}S₂ — ●TORBEN PETERSEN^{1,2}, MATTHIAS KALLÄNE^{1,2,3}, ADINA TIMM^{1,2}, TIM RIEDEL^{1,2}, and KAI ROSSNAGEL^{1,2,3} — ¹Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — ²Ruprecht Haensel Laboratory, Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — ³Kiel Nano, Surface and Interface Science KiNSIS, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany

Examining the charge density wave (CDW) phase transitions of transition metal-substituted transition metal dichalcogenides (TMDCs) provides insight into tuning transition behavior by doping. To this end, we use the 1T-Mo_xTa_{1-x}S₂ reference system, comparing the pristine sample with two doped samples (x = 0.5% and x = 1%) using 11 eV laser-based VUV-ARPES. We investigate work function changes alongside doping-induced band structure changes in the temperature range of 60 K to 370 K. This allows us to observe the high- and low-temperature CDW phase transitions known from the pristine material and determine how the CDW-induced band structure changes vary with doping.

TT 66.22 Wed 18:00 P2

STM/STS Studies of Single-Atom Fe Inclusions in MBE-grown Monolayer MoS₂/Gr/Ir(111) — ●ALINA DRECHSLER, MARTA PRZYCHODNIA, MACIEJ BAZARNIK, and ANIKA SCHLENHOFF — Institute of Physics, University of Münster, Germany

Transition metal dichalcogenides (TMDs) exhibit thickness-dependent electronic properties and are highly sensitive to structural defects, which can strongly modify their density of states even at low concentrations. Defect engineering has therefore become an important route to tailor their electronic, magnetic, optical, and catalytic behaviour. While most of the current research focuses on naturally occurring defects in chemical vapour-deposited TMDs, we focus on intentional single-atom inclusions in TMDs grown by molecular beam epitaxy (MBE) to improve control in defect engineering.

We present scanning tunneling microscopy and spectroscopy (STM/STS) studies of Fe-doped monolayer MoS₂ on Gr/Ir(111), achieved by co-evaporation Fe during MBE growth. By comparing to undoped MoS₂ grown under identical UHV conditions, we identify the Fe-related defects and measure their electronic signatures. STS reveals in-gap states associated with single-atom Fe inclusions, whose spatial distributions are resolved via differential conductance mapping. Additionally, resonant tunneling spectroscopy shows that Fe inclusions modify the image potential states by locally shifting their energetic positions. Our work demonstrates the potential of single-atom substitutions for tailoring the electronic properties of two-dimensional TMDs.

TT 66.23 Wed 18:00 P2

Layer thickness dependent band gap of MBE grown single- to

few-layer MoS₂ — •MACIEJ BAZARNIK¹, MARTA PRZYCHODNIA^{1,2}, THORSTEN DEILMANN³, and ANIKA SCHLENHOFF¹ — ¹Institute of Physics, University of Münster, Germany — ²Institute of Physics, Poznan University of Technology, Poland — ³Institute of Solid State Theory, University of Münster, Germany

In light of the rise of transition metal dichalcogenides as 2D semiconductors for device applications, band engineering becomes very important from an application point of view. In many of these materials, such as the canonical example of MoS₂, the semiconductor band gap depends on the layer number. There is a transition from an indirect band gap semiconductor in bulk to a direct band gap for a monolayer. Interestingly, it was predicted and experimentally confirmed that, by

thinning the material from bulk to a bilayer, the indirect transition blue-shifts.

Here, we present the results of scanning tunnelling spectroscopy measurements on MoS₂ that has been grown in situ via molecular beam epitaxy (MBE) on graphene on Ir(111) at thicknesses ranging from 1 to 6 layers. We observe a decrease in the band gap with increasing layer number. We also find a pinning of the conduction band, which vanishes for layer thicknesses beyond 4 layers. Comparing our experimental data with DFT and GW calculations indicates that a screening in addition to that of the substrate needs to be introduced to explain the experimentally obtained relation. We discuss possible sources of this additional screening in light of our findings.

TT 67: 2D Materials beyond graphene: Growth, structure and substrate interaction – Poster (joint session O/TT)

Time: Wednesday 18:00–20:00

Location: P2

TT 67.1 Wed 18:00 P2

In-Situ CVD growth of vertical Heterostructures of Borophene and Hexagonal Boron Nitride — •NIELS GANSER¹, MARKO KRIEDEL¹, SMRUTI RANJAN MOHANTY¹, KARIM OMAMBAC¹, MARIN PETROVIC², CHRISTIAN BRAND¹, STEFFEN FRANZKA³, BIRK FINKE¹, TOBIAS HARTL⁴, THOMAS MICHELY⁴, FRANK-JOACHIM MEYER ZU HERINGDORF^{1,3}, and MICHAEL HORN-VON HOEGEN¹ — ¹Universität Duisburg-Essen — ²Institute of Physics, Zagreb — ³ICAN, Duisburg — ⁴Universität zu Köln

Intrinsic segregation provides a promising and scalable route for the in situ fabrication of 2D heterostructures. Using UHV chemical vapor deposition (CVD) of a single borazine (B₃N₃H₆) precursor [1], we demonstrate the growth of an hBN/borophene heterostructure on Ir(111). At high temperatures and low precursor pressures, boron dissolves into the Ir subsurface region, creating a boron reservoir below the surface [2]. Largely increasing the precursor dosing pressure shifts the chemical potential toward the formation of a complete hBN layer. Upon cooldown, the decreasing boron solubility of the Ir substrate drives segregation to the surface, where a borophene layer forms underneath the hBN overlayer and thus completing the heterostructure. The resulting structure and its growth kinetics were investigated using a combined low energy electron diffraction (SPA-LEED) and microscopy (LEEM) approach.

[1] K. Omambac et al., ACS Nano 17 (2023) 17946

[2] K. Omambac et al., ACS Nano 15 (2021) 7421

TT 67.2 Wed 18:00 P2

Growth of 2D molecular networks on graphene — •HARUTO SHIBAHARA and TOYO KAZU YAMADA — Dept. Materials Science, Chiba Univ., Chiba, Japan

We demonstrate the engineering of qubits on solid surfaces using organic molecules and transition-metal magnetic atoms. Atomically flat and clean graphene (Gr) grown on an Ir(111) substrate was selected as the platform. Scanning tunneling microscopy (STM) and low-energy electron diffraction (LEED) revealed the characteristic moiré pattern, while scanning tunneling spectroscopy (STS) and angle-resolved photoemission spectroscopy (ARPES) confirmed the presence of Dirac bands. Although single atoms can in principle serve as qubits, they tend to thermally diffuse on surfaces and their energy levels may remain degenerate. To overcome these issues, it is necessary to coordinate the atoms with organic ligands, whose ligand fields can lift the degeneracy. As a first approach, we attempted to employ 1,3,5-tris(4-bromophenyl)benzene (TBB) molecules to form a two-dimensional (2D) covalent organic framework. However, on the Gr surface we found that thermal activation desorbed the TBB molecules before they could undergo Ullmann coupling. As a second approach, we attempted to grow a 2D metal organic framework (MOF) on Gr. The details of this effort will be discussed.

TT 67.3 Wed 18:00 P2

Probing the Electrostatic Potential of hBN by AFM with Oxygen-Terminated Copper Tips — •JAN TER GLANE^{1,2}, PHILIPP WIESENER^{1,2}, THORSTEN DEILMANN³, MILENA MERKEL^{1,2}, MACIEJ BAZARNIK², ANIKA SCHLENHOFF², and HARRY MÖNIG^{1,2} — ¹Center for Nanotechnology, University of Münster, Germany — ²Institute of Physics, University of Münster, Germany — ³Institute of

Solid State Theory, University of Münster, Germany

Monolayer hexagonal boron nitride (hBN) hosts point defects with promising optoelectronic properties, yet their atomic structure remains unclear [1]. Conventional scanning tunneling (STM) and atomic force microscopy (AFM) lack elemental contrast, making it difficult to reliably distinguish B and N sites. Non-contact AFM with oxygen-terminated copper tips (CuOx-tips) has previously enabled elemental discrimination and defect identification on metal oxides [2].

Using CuOx-tip AFM, we demonstrate elemental contrast on NaCl thin films, suggesting its broad applicability to polarized surfaces. Leveraging this capability, we investigate its application to monolayer hBN. DFT-optimized electrostatic potential calculations predict clear B-N contrast. To realize these measurements, we employ in-situ chemical vapor deposition growth procedures for high-quality hBN on single-crystalline substrates. We outline the benefits of CuOx-tip AFM and present initial results towards correlating STM/STS measurements, aiming to enable atom-specific defect identification in hBN.

[1] Grosso *et al.*, Nat. Commun. 8, 705 (2017)

[2] Wiesener *et al.*, ACS Nano 18, 21948 (2024)

TT 67.4 Wed 18:00 P2

Pt-doped borane nanomembranes — •MARTHA FREY¹, JULIAN PICKER¹, CHRISTOF NEUMAN¹, JAN MACHÁČEK², TOMÁŠ BAŠE², and ANDREY TURCHANIN¹ — ¹Friedrich Schiller University Jena, Institute of Physical Chemistry, Lessingstraße 10, 07743 Jena, Germany — ²The Czech Academy of Sciences, Institute of Inorganic Chemistry, 250 68 Husinec Rez, 1001, Czech Republic

Boranes are clusters of boron and hydrogen atoms that form three-dimensional, cage-like molecules. We have recently employed them as convenient starting precursors for synthesising two-dimensional (2D) carbon-free nanomembranes. In this study, we present the preparation and characterisation of the self-assembled monolayers (SAMs) of two thiolated *syn*-B₁₈H₂₂ clusters on silver substrates. Subsequently, these SAMs were cross-linked laterally to form boron nanomembranes (BNMs) via low-energy electron irradiation under ultra-high vacuum (UHV) conditions. We investigated the structural and chemical properties of these 2D nanomembranes using surface-sensitive techniques such as X-ray photoelectron spectroscopy (XPS) and scanning tunnelling microscopy (STM). Both the starting SAMs and the resulting boron nanomembranes exhibited reactivity toward Pt-containing complexes. While such reactivity was expected for the SAMs, it was particularly noteworthy that the BNMs also enabled the insertion of Pt atoms. This Pt-doping positions borane-derived SAMs and BNMs as a promising 2D platform for nanoscale catalytic studies.

TT 67.5 Wed 18:00 P2

Defects and Initial Approaches to TMDC Heterostructure Growth on Pt_xTe_y films — •ISABELLA STOLLBERG, ANDREAS RAABGRUND, and M. ALEXANDER SCHNEIDER — Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

Transition-metal dichalcogenides (TMDCs) can generally be synthesised either by co-evaporating the metal and chalcogen onto a suitable substrate [1] or by depositing only the chalcogen onto the desired metal surface. Using STM, STS, and DFT, we investigate Pt_xTe_y films on Pt(111) prepared via the latter approach. With increasing Te content, different initial growth surface telluride structures are ob-

served, followed by the formation of Pt_2Te_2 and PtTe_2 layers [2]. This contribution focuses on STM and spatially resolved STS analyses of point defects in PtTe_2 , as well as domain boundaries within a PtTe_2 or Pt_2Te_2 layer. Furthermore, we evaluate the suitability of these telluride films as substrates for TMDC heterostructure growth. First results on attempting to grow TiTe_2 and PdTe_2 demonstrate considerable intermixing. While TiTe_2 islands can be identified by their apparent height and other lattice constants, PdTe_2 islands cannot be distinguished from PtTe_2 based on topography due to their similar vertical and lateral lattice parameters.

[1] K. Lasek et al., Nano Lett. **22**, 23 (2022)

[2] T. Kifflinger et al., Phys. Rev. B **108**, 205412 (2023)

TT 67.6 Wed 18:00 P2

Boosting the Efficiency of Quantum Replica-Exchange Molecular Dynamics — •JAN-NIKLAS MOHR, SHUBHAM SHARMA, and MARIANA ROSSI — MPI for the Structure and Dynamics of Matter, Hamburg, Germany

Replica exchange molecular dynamics can be combined with path-

integral techniques in order to incorporate quantum statistics in the sampled ensembles [1]. However, the efficiency in swapping replicas is decreased to a point that makes simulations extremely inefficient at lower temperatures.

We propose a new acceptance criterion for path-integral replica-exchange molecular dynamics (PI-REMD) that incorporates the path-integral spring term in the Hamiltonian and rescales it consistently. As a result, the acceptance probability is only sensitive to potential-energy differences, and the efficiency of the method is thus increased. Benchmarking on several test systems, including asymmetric double wells and glassy-like potentials, shows that our method outperforms standard PI-REMD in sampling efficiency and exchange frequency. We also show improvements for realistic materials, such as monolayer 1H-TaS_2 [2], where it is paramount to obtain an accurate description of the charge-density-wave phase transition. Our acceptance criterion therefore provides an efficient and reliable tool for studying quantum phase transitions and exploring thermodynamic ensembles under challenging conditions.

[1] Kapil et al., Comput. Phys. Commun. **236**, 214-223 (2019).

[2] Schober et al., SciPost Phys. **16**, 046 (2024)

TT 68: Graphene: Electronic structure, excitations, etc. – Poster (joint session O/TT)

Time: Wednesday 18:00–20:00

Location: P2

TT 68.1 Wed 18:00 P2

Strong-Field Bloch Electron Interferometry for Band-Structure Retrieval — •TAMARA PRÖBSTER, TOBIAS WEITZ, CHRISTIAN HEIDE, and PETER HOMMELHOFF — Friedrich-Alexander-Universität Erlangen-Nürnberg, Department Physik, Staudtstr. 1, 91058 Erlangen

Strong optical fields drive electrons in solids far from equilibrium, enabling access to ultrafast quantum dynamics that directly reflect the underlying band structure. When Bloch electrons in graphene are exposed to an intense few-cycle laser field, they undergo coherent intraband motion during which they accumulate a quantum phase determined by the local band curvature. If this laser-driven trajectory encounters an avoided crossing between the valence and conduction bands, the electron wave packet can coherently split via a Landau-Zener transition. In our work, we exploit pairs of such transitions to realize strong-field Bloch electron interferometry, forming an interferometric sequence fully embedded in the electronic band structure. The resulting interference encodes band information in the phase-dependent photocurrent. We retrieve the Fermi velocity of graphene near the K points as $1.07 \pm 0.04 \text{ nm}\cdot\text{fs}^{-1}$, in excellent agreement with theoretical expectations. Our results establish strong-field Bloch electron interferometry as a general and versatile approach for band-structure reconstruction under ambient conditions. Because the method relies solely on ultrafast optical driving and detection, it is naturally suited for tracking light-induced modifications of electronic structure with femtosecond temporal resolution.

TT 68.2 Wed 18:00 P2

Folding the electronic band structure of graphene-Bi and graphene-Pb heterobilayers — •JOHANNA SCHURR, ALEXANDER KORN, ANDRES UNIGARRO, SIBYLLE GEMMING, and NEBAHAT BULUT — Institute of Physics, TU Chemnitz, Germany

Translational and rotational degrees of freedom in 2D material stacks open up a wealth of tunable materials properties, such as electrical conductivity, magnetism, or optical properties, in particular if heavy intercalant atoms are present. In this study, the band structure of the two hexagonal hetero-bilayer systems bismuthene-graphene and plumbene-graphene were investigated, because experiment gives evidence for a large number of structural varieties especially for plumbene.

The aim was to identify and characterize the influence of bismuthene and plumbene layers on the band structure of graphene. For this purpose a code was generated to correlate the k-path of the band structures calculated for supercells and primitive cells within their respective Brillouin zones. Subsequent folding back of the bands into the first Brillouin zone of the supercell, while maintaining the information of the original k-path in the primitive cell, provided an overview of all existing bands and the origin of their Brillouin zone.

TT 68.3 Wed 18:00 P2

A tool for folding and unfolding of electronic band structures applying it to graphene and the gold(111)-surface — •ALEXANDER KORN, NEBAHAT BULUT, and SIBYLLE GEMMING — Institute of Physics, TU Chemnitz, Germany

The electronic band structure is an important property of materials. For comparison with experiments and other studies, as well as for better readability, it is useful to display and analyse the band structure of the primitive cell rather than a supercell. Studying more complex materials with dopants or adatoms is only possible using a supercell instead. Therefore, one must unfold the band structure of the supercell into the primitive cell.

For this purpose, we offer a tool for abinit (www.abinit.org) that can be used to unfold all possible supercells. The unit vectors of the supercell can be stretched and also rotated relative to the unit vectors of the primitive cell. We also offer an additional qualitative tool for band folding that also tracks the origin of the Brillouin zone of each band at each k-point. We provide a practical example of folding and unfolding using the gold(111) surface with sulfur as an adatom.

TT 68.4 Wed 18:00 P2

Enhanced Screening in Indium Intercalated Graphene Enabled by 2D Nearly Free Electron States — •LUKAS GEHRIG^{1,2}, CEDRIC SCHMITT^{1,2}, KILIAN STRAUSS^{1,2}, JONAS ERHARDT^{1,2}, STEFAN ENZNER^{2,3}, MARTIN KAMP^{1,4}, TIMUR KIM⁵, GIORGIO SANGIOVANNI^{2,3}, JÖRG SCHÄFER^{1,2}, SIMON MOSER⁶, and RALPH CLAESSEN^{1,2} — ¹Physikalisches Institut, Universität Würzburg, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Germany — ³Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany — ⁴Röntgen Center for Complex Material Systems, Würzburg, Germany — ⁵Diamond Light Source, Harwell Science and Innovation Campus, Didcot, United Kingdom — ⁶Experimentalphysik IV - AG Oberflächen, Ruhr-Universität Bochum, Germany

Intercalation of epitaxial graphene on SiC has been intensively explored to modify graphene's electronic properties, but previous intercalants provide only weak screening, leading to pronounced electron-plasmon coupling and the appearance of plasmaron bands in ARPES [1]. Here, we demonstrate that intercalated bilayer indium exhibits strongly Rashba-split bands, which acquire nearly free-electron-like character at the Fermi level. This induces exceptionally strong screening in graphene, significantly reducing many-body renormalization effects in the graphene bands, which arise from plasmaron coupling. This approach opens new opportunities to explore and control many-body interactions in graphene-based heterostructures.

[1] Bostwick A et al., Nat. Phys. **3**, 36-40 (2007)

TT 68.5 Wed 18:00 P2

Terbium intercalation as a route to n-doping of graphene past the van Hove singularity — •BHARTI MATTA¹, PHILIPP

ROSENZWEIG¹, CRAIG POLLEY², KATHRIN KÜSTER¹, and ULRICH STARKE¹ — ¹Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — ²MAX IV Laboratory, Lund, Sweden

Exotic ground states driven by many-body interactions, such as unconventional chiral superconductivity and spin-density waves, were theoretically predicted more than a decade ago for heavily n-doped graphene near the van Hove singularity (VHS). In recent years, achieving such high doping levels in epitaxial graphene on SiC via intercalation has attracted considerable interest. Intercalation of rare-earth elements such as Gd, Yb, and Er has already proven promising in reaching these regimes. Here, we demonstrate that intercalation of Tb atoms at the graphene/SiC interface provides access to extreme n-doping levels beyond the π^* VHS, without requiring any adsorbates on the graphene surface. The extended VHS is shifted by 0.07 eV below the Fermi level (E_F) as seen in angle-resolved photoemission spectroscopy. From the area enclosed by the giant hole pocket around Γ , we extract an electron density of $\approx 5 \times 10^{14} \text{ cm}^{-2}$. Strong renormalization of the graphene bands leads to a Dirac point about 1.55 eV below E_F , indicating that the doping cannot be described by a rigid single-particle band shift. Based on these experimental parameters, theoretical calculations predict the emergence of topological superconductivity with a critical temperature up to 600 mK (S. A. Herrera *et al.*, *ACS Nano* 18 (51), 34842–34857 (2024)).

TT 68.6 Wed 18:00 P2

Vanishing Fermi velocity in Periodically Strained Graphene

— •LEO-MALIK BENNEKA¹, TAHER RHOUMA², GUY TRAMBLY DE LAISSARDIÈRE², CLEMENS WINKELMANN¹, MARK ZELSMANN³, and VINCENT RENARD¹ — ¹Université Grenoble Alpes, CEA-IRIG-PHELIQS, 38000 Grenoble, France — ²CNRS-LPTM, CY Cergy Paris Université, 95302 Cergy-Pontoise, France — ³CNRS-LTM, 38000 Grenoble, France

Intense research has been made in engineering flat bands in twisted bilayer graphene, leading to various correlated phases [1]. An alternative route to realizing similar flat bands involves a monolayer graphene strained by a periodic triangular superlattice induced by a corrugated substrate. The height modulation h and the superlattice periodicity L serve as tuning parameters for controlling band flattening and the Fermi velocity v_F near the Dirac cones [2, 3]. Tight-binding calculations were performed by explicitly accounting for relative rotations between the graphene lattice and the superlattice, as would occur in an experimental device. These calculations not only reproduce the known decrease of the Fermi velocity with increasing h [4], but also reveal a renormalization of v_F that depends on the specific ratio $\sqrt{a_C C L}/h$ and on the relative lattice orientation. Remarkably, this behavior is universal for any superlattice size L . These predictions may assist in the design of experimental devices aimed at engineering flat bands. [1] Cao *et al.*, *Nature*, 556 (2018) 43-50 ; [2] Mao *et al.*, *Nature*, 7820 (2020) 215-220 ; [3] Yuan *et al.*, *Phys. Rev. B*, 24 (2024) 245408 ; [4] S. P. Milovanović *et al.*, *Phys. Rev. B*, 24 (2020) 245427.

TT 68.7 Wed 18:00 P2

Optimizing the excitation cross section for graphene phonons in inelastic electron tunnelling via intercalation.

— KARL ROTHE¹, •NICOLAS NÉEL¹, MADS BRANDBYGE², and JÖRG KRÖGER¹ — ¹Institut für Physik, Technische Universität Ilmenau, D-98693 Ilmenau, Germany — ²Center of Nanostructured Graphene, Department of Physics, Technical University of Denmark, DK-2800 Kongens Lyngby, Denmark

Platinum-intercalated graphene on a (111)-oriented iridium surface gives rise to a variety of rotational domains, which exhibit characteristic moiré patterns. Independent of the twist angle subtended by the graphene and substrate lattice, inelastic electron tunnelling spectroscopy reveals elevated graphene phonon excitation only on the in-

tercalated phases. Combining spatially resolved spectroscopy of the electronic structure with non-equilibrium Green's function simulations highlights the relevance for effective phonon creation of the balance between elastic and inelastic electron transport. The intercalation-induced shift of electron density of states from the Brillouin zone centre to its boundary enhances the inelastic channel at the expense of the elastic channel and thereby increases the phonon excitation cross section. Financial support by the Deutsche Forschungsgemeinschaft through KR 2912/18-1 is acknowledged.

TT 68.8 Wed 18:00 P2

Se-intercalation of graphene on SiC(0001) — •SUSANNE WOLFF^{1,2} and THOMAS SEYLLER^{1,2} — ¹Institut für Physik, Technische Universität Chemnitz — ²Research Center for Materials, Architectures and Integration of Nanomembranes (MAIN), Technische Universität Chemnitz

The epitaxial growth of graphene on SiC in an argon atmosphere is a well-established method to produce homogeneous, high quality carbon layers. The first-grown carbon layer exhibits a $(6\sqrt{3} \times 6\sqrt{3}) R30^\circ$ periodicity and is partially covalently bound to the SiC substrate. Therefore, this so-called buffer layer lacks the typical electronic properties of graphene. One pathway to decouple the buffer layer from the substrate and obtain graphene-like electronic properties is intercalation, which involves introducing a certain element at the buffer layer/SiC interface. Furthermore, the choice of intercalant influences the electronic properties of the decoupled graphene.

In this study, we investigated the intercalation of a buffer layer with selenium (Se). This process was carried out in a two-zone tube furnace, with the selenium precursor SnSe₂ and the buffer layer positioned in different temperature zones. The samples were characterized using X-ray photoelectron spectroscopy (XPS) and angle-resolved photoelectron spectroscopy (ARPES). XPS revealed successful decoupling of the buffer layer with intercalated Se at the interface and not-intercalated Se on the surface. ARPES measurements in the vicinity of the Dirac point of graphene showed a p-type doping of the decoupled carbon layer.

TT 68.9 Wed 18:00 P2

Mesoscopic Lateral Intercalation Dynamics of Indium Between the Epitaxial Zero-Layer of Graphene and SiC

— •BENNO HARLING¹, ZAMIN MAMIYEV², NARMINA BALAYEVA², DIETRICH R.T. ZAHN², CHRISTOPH TEGENKAMP², and MARTIN WENDEROTH¹ — ¹IV. Physikalisches Institut, Georg-August-Universität, Friedrich-Hund-Platz 1, 37077, Göttingen, Germany — ²Institut für Physik, Technische Universität Chemnitz, Reichenhainer Str. 70, 09126, Chemnitz, Germany

Intercalation, the process of diffusing a material species in-between layered materials, can be utilized for both bulk and 2D systems to achieve tailored electronic properties. [1] For the 2D limit, this work investigates the lateral diffusion dynamics of indium intercalation into the epitaxial zero-layer of graphene on SiC using Kelvin Probe Force Microscopy (KPFM). For tin, material transfer across surface substrate steps is observed at local sites at the mesoscopic scale. [2] With the used experimental parameters, we find that this is not the case for indium intercalation. Instead, only terrace transport is observed. The KPFM measurements were complemented by micro-Raman spectroscopy, assessing the extent and uniformity of In intercalation. Remarkably, intercalation through the carbon layer seems to be dependent on the graphene or substrate properties that still need to be further resolved. This leads to a situation where just some of the terraces are observed to be intercalated. Financial support by the DFG within Research Unit FOR5242 is acknowledged. [1] Stark *et al.*, *Adv. Mater.* 2019, 31, 1808213 [2] Harling *et al.*, *Carbon* 244 (2025) 120711

TT 69: Focus Session: Nickelate Superconductivity: Insights into Unconventional Pairing and Correlation Effects II (joint session TT/DS/MA)

Time: Thursday 9:30–12:30

Location: HSZ/0003

TT 69.1 Thu 9:30 HSZ/0003

Bulk High-Temperature Superconductivity and Density Waves in Layered Nickelates — •JUN LUO^{1,2}, JIE DOU^{1,2}, SHUO LI¹, QIN XIN SHEN^{1,2}, XU YANG FENG^{1,2}, DE MIN CHAI^{1,2}, RAN SHENG JIA^{1,2}, JIE YANG^{1,2}, and RUI ZHOU^{1,2} — ¹Institute of Physics, Chinese Academy of Sciences, and Beijing National Laboratory for Condensed Matter Physics, Beijing 100190, China — ²School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100190, China

The recent advances in bilayer nickelates $\text{La}_3\text{Ni}_2\text{O}_7$ have revealed fascinating high-temperature superconductivity (HTSC) under high-pressure conditions, offering a promising platform to explore unconventional superconducting mechanisms. In this talk, I will first discuss the discovery of bulk HTSC in Pr-doped $\text{La}_2\text{PrNi}_2\text{O}_7$, where Pr substitution effectively suppresses intergrowth phases, resulting in nearly pure bilayer structures. Superconducting onset temperature reaches 82.5 K at 16 GPa. Clear diamagnetic signals confirm the bulk nature of HTSC. I will also present microscopic evidence of charge and spin density wave (CDW/SDW) orders in $\text{La}_3\text{Ni}_2\text{O}_7$, revealed through ^{139}La nuclear quadrupole resonance (NQR). Below the density wave transition temperature, we observe distinct line splitting and magnetic broadening, indicating unidirectional CDW order coupled with SDW order. By integrating insights from high-pressure and NQR studies, this work provides a comprehensive understanding of the structural and electronic mechanisms underlying HTSC in bilayer nickelates, paving the way for future experimental and theoretical investigations.

TT 69.2 Thu 9:45 HSZ/0003

ARPES spectra and the role of interstitial-*s* orbital in infinite-layer nickelates calculated by DFT+DMFT — •LEONARD VERHOFF¹, LIANG SI^{1,2}, and KARSTEN HELD¹ — ¹Institut für Festkörperphysik, Technische Universität Wien, Wien, Austria — ²School of Physics, Northwest University, Xi'an, China

Infinite-layer nickelates, such as NdNiO_2 , are a compelling platform to explore the microscopic origin of unconventional high-temperature superconductivity, from both theoretical and experimental perspectives.

Experimentally, infinite-layer nickelates are reduced from the stable perovskite phase, leaving an empty apical oxygen site. *Density functional theory* (DFT) calculations show that the resulting interstitial vacancy hosts localized, *s*-like states about 2 eV above the Fermi level, while recent *angle-resolved photoemission spectroscopy* (ARPES) measurements of superconducting NdNiO_2 thin films conjectured Fermi surfaces with major *s*-like orbital character, highlighting a possible role of interstitial-*s* states in superconductivity.

We present DFT and *dynamical mean field theory* calculations of Fermi surfaces and band structures for both bulk and slab geometries, directly comparable to ARPES spectra. Our ARPES simulations explicitly include first-principles photoemission matrix elements, capturing the impact of orbital shapes on the measured intensity. We show how the correlated band structure reproduces low-energy ARPES spectra and identify the features dominated by interstitial-*s* character.

We acknowledge support through a joint German and Austrian Science Funds (DFG and FWF) project; FWF project ID I5398.

TT 69.3 Thu 10:00 HSZ/0003

A photoinduced two-dimensional electron gas (2DEG) at infinite-layer nickelate/strontium titanate interfaces — •D. SANCHEZ-MANZANO¹, G. KRIEGER², A. RAJI³, B. GEISLER⁴, V. HUMBERT¹, H. JAFFRES¹, J. SANTAMARIA⁵, R. PENTCHEVA⁴, A. GLOTTER³, D. PREZIOSI², and JAVIER E. VILLEGAS¹ — ¹Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay, France. — ²Institute of Physics and Chemistry of Materials of Strasbourg, CNRS, University of Strasbourg, France. — ³Laboratoire de Physique des Solides, CNRS, Université Paris-Saclay, France. — ⁴Department of Physics and Center for Nanointegration (CENIDE), University of Duisburg-Essen, Germany — ⁵Departamento de Física de Materiales, Universidad Complutense de Madrid, Spain

We demonstrate, through experiments (transport, electron microscopy & spectroscopy) and density functional theory (DFT), that a high-mobility 2DEG can be optically switched on and off at an oxide interface where such a state does not naturally exist [1]. We show that

near-ultraviolet light instantly creates a volatile 2DEG at the interface between SrTiO_3 (a band insulator) and infinite-layer NdNiO_2 (a poor metal), resulting in a conductivity increase of up to five orders of magnitude. This stems from structural and electronic reconstructions that, along with a built-in interfacial electric field, facilitate the Ti-3d band occupation by photogenerated carriers. These findings open venues for engineering photoconductance in strongly correlated systems.

[1] Sanchez-Manzano et al., Nat. Mater. (2025).

<https://doi.org/10.1038/s41563-025-02363-y>

TT 69.4 Thu 10:15 HSZ/0003

Democratizing nickelates superconductors: Topotactic reduction induced by aluminum sputter deposition — •LUCÍA IGLESIAS¹, DONGXIN ZHANG¹, ARAVIND RAJI^{2,3}, LUIS M. VICENTE-ARCHE¹, ALEXANDRE GLOTTER², and MANUEL BIBES¹ — ¹Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay — ²Laboratoire de Physique des Solides, CNRS, Université Paris-Saclay — ³Synchrotron SOLEIL

Superconductivity in infinite-layer (IL) nickelates (ABO_2) was discovered in 2019, opening a new research frontier. However, progress remains limited by the challenging topotactic reduction needed to remove all apical oxygens from the perovskite precursor, typically achieved through a complex *ex situ* CaH_2 method. Although recent *in situ* approaches, such as metal overlayer deposition via molecular beam epitaxy and atomic hydrogen bombardment, have improved control and reproducibility, their restricted accessibility highlights the need for simpler synthesis routes. Here, we demonstrate a broadly accessible method to fabricate superconducting IL $\text{Pr}_{0.8}\text{Sr}_{0.2}\text{NiO}_2$ films via aluminum deposition using direct-current magnetron sputtering. The sputtered Al drives the reduction through a redox reaction, converting the precursor perovskite into the superconducting IL phase. Systematic optimization of Al-induced reduction yields high-quality films with a maximum transition temperatures of 17 K, consistent with the best reported values. This accessible and highly reproducible approach provides an effective alternative to existing techniques and lowers barriers to the exploration of nickelate superconductors.

TT 69.5 Thu 10:30 HSZ/0003

Two-dimensional vortex matter in infinite-layer nickelates — •DAVID SANCHEZ-MANZANO¹, VINCENT HUMBERT¹, ARACELI GUTIÉRREZ-LLORENTE^{1,2}, DONGXIN ZHANG¹, JACOBO SANTAMARÍA³, MANUEL BIBES¹, LUCIA IGLESIAS¹, and JAVIER E. VILLEGAS¹ — ¹Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay, 91767 Palaiseau, France — ²Escuela Superior de Ciencias Experimentales y Tecnología, Universidad Rey Juan Carlos, 28933 Madrid, Spain — ³GFMC, Dpto. de Física de Materiales, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain

Characterizing the dimensionality of the superconducting state in the infinite-layer (IL) nickelates is crucial to understanding its nature. Most studies have addressed the problem by studying the anisotropy of the upper critical fields. Yet, the dominance of Pauli-paramagnetism effects over orbital ones makes it challenging to interpret the experiments in terms of dimensionality. Here we address the question from a different perspective, by investigating the vortex phase diagram in the mixed-state. We demonstrate that superconducting $\text{Pr}_{0.8}\text{Sr}_{0.2}\text{NiO}_2$ thin films present a vortex liquid-to-glass transition of a two-dimensional nature. The obtained results suggest that bidimensionality is an intrinsic property, and that superconductivity resides in fully-decoupled NiO_2 planes. In this scenario, the coherence length along the *c*-axis must be shorter than the distance between those planes, while Josephson and magnetostatic coupling between them must be negligible. We believe that these conclusions are relevant for theories on the origin of superconductivity in the IL-nickelates.

TT 69.6 Thu 10:45 HSZ/0003

Systematically Controlled Disorder to Probe Pairing Symmetry in Infinite-Layer Nickelates — •A. RANNA¹, R. GRASSET², M. GONZALEZ³, K. LEE³, B. Y. YANG³, D. ZHANG⁴, W. SUN⁵, C. PARZYCK⁶, Y. WU⁶, M. KONCZYKOWSKI², M. BIBES⁴, K. M. SHEN⁶, Y. F. NIE⁵, L. IGLESIAS⁴, H. Y. HWANG³, A. P. MACKENZIE¹, and B. H. GOODE¹ — ¹MPI CPFS, Germany — ²LSI, Ecole Polytech-

nique, France — ³Stanford University, USA — ⁴CNRS Thales, France — ⁵Nanjing University, China — ⁶Cornell University, USA

Superconductivity in infinite-layer nickelates has expanded rapidly with advances in thin-film synthesis and reduction techniques. A central question is the symmetry of the superconducting gap in these materials. Because superconducting samples can only be stabilized as thin films and suffer surface degradation during the post-growth reduction process, some conventional probes to determine the gap symmetry remain challenging to perform and interpret. Here, we leverage high-energy electron irradiation to controllably introduce point-like defects without altering film stoichiometry or crystallinity. Tracking superconductivity with systematically increasing disorder shows a steady suppression of transition temperature and rising normal state resistivity, indicative of an unconventional, sign-changing gap [1]. Additionally, this method offers a unique way to study the effect of point defects on superconducting and electronic properties in nickelates across rare-earth compositions, doping, and strain to disentangle intrinsic behavior from synthesis-related variability.

[1] Ranna et al., *PRL* **135**, 126501 (2025).

15 min. break

TT 69.7 Thu 11:15 HSZ/0003

Correlated electronic structure of $\text{La}_3\text{Ni}_2\text{O}_6$ and $\text{La}_3\text{Ni}_2\text{O}_{6.5}$ — ●FRANK LECHERMANN, STEFFEN BÖTZEL, and ILYA M. EREMIN — Theoretische Physik III, Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, Bochum, Germany

There are two known superconducting nickelate families, i.e. low-valence $\text{Ni}(3d^{9-\delta})$ compounds and Ruddelsden-Popper (RP) compounds with $\text{Ni}(3d^{8\pm\delta})$ valence. While both families host NiO_2 square planes, key difference is given by the missing apical oxygen atoms in the low-valence nickelates. A possible route to connect both nickelate families might be given by the reduction of the $\text{La}_3\text{Ni}_2\text{O}_7$ RP bilayer compound, i.e. by removing its apical oxygens. Complete removal results in the $\text{La}_3\text{Ni}_2\text{O}_6$ compound, while taking out only half of the apical oxygens results in the $\text{La}_3\text{Ni}_2\text{O}_{6.5}$ compound. Both reduced materials are so far only scarcely characterized experimentally, but display quite intriguing correlation physics from theory. We will discuss the results of advanced first-principles many body calculations for these two nickelates, highlighting different mechanisms of Mott criticality as well as challenging low-temperature physics.

TT 69.8 Thu 11:30 HSZ/0003

Superconductivity governed by Janus-faced fermiology in strained bilayer nickelates — ●SIHEON RYEE¹, NIKLAS WITT², GIORGIO SANGIOVANNI², and TIM WEHLING¹ — ¹University of Hamburg, Hamburg, Germany — ²University of Würzburg, Würzburg, Germany

High-temperature superconductivity in pressurized and strained bilayer nickelates has emerged as a new frontier. One of the key unresolved issues concerns the fermiology that underlies superconductivity. On both theoretical and experimental sides, no general consensus has been reached, and conflicting results exist regarding whether the relevant Fermi surface involves a γ pocket—a hole pocket with $d_{x^2-y^2}$ -orbital character centered at the Brillouin zone corner. Here, we address this issue by unveiling a Janus-faced role of the γ pocket in spin-fluctuation-mediated superconductivity. We show that this pocket simultaneously induces dominant pair-breaking and pair-forming channels for the leading s_{\pm} -wave pairing. Consequently, an optimal superconducting transition temperature T_c is achieved when the γ pocket surfaces at the Fermi level, placing the system near a Lifshitz transition. This suggests that superconductivity can emerge, provided the maximum energy level of the γ pocket lies sufficiently close to the Fermi level, either from below or above. Our finding not only reconciles two opposing viewpoints on the fermiology, but also naturally explains recent experiments on $(\text{La},\text{Pr})_3\text{Ni}_2\text{O}_7$ thin films, including the superconductivity under compressive strain, two conflicting measurements on the

Fermi surface, and the dome shape of T_c as a function of hole doping.

TT 69.9 Thu 11:45 HSZ/0003

Bonding-antibonding s_{\pm} superconductivity in bilayer nickelates: potential experimental signatures — ●STEFFEN BÖTZEL, FRANK LECHERMANN, and ILYA EREMIN — Ruhr-Universität Bochum, Bochum, Germany

The discovery of high- T_c superconductivity in Ruddelsden-Popper bilayer nickelates under applied high pressure and/or compressive strain provides a promising platform to study the interplay of multiorbital intralayer and interlayer Cooper-pairing in bilayer systems. In particular, dominant interlayer pairing may naturally lead to a bonding-antibonding s_{\pm} -gap structure, which directly reflects the bilayer geometry. Such a scenario would produce characteristic experimental signatures that differ from d -wave type gap symmetries. In this contribution, we theoretically address the possible gap structures in bilayer nickelates and discuss how a interlayer-dominated bonding-antibonding s_{\pm} -gap structure can be potentially distinguished from a d -wave type pairing using experimentally observables.

TT 69.10 Thu 12:00 HSZ/0003

Interlayer interaction-driven s^{\pm} -to- d_{xy} -wave superconductivity in $\text{La}_3\text{Ni}_2\text{O}_7$ under pressure — ●LAURO B. BRAZ¹, GEORGE B. MARTINS², and LUIS G. G. DE V. D. DA SILVA¹ — ¹Instituto de Física, Universidade de São Paulo, Rua do Matão 1371, São Paulo, São Paulo 05508-090, Brazil — ²Instituto de Física, Universidade Federal de Uberlândia, Uberlândia, Minas Gerais 38400-902, Brazil

Experimental and theoretical progress on the normal-state properties of the high-temperature superconductor $\text{La}_3\text{Ni}_2\text{O}_7$ has provided evidence of strong interlayer interactions. To better understand the effects of interlayer interactions in $\text{La}_3\text{Ni}_2\text{O}_7$ under high pressure, we investigate a two-layer, two-orbital electron model that includes both intra- and interlayer Coulomb interaction terms within the framework of the matrix random-phase approximation. Our analysis reveals that interlayer interactions play a crucial role in determining the preferred superconducting pairing symmetry. Specifically, when interlayer interactions are included, a d_{xy} -wave pairing symmetry is favored over the s^{\pm} -wave symmetry, which was previously found to dominate in their absence. Furthermore, we find that interlayer interactions enhance interorbital pairing by incorporating contributions from all three electron pockets, which originate from both $d_{3z^2-r^2}$ and $d_{x^2-y^2}$ orbital characters. This results in the emergence of nodes in the superconducting gap function - features absent in the s^{\pm} -wave state - ultimately stabilizing the d_{xy} -wave pairing symmetry.

TT 69.11 Thu 12:15 HSZ/0003

Incommensurate spin-fluctuations and competing pairing symmetries in $\text{La}_3\text{Ni}_2\text{O}_7$ — ●HAN-XIANG XU¹ and DANIEL GUTERDING² — ¹Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing, China — ²Technische Hochschule Brandenburg, Brandenburg an der Havel, Germany

The discovery of superconductivity in the bilayer nickelate $\text{La}_3\text{Ni}_2\text{O}_7$ under high pressure raises key questions about the pairing symmetry and microscopic mechanism. Using a three-dimensional multi-orbital Hubbard model including all Ni 3d and O 2p states, we analyze the superconducting instability within the random phase approximation. Spin fluctuations with incommensurate wave vectors $(\pi/2, \pi/2)$ and $(7\pi/10, 7\pi/10)$ coexist and compete, leading to nearly degenerate sign-changing s_{\pm} - and $d_{x^2-y^2}$ -wave pairing channels. The leading symmetry depends sensitively on pressure and the ratio of Hund's rule to Coulomb interactions. Cooperative incommensurate fluctuations stabilize a $d_{x^2-y^2}$ -wave state for realistic parameters, while their competition may explain the absence of magnetic order. These findings reconcile previous contradictory results and highlight the importance of careful model construction for bilayer nickelates.

[1] H.-X. Xu and D. Guterding, arXiv:2501.05254

TT 70: Correlated Electrons: Method Development III

Time: Thursday 9:30–10:45

Location: HSZ/0101

TT 70.1 Thu 9:30 HSZ/0101

Lineon Condensation in the XY toric code — ●MAXIMILIAN VIEWEG, VIKTOR KOTT, MATTHIAS MÜHLHAUSER, and KAI PHILLIP SCHMIDT — Staudtstraße 7, 91058 Erlangen, Germany

In this work, we study the XY toric code[1] in an external magnetic field and determine its quantum phase diagram using high-order series expansions. The XY toric code is a generalization of the toric code that introduces anisotropic couplings on the star operators. The phase diagram of the XY toric code without a magnetic field is exactly solvable via duality mappings and hosts both topologically ordered and spontaneous-subsystem-symmetry-broken phases (SSSB), and therefore supports fractons and subdimensional particles as excitations in the SSSB phase. Our results for the transitions out of the SSSB in certain parameter regimes are consistent with an exotic second-order phase transition that is not described by a scale-invariant theory.

[1] M. Vieweg, K.P. Schmidt, Phys. Rev. Res. 7 (2025)

TT 70.2 Thu 9:45 HSZ/0101

Real Green functions for the Anderson disorder model — ●MARCUS KOLLAR¹, MARTIN BIEHLE¹, YANNICK SCHÄFFER¹, and BAS LODEWIJKS² — ¹Theoretical Physics III, Institute of Physics, University of Augsburg — ²Probability Group, School of Mathematical and Physical Sciences, University of Sheffield

Green functions for the Anderson model on the Bethe lattice fulfill a recursion relation, leading to a self-consistent solution for the complex self-energy [1]. Recently a new criterion for the localization transition was introduced [2] using the susceptibility of real cavity Green functions to changes of the disorder potential at distant lattice sites, which can be expressed in terms of repeated applications of an asymmetric integral kernel corresponding to the conditional probability distribution of cavity Green functions on neighboring sites. We derive a system of equations that connects this integral kernel and the distributions of real local and cavity Green functions to an arbitrary disorder distribution. For the special case of Cauchy disorder we use it to determine the Green function distributions explicitly for all energies. Furthermore for the band center we determine the complete kernel spectrum exactly, from which typical Lyapunov exponents and Green function correlation functions are obtained. Applications to other disorder distributions are also discussed.

[1] R. Abou-Chacra et al., J. Phys. C 6, 1734 (1973).

[2] G. Parisi et al., J. Phys. A 53, 014003 (2019).

TT 70.3 Thu 10:00 HSZ/0101

CFET-Enhanced TDVP Simulations of Floquet Dynamics in the Driven t-V Model — ●TOBIAS BLUM¹, KARUN GADGE², SALVATORE MANMANA², and REINHARD NOACK¹ — ¹Philipps-Universität Marburg, 35032 Marburg, Germany — ²Georg-August-University Göttingen, 37077 Göttingen, Germany

Periodically driven interacting systems feature characteristic Floquet sidebands and frequency-dependent heating, but time evolution remains challenging for explicitly time-dependent Hamiltonians. We study the one-dimensional t-V model using the time-dependent variational principle (TDVP) combined with commutator-free exponential time propagators (CFET). We describe the integration of CFET into an already existing implementation of TDVP within the MPS framework. Its integration allows significantly reduced time-evolution errors. We compare standard TDVP and TDVP enhanced with CFET and analyze heating rates and the structure of Floquet sidebands for different driving frequencies, going from high-frequency regimes to low-frequency behavior. The results show that CFET-enhanced TDVP substantially improves the accuracy of calculated observables in explicitly time-dependent strongly correlated systems.

TT 70.4 Thu 10:15 HSZ/0101

Noninteracting tight-binding models for Fock parafermions — ●EDWARD MCCANN — Department of Physics, Lancaster University, Lancaster, LA1 4YB, United Kingdom

By mapping itinerant spin-1/2 fermions to four-state Fock parafermions, we construct noninteracting tight-binding models for Fock parafermions in one dimension. They have single-particle real energy spectra consisting of a sum of single-particle energy levels each multiplied by a parafermionic occupation number. The single-particle levels may be determined by diagonalizing a square matrix whose order scales linearly with system size, and these levels are the same as those of noninteracting fermionic models. We generalize the approach to describe tight-binding models in two dimensions. We show that the thermodynamic distribution function for the occupation numbers of noninteracting four-state parafermions, the internal energy, and the heat capacity are consistent with the mapping to spin-1/2 fermions.

TT 70.5 Thu 10:30 HSZ/0101

A new take on an old method for approximating quantum many-body ground states — ●JOE CROSSLEY¹, BRUNO BERTINI², ARASH JAFARIZADEH³, MOLLY GIBBINS¹, and ADAM GAMMON-SMITH¹ — ¹University of Nottingham, United Kingdom — ²University of Birmingham, United Kingdom — ³None

For decades, quantum chemists have been using so-called “post Hartree-Fock” methods to study systems of many interacting electrons moving on a fixed structural background. This set-up closely resembles many important problems from the world of condensed matter physics. However, despite the conceptual overlap, these methods have seen little adoption within the physics community. In this talk, I will discuss our recent progress on exploring the potential of post Hartree-Fock techniques applied to condensed matter problems—particularly in regimes where standard tools such as tensor networks and quantum Monte Carlo are known to struggle.

TT 71: Ultrafast Phenomena

Time: Thursday 9:30–11:15

Location: HSZ/0103

TT 71.1 Thu 9:30 HSZ/0103

Ultrafast control of competing FM and CDW orders in SmNiC₂ — ●CHANDRA V KOTYADA¹, BHAGEERATH SWARAJ¹, AMON. P LANZ¹, PRIYANKA YOGI¹, AMIR.A HAGHIGHIRAD², SOFIA. M SOULIOU², MATTHIEU LE TACON², and JURE DEMSAR¹ — ¹JGU Mainz — ²KIT

SmNiC₂ belongs to the rare-earth (R) transition-metal carbide family RNiC₂, a unique class of intermetallic compounds that crystallize in the non-centrosymmetric orthorhombic CeNiC₂-type structure and exhibit pronounced quasi-one-dimensional characteristics. Diffraction studies on SmNiC₂ reveal an incommensurate charge-density-wave (CDW) modulation with wavevector (0.5, 0.5 + δ , 0) below $T_{CDW} \approx 148$ K. Upon lowering the temperature, a first-order phase transition into a ferromagnetic (FM) state occurs at $T_M \approx 18$ K, accompanied by a complete suppression of the CDW order.

Here, we apply optical pump-probe spectroscopy to investigate collective response in both symmetry-broken phases. Using CDW am-

plitude mode as a fingerprint of the CDW order, we then use the quench-pump-probe approach to track the dynamics of the photoinduced FM-to-CDW phase transition. We show that the buildup of the CDW after quenching the FM order is limited by the demagnetization time of 10 ps.

TT 71.2 Thu 9:45 HSZ/0103

Experimental signature of transient symmetry breaking in a cavity superconductor — ●SIYU DUAN^{1,2}, JINGBO WU¹, XIAOQING JIA¹, HUABING WANG¹, ILYA M. EREMIN³, GÖTZ S. UHRIG², BIAOBING JIN¹, and ZHE WANG² — ¹Research Institute of Superconductor Electronics (RISE) & Key Laboratory of Optoelectronic Devices and Systems with Extreme Performances of MOE, School of Electronic Science and Engineering, Nanjing University, Nanjing 210023, China — ²Department of Physics, TU Dortmund University, 44227 Dortmund, Germany — ³Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44801 Bochum, Germany

Transient states of matter far from equilibrium may exhibit physical properties beyond those allowed by the equilibrium-state crystalline symmetries. We explore ultrafast and direct electronic excitations of transient states in a cavity superconductor by using time-resolved terahertz-pump terahertz-probe spectroscopy. Our results show that the strong terahertz field can transiently modify the symmetries of the electronic subsystems via the injection of a transient supercurrent, leading to high-order nonlinear dynamical responses that are not compatible with the equilibrium-state symmetries, which evidences for transient symmetry breaking on the picosecond time scale. Our study also finds that the strong coupling of the superconductor to the designed microcavities enables the sensitive detection of the nonlinear responses associated to the transient symmetry breaking.

TT 71.3 Thu 10:00 HSZ/0103

Giant Dynamical Paramagnetism in the driven fluctuating superconductors — ●MARIOS MICHAEL¹, DUILIO DE SANTIS², EUGENE DEMLER², and PATRICK LEE³ — ¹Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38 01187 Dresden Germany — ²Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland — ³Department of Physics, MIT, 77 Massachusetts Avenue, 02139 Cambridge, MA, USA

In the past decade, photo-induced superconducting-like behaviors have been reported in a number of materials driven by intense pump fields. Of particular interest is the high-Tc cuprate Y Ba₂ Cu₂ O(6+x) (YBCO), where such effect has been reported up to the so-called pseudogap temperature $T^* \sim 300$ -400 K. In a recent tour-de-force experiment, a transient magnetic field which is proportional to and in the same direction of an applied field has been observed outside the sample, suggestive of flux exclusion due to the Meissner effect. In this talk I will present a different explanation of these experiments, based on the model of preformed Cooper pairs in the pseudogap phase. I will demonstrate that a combination of external magnetic field and strong terahertz drive used in experiments by Fava et al. Nature 2024, results in a novel Floquet instability in the model. This instability results in currents at the edges of the bilayer formed by defects or grain boundaries, with the current flowing in the opposite direction of the equilibrium screening current, producing a giant paramagnetic magnetization in the same direction as the applied field. We show how this scenario can fit most of the available data.

TT 71.4 Thu 10:15 HSZ/0103

Two-dimensional coherent spectroscopy of multiband superconductor — ●SILVIA NERI — Max Planck for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart

An intriguing question in superconductivity is how to efficiently detect signatures of the collective excitations associated with the superconducting order parameter. The features associated with collective modes can indeed provide insight into various aspects of the superconducting state. We address this question by theoretically modeling a 2D THz pump probe spectroscopy experiment for a two-band superconductor. Two-dimensional spectroscopy is a powerful method with wide applications, from rovibronic excitations in biomolecular systems to magnons in antiferromagnets, and it has been recently applied to superconducting collective modes [1]. To numerically compute the dynamics of our model, we adopt a pseudospin description and choose realistic parameters for both the pulses and the superconducting state, reflective of MgB₂. The numerically evaluated 2D spectrum shows, in addition to the first- and third-harmonic signals, the presence of sidebands associated with the Leggett-mode frequency of the system. We then derive an analytical expression for the nonlinear current to identify the process responsible for this numerical finding. Our results suggest that applying 2D techniques to superconductors offers a promising route for exploring their collective dynamics.

[1] A. Dutta et al., J. Phys.: Condens. Matter 37, 203002 (2025)

TT 71.5 Thu 10:30 HSZ/0103

Ultrafast coherent dynamics in open quantum systems: Auger-Meitner decay and controlled steering of interactions in SF₆ — ●SINA SHOKRI¹, PATRICK RUPPRECHT^{2,3}, THOMAS PFEIFER³, and MAURITS W. HAVERKORT¹ — ¹ITP, Universität Heidelberg, 69120 Heidelberg, Germany — ²UC Berkeley Dept. of Chemistry and LBNL Chemical Sciences Division, Berkeley, CA 94720, USA — ³MPI für Kernphysik, 69117 Heidelberg, Germany

Ultrafast x-ray pump-probe spectroscopy provides a powerful tool to study and steer quantum materials on their intrinsic time and length scales. In correlated molecules and solids, theoretical understanding remains challenging due to the interplay of competing interactions. In small molecules, quantitative modeling of the coupled electronic and vibrational dynamics is possible.

The coupling to many continuous degrees of freedom can lead to rapid loss of coherence. This results in long-time dynamics that are determined by classical equations of motion. Descriptions on the intermediate time scale that show how one goes from coherent quantum dynamics to classical equations of motion are highly non-trivial.

In this work, we employ nonlinear response theory to predict the transient dynamics and Auger-Meitner-induced lifetimes of electronic excitations in x-ray absorption spectroscopy of SF₆, following excitation by an intense infrared laser field. Based on first-principles density functional theory calculations, we show how the intense laser field can modify the Auger-Meitner decay channels and, with that, the coherent lifetimes of excitations.

TT 71.6 Thu 10:45 HSZ/0103

Charged three-particle bound states at the L₂₃-edge in SrTiO₃ — ●SARAH L. GÖRLITZ¹, WIDAD LOUAFI², SINA SHOKRI¹, MARTIN BRASS¹, MARC MERSTORF¹, JONAS HOECHT¹, KEVIN ACKERMANN¹, and MAURITS W. HAVERKORT¹ — ¹Institut für Theoretical Physics, Heidelberg University, 69120 Heidelberg — ²Laboratory of Theoretical Physics, Faculty of Exact Sciences, University of Bejaia, 06000 Bejaia, Algeria

Few-body bound states underpin phenomena across physics-from hadronic three-body systems to excitons and trions in semiconductors-their formation and decay remain poorly understood.

We report analogous physics in bulk SrTiO₃ in Ti 2p → 3d core excitations. The XAS spectrum shows seven sharp peaks, understood from atomic physics as a Ti 2p hole interacting with a local Ti 3d electron in a cubic point group. Fluorescence and Auger-Meitner decay calculations explain the linewidth of the first four peaks but predict much sharper excitations than observed for the last two. Because these highest excited states are degenerate with the continuum, their broadening may arise if they are continuum excitations or resonances rather than bound excitons. To test this, we performed ab initio GW+BSE calculations, which agree with parameter-based atomic multiplet theory and reveal seven infinitely sharp excitons. In contrast, an Anderson-impurity model yields a finite linewidth for the highest excitons. We show that these are three-particle bound states composed of two locally bound Ti 3d electrons, one Ti 2p hole, and an additional free hole in the O 2p valence band.

TT 71.7 Thu 11:00 HSZ/0103

Study of light-induced band inversion in SnTe via Ab Initio Calculations — ●ASIER RIBECHINI¹, ÁLVARO R. PUENTE-URIONA¹, and JULEN IBAÑEZ-AZPIROZ^{1,2,3} — ¹Centro de Física de Materiales (CSIC-EHU), 20018, Donostia, Spain — ²IKERBASQUE, Basque Foundation for Science, 48009 Bilbao, Spain — ³Donostia International Physics Center (DIPC), 20018 Donostia, Spain

Modern technology enables precise control of matter through light-matter interactions. Periodically driven quantum systems, described by Floquet theory, offer a powerful framework for predicting light-induced phenomena, including topological phases and quantum phase transitions [1], though their experimental detection remains challenging.

We evaluate the method of our group [2] for computing the Floquet quasienergy spectrum of SnTe using the velocity gauge in a truncated Hilbert space to build the ab initio time-periodic Hamiltonian. From it, we construct the effective Floquet Hamiltonian and obtain the quasienergy spectrum. Our results reveal a light-induced gap opening between conduction and valence band Floquet replicas near resonant driving, as well as a band-character inversion indicative of a possible light-induced topological phase transition. We further compute the corresponding topological invariants to characterize this transition and discuss our findings in relation to recent time-resolved ARPES evidence for light-induced topological behavior[3].

[1] J. I. Inoue et al., Phys. Rev. Lett. 105, 017401 (2010)

[2] Á. R. Puente-Urión et al., Phys. Rev. B 110, 125203 (2024)

[3] F. Chassot et al., arXiv:2502.11967v1

TT 72: Correlated Magnetism – Spin Liquids I

Time: Thursday 9:30–12:00

Location: HSZ/0105

TT 72.1 Thu 9:30 HSZ/0105

Anisotropic Spin Ice on a Breathing Pyrochlore Lattice — ●GLORIA ISBRANDT^{1,2}, FRANK POLLMANN^{1,2}, and MICHAEL KNAP^{1,2} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Spin ice systems represent a prime example of constrained spin systems and exhibit rich low-energy physics. We investigate how a tunable anisotropic spin coupling modifies the classical Ising spin-ice Hamiltonian on the breathing pyrochlore lattice. Introducing sublattice-dependent anisotropy reshapes the ground-state manifold, reduces the residual entropy, and induces qualitative changes in the spin-structure factor. We theoretically uncover a rich phase diagram by varying the anisotropy and demonstrate how this modification reduces the ground state degeneracy across different phases. Using Monte Carlo simulations, we find that at low temperatures the system either crosses over into a constrained spin-ice manifold, whose entropy density falls below the Pauling value, or undergoes a transition into an ordered, symmetry-broken state. We further compute spin-structure factors for the anisotropic model and show that they are well captured by a self-consistent Gaussian approximation. Our results develop the understanding of spin ice in anisotropic limits, which may be experimentally realized by strain, providing, among others, key signatures in entropy and specific heat.

TT 72.2 Thu 9:45 HSZ/0105

The monopole plasma resonance: an opto-electronic smoking gun of 3D U(1) spin liquids — ●ANISH KOLEY, SARANYO MOITRA, and INTI SODEMANN VILLADIEGO — Institut für Theoretische Physik, Universität Leipzig, 04103 Leipzig, Germany

Certain 3D U(1) spin liquids, such as those arising in quantum spin ice models, have a low-energy "monopole-like" emergent particle which acts as the source of an emergent magnetic field that has the same transformations under symmetries as an electric polarization. As a consequence, these monopoles carry a polarization physical electric charge. Curiously, at finite temperatures these monopoles form a finite density plasma, but due to their coupling to emergent gauge fields, the full physical system behaves as an electrical insulator from the point of view of DC transport. Remarkably, however, we have found that when the system is probed at finite frequencies, the monopoles can display a sharp and low frequency plasma resonance analogous to a metal. This offers a new blueprint to experimentally detect these elusive but fascinating states in real materials.

TT 72.3 Thu 10:00 HSZ/0105

Spin-liquid-like ground states in the double hydroxyperovskites CuSn(OD)₆ and MnSn(OD)₆ evidenced by μ SR spectroscopy — ●MOUMITA NASKAR¹, ANTON A. KULBAKOV¹, KAUSHICK K. PARUI¹, JONAS A. KRIEGER², ELLEN HÄUSSLER³, THOMAS DOERT³, DARREN C. PEETS¹, HANS HENNING KLAUSS¹, DMYTRO S. INOSOV^{1,4}, and RAJIB SARKAR¹ — ¹Institut für Festkörper und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — ²Laboratory for Muon Spin Spectroscopy, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — ³Fakultät für Chemie und Lebensmittelchemie, Technische Universität Dresden, 01062 Dresden, Germany — ⁴Würzburg-Dresden Cluster of Excellence on Complexity and Topology in Quantum Matter - ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

Muon spin rotation measurements were carried out on the hydroxy perovskites CuSn(OD)₆ and MnSn(OD)₆ over the temperature range 0.053–50 K. The absence of long range magnetic order is confirmed down to 0.053 K. The temperature dependence of the muon relaxation rates show an increase with decreasing temperature, indicating that spin fluctuations remain present down to 0.053 K in both the compounds. Spin correlations results from both samples indicate homogeneous spin dynamics. These observations suggest that both compounds possess a fluctuating ground state consistent with a spin-liquid phase.

TT 72.4 Thu 10:15 HSZ/0105

Emergent magnetic order and spin dynamics in a Yb-based

triangular lattice delafossite — ●ARJUN UNNIKRISHNAN^{1,2,3}, BISHNU PRASAD BELBASE¹, PIYUSH CHHALLARE¹, MOHAN BIKRAM NEUPANE¹, EUN SANG CHOI⁴, PHILIPP GEGENWART², and ARNAB BANERJEE¹ — ¹Department of Physics and Astronomy, Purdue University, West Lafayette, Indiana 47906, USA — ²Experimental Physics VI, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, Augsburg 86159, Germany — ³Solid State and Structural Chemistry Unit (SSCU), Indian Institute of Science, Bengaluru - 560012, India — ⁴National High Magnetic Field Laboratory, Tallahassee, Florida - 32310, USA

We have synthesized a new member of the AYbX₂ (A = monovalent cation; X = O, S, Se, Te) delafossite family and investigated its magnetic properties using magnetization and heat-capacity measurements. At zero magnetic field, the system shows no evidence of long-range magnetic order down to 20 mK. When a magnetic field is applied along the *ab*-plane, multiple field-induced magnetic phases emerge above ~ 2.5 T, followed by full spin polarization near 17 T. The material exhibits stronger exchange interactions compared to other known Yb-based delafossites. We will discuss the magnetic phase transitions and the evolution of the spin dynamics under applied fields. The heat-capacity results suggest the presence of a possible quantum spin liquid (QSL) phase at low temperatures and low magnetic fields, highlighting this system as a promising platform for exploring QSL physics.

TT 72.5 Thu 10:30 HSZ/0105

Microscopic modelling of the honeycomb system Na₃Ni₂BiO₆ and its field-induced phases — ●AMANDA ANNA KONIECZNA, PANAGIOTIS STAVROPOULOS, and ROSER VALENTÍ — Goethe Universität, Frankfurt am Main, Germany

Frustration in magnetic systems has for decades provided a central testbed for the investigation of unconventional properties. Among others, frustrated systems may show magnetic-field-induced phases with characteristic magnetization plateaus, as is the case in triangular lattice and Kagome lattice spin-1/2 systems, where magnetic frustration arises due to the geometry of the lattice. Although the honeycomb lattice geometry is not geometrically frustrated, frustration may still appear due to bond-dependent magnetic exchanges, as proven by the Kitaev honeycomb model with its quantum spin liquid ground state.

Experimental evidence for a one-third magnetization plateau at intermediate magnetic fields has been reported for the spin-1 honeycomb compound Na₃Ni₂BiO₆. The aim of this talk is to present our approach based on an *ab initio* scheme in order to understand the origin of the plateau phase. The approach involves the modeling of an *ab-initio*-derived multiorbital relativistic Hubbard Hamiltonian and utilize projective diagonalization techniques to construct an effective spin model. The data extracted from the model is compared to and discussed in the context of experimental findings.

TT 72.6 Thu 10:45 HSZ/0105

Evolution of Na₃Co₂SbO₆ under pressure — ●THORE MARTENS¹, PRASHANTA MUKHARJEE², PHILIPP GEGENWART², and ALEXANDER A. TSIRLIN¹ — ¹Leipzig University — ²University of Augsburg

Na₃Co₂SbO₆ is a potential candidate for the Kitaev spin liquid where the high-spin S=3/2-state is turned into the J_{eff}=1/2-state under spin-orbit coupling. Recently, the impact of the trigonal field in Na₃Co₂SbO₆ on the formation of the spin liquid phase has been discussed and theorized that finetuning of the trigonal field by applying pressure may lead to the desired Kitaev state. Therefore, neutron diffraction experiments are performed to obtain the lattice parameters and probe the evolution of the magnetically ordered state of Na₃Co₂SbO₆ under pressure. Using density functional theory, new relaxed unit cells are calculated as well as the subsequent exchange couplings and trigonal field as a function of pressure.

15 min. break

TT 72.7 Thu 11:15 HSZ/0105

Low temperature thermodynamic studies on the Kitaev candidates Na₂Co₂TeO₆ and Na₃Co₂SbO₆ — ●SEBASTIAN ERDMANN¹, PRASHANTA MUKHARJEE¹, CHANHYEON LEE², KWANG-YONG CHOI³, and PHILIPP GEGENWART¹ — ¹Experimental Physics

VI, University of Augsburg, Germany — ²Department of Physics, Chung-Ang University, Republic of Korea — ³Department of Physics, Sungkyunkwan University, Republic of Korea

Cobalt-based honeycomb magnets have recently attracted considerable attention as a new class of materials that may host bond-directional Kitaev interactions [1]. Among these, $\text{Na}_2\text{Co}_2\text{TeO}_6$ and $\text{Na}_3\text{Co}_2\text{SbO}_6$ undergo antiferromagnetic ordering below 27 K and 5 K, respectively [2, 3]. We employed heat-capacity and magnetic Grüneisen parameter measurements to study the nature of the various low-temperature field-induced phase transitions, building on our previous work with the sister compound $\text{BaCo}_2(\text{AsO}_4)_2$ [4]. The phase diagrams are extended to below 2 K and the entropy $S(T, B)$ of the different field-induced phases is determined. Our results provide new insights on proposed field-induced spin liquid states and reveal commonalities and distinctions of different prototype Kitaev candidate materials.

[1] H. Liu, G. Khaliullin, Phys. Rev. B 97, 014407 (2018).

[2] E. Lefrançois et al., Phys. Rev. B 94, 214416 (2016).

[3] J.-Q. Yan et al., Phys. Rev. Materials 3, 074405 (2019)

[4] Prashanta K. Mukharjee et al., Phys. Rev. B 110, L140407 (2024).

TT 72.8 Thu 11:30 HSZ/0105

High pressure phase transition of quantum spin liquid candidate $\text{Na}_2\text{Co}_2\text{TeO}_6$ observed using Raman spectroscopy — ●IHSAN AHMED KOLASSERI¹, SUBHADIP DAS^{1,2}, and YONG P. CHEN¹ — ¹Aarhus University, Aarhus, Denmark — ²University of Copenhagen, Copenhagen, Denmark

Quantum spin liquids (QSL) are materials that have possible data storage applications in quantum computing. Conflicting neighbor electron spin interactions of antiferromagnetically coupled magnetic atoms on triangle-based geometries can lead to QSL phase. Two structural phases of NCTO have been reported: the hexagonal P6_322 phase and the monoclinic C2/m phase. The hexagonal phase of NCTO has an antiferromagnetic ordering at 27 K. An in-plane magnetic field of 7T can suppress the QSL state because of the material's structure. Under-

standing and discovering different structural phases of these classes of materials is crucial to learn about QSL states. In this study we applied pressures upto 20 GPa on hexagonal NCTO single crystal and observed significant changes in the Raman peak profile. We have classified the pressure evolution into four pressure regions where the Raman peak profiles change drastically. High pressure single crystal X-ray diffraction and high pressure polarization dependent Raman study could be conducted to confirm this conclusion. Those data are currently under analysis, but will be briefly mentioned.

TT 72.9 Thu 11:45 HSZ/0105

Pressure dependent ab-initio studies of the Kitaev candidate $\text{Ag}_3\text{LiRh}_2\text{O}_6$ — ●BOLIVAR EFRAN INSUASTI PAZMINO¹, RAMESH DHAKAL², SHI FENG³, STEVE M. WINTER², JOHANNES KNOLLE³, and ALEXANDER A. TSIRLIN¹ — ¹Leipzig University, Germany. — ²Wake Forest University, USA — ³Technical University of Munich, Germany

$\text{Ag}_3\text{LiRh}_2\text{O}_6$ is created by substituting Li with larger Ag atoms in Li_2RhO_3 [1]. This "negative pressure" expands the lattice and distorts the RhO_6 octahedra, altering the Rh-O-Rh angle that governs proximity to the quantum spin liquid state. Under hydrostatic pressure, the compound shows a sharp reduction in Néel temperature up to 4 GPa, with a transition to a non-magnetic state only at 6.6 GPa [2].

We perform ab initio calculations on the ideal crystal. Geometry optimization and Wannier functions are obtained using DFT. Magnetic couplings are derived from second-order perturbation theory and exact cluster diagonalization. Both methods agree well on the general trends of the couplings, but also reveal differences. While a large negative off-diagonal Γ' along with the sizable trigonal crystal field may indicate deviations from the $j_{\text{eff}}=1/2$ state, the strong Kitaev coupling suggests the material remains close to that limit. The talk will address these questions by discussing the material's microscopic behavior. This work was supported by DFG via TRR360 (492547816).

[1] F. Bahrami et al., Sci. Adv. 8, eabl5671 (2022)

[2] P. Sakrkar, B. Shen, E. Poldi et al., Nat. Com. 16:4712 (2025)

TT 73: Superconductivity: Tunneling and Josephson Junctions

Time: Thursday 9:30–12:45

Location: CHE/0089

TT 73.1 Thu 9:30 CHE/0089

Transparency-controlled multiple charge transfer in superconducting tunnel junctions at atomic scale — ●JIASSEN NIU^{1,2,3}, YUDAI SATO^{1,2,3}, MAIALEN LARRAZABAL⁴, JIAN-FENG GE⁵, and MILAN ALLAN^{1,2,3} — ¹Leiden Institute of Physics, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands — ²Fakultät für Physik, Ludwig-Maximilians-Universität, Schellingstrasse 4, München 80799, Germany — ³Munich Center for Quantum Science and Technology (MCQST), München, Germany — ⁴Debye Institute of Nanomaterials Science, Utrecht University, PO Box 80000, 3508 TA Utrecht, The Netherlands — ⁵Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Charge transport in superconducting junctions enable multi-charge transfer and can be identified through shot noise. Using shot noise STM with a newly developed amplifier, we measured $\text{Pb}(111)$ junctions with tunable transparency. At low transparency, the effective charge is strongly suppressed ($q < ne$), while increasing transparency enhances AR/MAR, driving q toward $2e$ in SIN junctions and ne in SIS junctions. The measurements agree quantitatively with single-channel simulations. Our results track the continuous evolution from multi-electron to single-electron transport and demonstrate transparency as a key parameter in controlling superconducting quantum transport.

TT 73.2 Thu 9:45 CHE/0089

The Evolution of the Josephson Effect: From Dynamical Coulomb Blockade to Dissipationless Supercurrent — ●IRENA PADNIUK¹, XIANZHE ZENG¹, JOACHIM ANKERHOLD², JUAN CARLOS CUEVAS³, KLAUS KERN^{1,4}, and CHRISTIAN R. AST¹ — ¹MPI für Festkörperforschung, Heisenbergstraße 1, Stuttgart — ²Institute for Complex Quantum Systems, University of Ulm, Albert-Einstein-Allee 11, Ulm — ³Departamento de Física Teórica de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Madrid, Spain — ⁴Institut de Physique, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

The Josephson effect measured with scanning tunneling microscopy (STM) offers a unique platform to study superconducting transport at the atomic scale. The tunneling of Cooper pairs in ultra-low temperature STM is typically dissipative due to the dynamical Coulomb blockade, involving energy exchange with the electromagnetic environment related to the junction's capacitance. In contrast, the well-known macroscopic Josephson effect between superconductors in planar tunnel junctions is dissipationless, allowing supercurrent to flow without energy loss. Until now, a direct connection between these two regimes has remained elusive. In my talk, I will discuss how, using our ultra-high energy resolution mK-STM, we investigate the evolution of the Josephson current over a wide range of junction transmissions. Our results provide insight into the transition between dissipative quantum transport and dissipationless Cooper pair tunneling in atomic-scale junctions.

TT 73.3 Thu 10:00 CHE/0089

Voltage fluctuations in atomic-scale Josephson junctions — ●VERENA CASPARI¹, WERNER M. J. VAN WEERDENBURG¹, CHRISTIAN LOTZE¹, CLEMENS B. WINKELMANN², and KATHARINA J. FRANKE¹ — ¹Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany — ²Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Phelips, Grenoble, France

Phase diffusion in Josephson junctions and the switching from the superconducting to the quasiparticle branch can be explained by the dynamics of a fictitious phase particle in the tilted washboard potential. Usually, only the average voltage is measured[1].

Here, we measure the voltage fluctuations in single-atom Pb-Pb junctions with MHz-bandwidth using a scanning tunneling microscope. In the current-bias regime, the current-voltage $V(I)$ curves show a hysteretic behavior that allows to set the junction into the phase-diffusion regime, where we observe multi-level transitions in time traces. These can be interpreted as phase-slips events leading to the finite average voltage in the superconducting state. In the voltage-bias regime, we

observe bistabilities indicating the transition between the superconducting and the quasiparticle branch. Our experiments allow access to the phase-slip dynamics in the STM-based Josephson junction.

[1] R. L. Kautz, J. M. Martinis, Phys. Rev. B 42, 9903 (1990)

TT 73.4 Thu 10:15 CHE/0089

Non-Linear Response Theory of the Josephson Effect — •CHRISTIAN R. AST¹ and JUAN CARLOS CUEVAS² — ¹MPI for Solid State Research, Stuttgart — ²Universidad Autónoma de Madrid, Spain

The dissipationless supercurrent in the Josephson effect depends linearly on the junction conductance in a planar superconductor-insulator-superconductor tunnel junction, if there is no interaction with the environment. In ultrasmall tunnel junctions, such as in a scanning tunneling microscope (STM), the interaction with the environment cannot be neglected, which leads to a dissipative supercurrent that depends quadratically on the junction conductance. This dissipative supercurrent has been very successfully modeled within the dynamical Coulomb blockade and $P(E)$ -theory based on Fermi's golden rule. In this talk, I will present a derivation of the dissipative supercurrent based on non-linear response theory. The result is basically identical to the existing model, although there are some distinct differences, which will be discussed.

TT 73.5 Thu 10:30 CHE/0089

Microwave mediated Cooper pair currents in single and double Josephson junctions — •STEFANO TRIVINI¹, LEONARD EDENS¹, JON ORTUZAR², and JOSE IGNACIO PASCUAL^{1,3} — ¹CIC nanoGUNE-BRTA, San Sebastian, Spain — ²Quantronics group SPEC, CEA-Saclay — ³Ikerbasque, Basque Foundation for Science, Bilbao, Spain

Tunnelling of Cooper pairs in STM Josephson junctions (JJs) is usually described as an incoherent process mediated by the junction's electromagnetic environment. Under microwave irradiation, photons can assist the tunnelling of quasiparticles as captured by the Tien-Gordon theory. For a current-biased, phase-coherent junction, Shapiro steps at voltages multiple of $h\nu/2e$ are expected. Here, we study Pb-Pb single JJs realized in bulk Pb and in double JJs systems, formed by small Pb islands, under microwave irradiation. The microwave power maps depend on the tip-sample distance and can be described either by the TG approach or the RCSJ model. In double JJs, we observe asymmetric microwave maps whose shape reflects Coulomb-blockade processes on the Pb island.

TT 73.6 Thu 10:45 CHE/0089

Supercurrent Transport and Shapiro response in phase-pure core/shell GaAs/InAs nanowire-based Josephson junctions — •FARAH BASARIC^{1,2}, YURI KUTOVY^{2,3}, ALEXANDER PAWLIS^{2,3}, DETLEV GRÜTZMACHER^{1,2}, and THOMAS SCHÄPERS^{1,2} — ¹Peter Grünberg Institut (PGI9), Forschungszentrum Jülich, 52425 Jülich, Germany — ²JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany — ³Peter Grünberg Institut (PGI10), Forschungszentrum Jülich, 52425 Jülich, Germany

We investigate Josephson junctions based on epitaxially grown, phase-pure core/shell GaAs/InAs nanowires comprising closed-loop states in the InAs shell. The core/shell architecture, combined with superconducting Al, enables confined states in the InAs shell that are expected to enhance proximity coupling at the InAs/Al interface. Using shadow-wall evaporation for junction and contact definition, we are able to realize nanowire-based Josephson junctions in the short junction limit. Current-voltage characteristics measurements under radio-frequency irradiation reveal both integer as well as fractional Shapiro steps, the latter commonly associated with ballistic junctions. Additionally, magnetoconductance measurements on nanowires with normal contacts provide insight into the transport properties of the nanowire segment forming the weak link. Together, these results demonstrate that GaAs/InAs core/shell nanowires constitute a very promising platform for future quantum circuits based on hybrid devices.

15 min. break

TT 73.7 Thu 11:15 CHE/0089

Supercurrent Interference in Planar Josephson Junction Arrays Probed by Microwave Excitations — •ALEXANDER KIRCHNER¹, SIMON FEYER¹, VJEKO DIMIĆ¹, SEBASTIAN RAMSAUER¹, JOHANNA BERGER¹, NARGES MOMENI¹, FRANCISCO JE-

SUS MATUTE-CAÑADAS², DAVIDE CURCIO³, MATTHIAS KRONSEDER¹, MICHAEL PRAGER¹, DIETER SCHUH¹, DOMINIQUE BOUGEARD¹, GIORGIO BIASIOL³, ALFREDO LEVY YEYATI², NICOLA PARADISO¹, CHRISTOPH STRUNK¹, and LEANDRO TOSI^{1,4} — ¹Institut für Experimentelle und Angewandte Physik, University of Regensburg, Regensburg, Germany — ²Departamento de Física Teórica de la Materia Condensada, Condensed Matter Physics Center (IFIMAC) and Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, Madrid, Spain — ³CNR-IOM Istituto Officina dei Materiali, Trieste, Italy — ⁴Centro Atómico Bariloche and Insitituto Balseiro, CNEA, CONICET, San Carlos de Bariloche, Río Negro, Argentina

We present measurements of one dimensional Josephson junction arrays based on a hybrid superconductor-semiconductor quantum well heterostructure probed at microwave frequencies. The behavior of their plasma modes as a function of an applied magnetic field reveals interference patterns: an out-of-plane field results in a Fraunhofer-like pattern, from which we extract the effective transparency of the junctions; furthermore, periodic oscillations of the inductance occur when applying an in-plane magnetic field. The periodicity of these oscillations scales with the length of the island, pointing towards an orbital origin.

TT 73.8 Thu 11:30 CHE/0089

Purely even harmonic Josephson current due to crossed pair transmission across strongly spin-polarized materials — •DANILO NIKOLIĆ, NIKLAS L. SCHULZ, and MATTHIAS ESCHRIC — Institut für Physik, Universität Greifswald, Felix-Hausdorff-Straße 6, 17489 Greifswald, Germany

We revisit the problem of the second harmonic generation in the current-phase relation across ferromagnetic bilayers placed between BCS superconductors. In particular, we consider a strongly spin-polarized metallic ferromagnet coupled to two superconducting leads via thin spin-active (left) and non-spin-active (right) insulating layers. The system is examined in the framework of the quasiclassical Green's function formalism both in the ballistic (Eilenberger) and the diffusive (Usadel) limit. Strong spin polarization allows for neglecting short-range mixed-spin correlations, and the Josephson supercurrent across the ferromagnet is fully mediated by long-range equal-spin triplet correlations. Using a diagrammatic technique for ballistic propagators, we describe the relevant Andreev processes responsible for the effective conversion of two spin-singlet Cooper pairs in the superconductor into two $\uparrow\uparrow$ and $\downarrow\downarrow$ pairs in the ferromagnet. Contrary to the naive picture of direct conversion, we show that the lowest order process involves four Cooper pairs in the superconductor, among which three are incoming and one is outgoing giving rise to net charge transport of $4e$ across the non spin-active interface. The self-consistent numerical treatment of the diffusive junction, typically more relevant in experiments, confirms this picture quantitatively.

TT 73.9 Thu 11:45 CHE/0089

Signatures of triplet pairing in FSF hybrid junctions — •ANDREAS COSTA¹, PABLO TUERO², CESAR GONZALEZ-RUANO^{2,3}, YUAN LU⁴, FARKHAD G. ALIEV², and JAROSLAV FABIAN¹ — ¹University of Regensburg, Germany — ²Universidad Autónoma de Madrid, Spain — ³Universidad Pontificia Comillas, Spain — ⁴Université de Lorraine, France

Interfaces between ferromagnets and conventional s-wave superconductors serve as prototype systems to explore the conversion of singlet into spin-polarized triplet Cooper pairs in superconducting spintronics.

Recent experimental studies found anomalous quasiparticle conductance modulations in ferromagnet/superconductor/ferromagnet (FSF) hybrids under a rotated in-plane magnetic field. In this talk, we will report on our theoretical conductance simulations performed to unravel the physical origin of these anomalies. We will demonstrate that the experimental data show strong signatures of nonuniform magnetization and complex interfacial spin-orbit fields present in these junctions. As both are expected to induce spin-triplet Cooper pairs by rotating the spin quantization axis, we propose the observed conductance anomalies to provide a possible experimental fingerprint of unconventional triplet superconductivity.

The theory part of this work has been supported by Deutsche Forschungsgemeinschaft (DFG; German Research Foundation)—454646522; 314695032.

TT 73.10 Thu 12:00 CHE/0089

Critical current surfaces of multiterminal graphene Josephson junctions — •PAUL MAIER, ROMAIN DANNEAU, and DETLEF

BECKMANN — Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, D-76021 Karlsruhe, Germany

Topological states are predicted to exist in the Andreev bound state spectrum of multiterminal Josephson junction with four or more terminals [1]. Superconductor graphene hybrid structures are especially suitable to realize such devices due to the gate tunability of graphene and high contact transparencies which are necessary to form Andreev bound states. Understanding the distribution of supercurrent in graphene multiterminal Josephson junctions is one step in the search for these states. We report on the experimental investigation of transport in four-terminal graphene Josephson junctions with current control or phase control by up to two superconducting loops and flux lines. We observe magnetic interference patterns in two-terminal measurements and critical current surfaces by controlling a total of three currents or phases in multiterminal measurements, the results show excellent agreement with theoretical simulations.

[1] R.P. Riwar et al., Nat Commun 7, 11167 (2016).

TT 73.11 Thu 12:15 CHE/0089

Preserving the Josephson coupling of twisted cuprate junctions via tailored silicon nitride circuits boards — •TOMMASO CONFALONE^{1,2}, KORNELIUS NIELSCH^{1,2}, GOLAM HAIDER¹, and NICOLA POCCIA^{1,3} — ¹IFW Dresden — ²TU Dresden — ³U. Naples

The fabrication of van der Waals (vdW) Josephson junctions (JJs) using the cuprate superconductor $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ (BSCCO) remains limited by the material's extreme sensitivity to heat and chemical processing, which hinders the integration of high-quality junctions into functional device architectures. Although the cryogenic stacking technique (CST) has enabled atomically sharp BSCCO interfaces with preserved superconducting properties [1], conventional CST-based devices rely on post-assembly contacting strategies that degrade junction performance or restrict circuit complexity. Here, we present a CST-compatible contact scheme in which electrodes embedded in a silicon

nitride membrane are directly transferred onto the BSCCO junction during assembly [2]. This membrane-based transfer eliminates high-temperature or chemically aggressive steps and preserves interface integrity. Using this approach, we realize twisted BSCCO JJs exhibiting the strongest Josephson coupling reported to date. The technique is fully compatible with ultra-high-vacuum (UHV) environments, enabling integration with emerging UHV-based vdW fabrication platforms. These results underscore the critical role of contact engineering and open the path for exploring the fundamental properties of these devices.

[1] Science 382,1422 (2023)

[2] Small e06520 (2025)

TT 73.12 Thu 12:30 CHE/0089

Cooper quartets in frustrated Josephson junction arrays — •ERIK LENNART WEERDA¹, MATTEO RIZZI^{1,2}, MICHELE BURRELLO³ und OLAV FREDRIK SYLJUÅSEN⁴ — ¹Forschungszentrum Jülich — ²Universität zu Köln — ³University of Pisa — ⁴University of Oslo

Josephson junction arrays in the shape of the dice lattice are the main candidates for a mesoscopic realization of superconductivity mediated by Cooper quartets of charge $4e$. Here, we analyze numerical signatures of this exotic phase emerging when these superconducting arrays are frustrated by the insertion of $1/3$ of a flux quantum per rhombic plaquette. Through the simulation of relaxation dynamics and two-dimensional infinite tensor network techniques, we examine the related classical XY model at finite temperature. We evaluate the characteristic properties of the supercurrent in this system, its correlation functions, and entropy. We also consider the effects of Josephson energy and flux disorder typical of Josephson junction arrays, and we address the role of charging energies in the full two-dimensional quantum model. Our results indicate that the peak of critical currents and temperatures at frustration $1/3$ corresponds to a Cooper quartet phase, and the related superconducting-insulating phase transition is caused by the deconfinement of half-vortices.

TT 74: Topological Insulators

Time: Thursday 9:30–12:45

Location: CHE/0091

TT 74.1 Thu 9:30 CHE/0091

Probing the Quantized Berry Phases of an Obstructed Atomic Band in 1H-NbSe₂ Using Scanning Tunneling Microscopy — DUMITRU CĂLUGĂRU^{1,2}, YI JIANG³, HAOJIE GUO³, SANDRA SAJAN³, •YONGSONG WANG³, HAOYU HU^{1,3}, JIABIN YU¹, B. ANDREI BERNEVIG^{1,3}, FERNANDO DE JUAN³, and MIGUEL M. UGEDA³ — ¹Princeton University, Princeton, USA — ²University of Oxford, Oxford, United Kingdom — ³Donostia International Physics Center, San Sebastián, Spain

Topologically trivial insulators can host obstructed atomic phases, where the electronic charge is localized at symmetry positions that do not coincide with atomic sites. Despite intense theoretical interest, such phases have lacked quantitative experimental confirmation. Here we provide direct experimental evidence that the narrow band at the Fermi level of monolayer 1H-NbSe₂ and TaSe₂ realizes an optimally compact obstructed atomic phase by means of STM/STS (1). Bias-dependent constant-height conductance maps reveal a strong redistribution of spectral weight between inequivalent high-symmetry positions within the unit cell. We identify these positions experimentally by using substitutional transition-metal alloys and chalcogen vacancies as local markers. By deconvolving the STM images with orbital-resolved wave functions from ab-initio calculations, we reconstruct the short-range inter-orbital correlations and real-space charge distribution associated with the band. The resulting pattern is centered at non-atomic positions and is uniquely consistent with an obstructed atomic insulator.

[1] Calugaru et al., Nature Physics, in press(2025).

TT 74.2 Thu 9:45 CHE/0091

Characterization of TI nanowire junctions using resonator circuits — •LUCAS MARTEN JANSSEN, JORGE ESTEBAN BOLIO, CHRISTIAN DICKEL, and YOICHI ANDO — Physics Institute II, University of Cologne, Zùlpicher Str. 77, 50937 Köln, Germany

Topological insulators (TIs) are being investigated for their potential to host Majorana Zero Modes (MZMs). Specifically, TI nanowires prox-

imitized by a conventional superconductor have shown signatures of potential topological phase transitions [1]. Microwave measurements can be used to investigate the hardness of the gap [2] and to reconstruct the current-phase relationship [3]. Additionally, high-frequency operation could be necessary to eventually realize topological qubits. To assess the quality of our TI nanowire junctions, we design co-planar waveguide resonator circuits of NbTiN with a parallel plate capacitor to ground on one side and a connection to ground through the nanowire junction on the other side. This allows us to measure the sub-gap resistance and the current-phase relationship of the junction. In order to investigate the TI nanowire in the topological regime, an in-plane magnetic field of about 1 T needs to be applied. The resonators are engineered to be compatible with such fields.

[1] Nikodem et al., arXiv:2412.07993 (2024)

[2] Schmidt et al., Nat. Commun. 9, 4069 (2018)

[3] Uhl et al., Phys. Rev. Applied 22, 064052 (2024)

TT 74.3 Thu 10:00 CHE/0091

Growth and quantum transport analysis of high mobility Bi₂Te₃ thin films — •JONAS BUCHHORN^{1,2}, ABDUR REHMAN JALIL^{1,3}, DETLEV GRÜTZMACHER^{1,2}, and THOMAS SCHÄPERS^{1,2} — ¹Peter-Grünberg-Institut (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — ²JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, 52425 Jülich, Germany — ³Institute of Experimental Physics III, Würzburg University, 97070 Würzburg, Germany

To improve future hybrid devices, underlying material properties and conduction mechanisms must be understood and controlled. In this work, we use quantum mechanical and classical models to describe the measured conductivity tensor of Bi₂Te₃ thin films. The crystals have been prepared by molecular beam epitaxy on sapphire substrates and were shaped into Hall bar structures by optical lithography and Ar-etching. At cryogenic temperatures non-linear Hall resistance and Shubnikov-de Haas oscillations were observed. A multi-channel model motivated from band structure calculations is used to extract classi-

cal carrier properties. Model residues are quantitatively analyzed to include electron-electron interaction, spin-orbit-effects and quantum oscillations of surface states. Considering these insights, we attempt to disentangle the complex conduction mechanisms of bulk and surface states of topological insulators. The proposed methods should also be applicable to the state-of-the-art ternary or quaternary compounds to identify remaining bulk-contributions.

TT 74.4 Thu 10:15 CHE/0091

Dual-gated hBN/BiSbTeSe/hBN heterostructures: fabrication and low-temperature magnetotransport — ●KIRILL TESLENKO, HOLGER MIRKES, ALEXANDRE BERNARD, and CHRISTOPH KASTL — Walter Schottky Institute, School of Natural Sciences, Technical University of Munich

Topological insulators with tunable surface states provide a platform for exploring quantum transport phenomena. We present the fabrication and characterization of dual-gated hBN/BiSbTeSe/hBN (BSTS) heterostructures designed to allow controlled access to the topological surface states. The devices are fabricated via optimized optical lithography, and the heterostacks are assembled using a dry-transfer stacker operated both under nitrogen atmosphere and under ambient conditions. Two approaches are used: transferring BSTS onto pre-patterned metal contacts, and assembling the full heterostack before metal evaporation. Photocurrent measurements on non-encapsulated BSTS, BTS, and SbTe flakes were carried out to assess their optoelectronic response. Furthermore, low-temperature magnetotransport measurements on the encapsulated devices are carried out to resolve characteristic signatures of topological surface states.

TT 74.5 Thu 10:30 CHE/0091

Field-induced band modification and large magnetoresistance in topological-insulator $\text{Bi}_{1-x}\text{Sb}_x$ thin films — ●E. OSMIC^{1,2}, P. BERCOFF³, F. COMMETO³, Y. SKOURSKI¹, F. GANSS⁴, J. WOSNITZA^{1,2}, and J. BARZOLA QUIQUIA⁵ — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — ²Institut für Festkörper- und Materialphysik, TU Dresden, Germany — ³Universidad Nacional de Córdoba, Córdoba, Argentina — ⁴Institut für Ionenstrahlphysik und Materialforschung, HZDR, Dresden, Germany — ⁵Felix-Bloch Institute for Solid-State Physics, Universität Leipzig, Germany

We studied the magnetic-field and temperature dependence of the electrical transport in topological-insulator $\text{Bi}_{1-x}\text{Sb}_x$ ($x = 0.1, 0.15, 0.2$) thin films. The resistivity $\rho(T)$ shows a clear crossover between metallic surface transport at low temperatures and semiconducting bulk behavior at higher temperatures. Below 10 K, $\rho(T)$ exhibits a characteristic two-dimensional electron-electron interaction contribution. Magnetoresistance measurements in pulsed magnetic fields up to 69 T reveal large, nonsaturating MR values reaching 2250 % over a broad temperature range. The full MR response can be consistently described using a modified two-band bulk model with field-dependent charge-carrier concentrations, complemented by a weak-antilocalization description of the surface states. These results highlight the possible field-induced band modification and the interplay between bulk and surface transport in Bi-Sb thin films.

TT 74.6 Thu 10:45 CHE/0091

THz Signatures of Boundary-Dominated Transport in Bi_2TeI — ●SHUHAN WANG¹, ANJAN N M¹, MOHAMMAD MEHMANDOUS², MICHAEL RUCK², and STEFAN KAISER¹ — ¹Institute of Solid State and Materials Physic, TUD Dresden University of Technology — ²Inorganic Chemistry II, TUD Dresden University of Technology

Bi_2TeI is a weak topological insulator made of stacked topologically nontrivial (QSH) layers separated by trivial insulating layers. Despite its weak topological indices, it still hosts symmetry-protected boundary states on specific crystal surfaces. Using terahertz time-domain spectroscopy (THz-TDS), we resolve its low-energy electrodynamics in thin films. The THz conductivity shows a low frequency Drude response dip at 15K-20 K. This behavior is consistent with dc transport measurements. Notably, these features are only seen in thin films which are absent in bulk crystals. The suppression of Drude weight points to a crossover toward boundary-dominated transport in Bi-TeI thin films.

15 min. break

TT 74.7 Thu 11:15 CHE/0091

Topological fragility and bilinear magneto-resistance in spin-momentum locked edge states — ●COSIMO GORINI¹, MATTHIEU BARD², and GIOVANNI VIGNALE³ — ¹SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif sur Yvette, France — ²Université Paris-Saclay, CNRS, Laboratoire de Physique des Solides, 91405 Orsay, France — ³Institute for Functional Intelligent Materials, National University of Singapore

Time-reversal symmetric and topologically non-trivial electronic systems generally host one-dimensional (1D) spin-momentum locked states at their edges/hinges. Such 1D states are in principle fully protected against backscattering, and thus referred to as perfectly conducting: disorder cannot induce backscattering – not even via spin-orbit coupling – unless time-reversal is broken. We show however that such protection hides a remarkable fragility, yielding a bilinear magneto-resistance much stronger than in standard 2D systems. The mechanism we propose is fundamental and general, being based on spin-orbit interaction with the ever-present disordered background. It should thus be relevant in any system hosting 1D Dirac-like states with linear dispersion. Our theory compares favourably with transport measurements in high-order topological hinge states in Bi.

TT 74.8 Thu 11:30 CHE/0091

Procrustean symmetrization formalism for statistical topological matter — ●JOHANNA ZIJDERVELD¹, ADAM YANIS CHAO², ISIDORA ARAYA DAY^{1,2,3}, and ANTON AKHMEROV¹ — ¹Kavli Institute of Nanoscience, Delft University of Technology, Delft, The Netherlands — ²Donostia International Physics Center, San Sebastian, Spain — ³QuTech, Delft University of Technology, Delft, The Netherlands

The standard approach to characterizing topological matter, computing topological invariants, is known to be problematic when the symmetry protecting the topological phase only holds on average in a disordered system. Because of reliance on making the symmetry exact, the topological invariants identify more topological phases than are present in the system. Alternatively, in the recently discovered intrinsic statistical topological insulators [1], making the symmetry exact is guaranteed to destroy the topological phase. We define a procedure of symmetry embedding that solves both problems and provides a unified framework for describing disordered topological matter.

[1] Phys. Rev. Lett. 134, 226601

TT 74.9 Thu 11:45 CHE/0091

Topological invariants for the SSH model coupled to a single mode cavity — ●ANNA RITZ-ZWILLING and OLESIA DMYTRUK — CPHT, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France

Coupling electronic systems to cavity photons offers a promising route to probe and control material properties through light-matter interactions. In particular, coupling to light might enable manipulation of topological phases of matter, which have gained significant attention due to their potential applications in quantum technologies. Yet, while the topological classification of non-interacting fermionic systems is well understood within the tenfold way, much less is known about how to identify topological protection when photonic operators enter the problem. In this work, we consider the Su-Schrieffer-Heeger (SSH) model as a paradigmatic one-dimensional topological insulator. In its topological phase, the SSH model exhibits zero-energy edge states protected by chiral symmetry. When the system is coupled to a cavity, however, it remains unclear whether chiral symmetry and topological protection survive. To address this question, we use a recently developed high-frequency expansion of the light-matter Hamiltonian, which traces out photonic degrees of freedom and yields an effective fermionic model. Light-matter coupling then manifests as additional interaction terms, allowing us to apply known results for interacting topological insulators. We discuss the symmetries of this effective model, compute observables such as the electronic polarization as potential topological invariants and analyze the fate of edge states.

TT 74.10 Thu 12:00 CHE/0091

Z_2 topological invariants from the Green's function diagonal zeros — FLORIAN SIMON¹ and ●CORENTIN MORICE² — ¹Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden — ²Laboratoire de Physique des Solides, Université Paris Saclay, CNRS, Orsay, France

We investigate the relationship between the analytical properties of the Green's function and Z_2 topological insulators, focusing on three-dimensional inversion-symmetric systems. We show that the diagonal

zeros of the Green's function in the orbital basis provide a direct and visual way to calculate the strong and weak Z_2 topological invariants. We introduce the surface of crossings of diagonal zeros in the Brillouin zone, and show that it separates TRIMs of opposite parity in two-band models, enabling the visual computation of the Z_2 invariants by counting the relevant TRIMs on either side.

TT 74.11 Thu 12:15 CHE/0091

Volkov-Pankratov states in shaped topological insulator nanowires — •LILIAN SEYVE and COSIMO GORINI — SPEC, CEA, Gif-Sur-Yvette, France

Topological insulators (TIs) host robust electronic states at interfaces where the bulk topological invariant changes, giving rise to protected Dirac surface modes. Beyond these gapless states, Volkov and Pankratov showed that smooth band inversions can also generate massive interface modes, now known as Volkov-Pankratov (VP) states. These states coexist with the topological zero mode and interpolate continuously between topological and bulk physics. While VP states have been studied in planar structures, how they behave in curved systems, such as nanowires, is still very much unknown.

In this work, we explore analytically and numerically how VP states appear in nanowires with cylindrical symmetry, where geometry and confinement strongly influence the electronic structure. Using a Dirac-model description with a smoothly varying mass at the wire's edge, we show how curvature, angular momentum, and longitudinal motion combine to create a set of quantized interface states. We obtain analytical expressions for their energies and spatial profiles and describe how interface curvature affects the physical properties of our system.

TT 74.12 Thu 12:30 CHE/0091

Accessing buried topological states: Revealing Dirac cones with ferromagnetic resonance — LAURA PIETANESI¹, •MAGDALENA MARGANSKA^{2,3}, THOMAS MAYER², MICHAEL BARTH³, LIN CHEN¹, JI ZOU⁴, ADRIAN WEINDL², ALEXANDER LIEBIG², REBECA DIAZ-PARDO¹, DHAVALA SURI^{1,5}, FLORIAN SCHMID², FRANZ GIESSIBL², KLAUS RICHTER², YAROSLAV TSEKOVNYAK⁴, MATTHIAS KRONSEDER², and CHRISTIAN BACK¹ — ¹Technical University of Munich, Germany — ²University of Regensburg, Germany — ³Wrocław University of Science and Technology, Poland — ⁴University of California, Los Angeles, USA — ⁵Indian Institute of Science, Bengaluru, India

Ferromagnetic resonance is used to reveal features of the buried electronic band structure at interfaces between ferromagnetic metals and topological insulators [1]. The evolution of magnetic damping in a hybrid ferromagnet/3D topological insulator structure reveals a clear fingerprint of the Dirac point with additional features. The high energy resolution of this method allows us to resolve the energetic shift of the local Dirac points due to local variations of the electrostatic potential. The underlying spin-pumping mechanism relies on the dissipation of angular momentum by topological surface states (TSSs). Tuning of the Fermi level within the TSS was verified both by varying the stoichiometry of the 3DTI layer and by electrostatic backgating with a remarkable agreement. Calculations based on the chiral tunneling process naturally occurring in TSSs agree well with the experimental results.

[1] PRB 109, 064424 (2024)

TT 75: Many-body Quantum Dynamics I (joint session DY/TT)

Time: Thursday 9:30–12:45

Location: HÜL/S186

TT 75.1 Thu 9:30 HÜL/S186

Nonequilibrium transport in adaptive fermionic circuits — •PAUL WEISS¹, KARIM CHAHINE², and MICHAEL BUCHHOLD¹ — ¹Department of Theoretical Physics, Universität Innsbruck, Austria — ²Institute for Theoretical Physics, University of Cologne, Germany

We investigate nonequilibrium dynamics in one-dimensional adaptive fermionic circuits, where monitored fermions undergo local unitary evolution conditioned on measurement outcomes. By tuning the measurement strength and the duration of the unitary gates, the dynamics can be continuously interpolated between incoherent, classical transport and coherence-dominated quantum transport. In the classical limit, we recover the asymmetric simple exclusion process (ASEP), while in the quantum regime we uncover a coherent analogue of the Burgers equation along with coherence-enhanced Kardar-Parisi-Zhang (KPZ) transport. Our analytical approach, based on transport equations and Keldysh field theory, is supported by numerical simulations.

TT 75.2 Thu 9:45 HÜL/S186

Frustration-Free Control and Absorbing-State Transport in Entangled State Preparation — •TOBIAS DÖRSTEL^{1,2}, THOMAS IADECOLA^{3,4,5}, JUSTIN H. WILSON^{6,7}, and MICHAEL BUCHHOLD^{1,2} — ¹Department of Theoretical Physics, University of Innsbruck, Austria — ²Institute for Theoretical Physics, University of Cologne, Germany — ³Department of Physics, The Pennsylvania State University, USA — ⁴Institute for Computational and Data Sciences, The Pennsylvania State University, USA — ⁵Materials Research Institute, The Pennsylvania State University, USA — ⁶Department of Physics and Astronomy, Louisiana State University, USA — ⁷Center for Computation and Technology, Louisiana State University, USA

We study frustration-free control, a measurement-feedback protocol for quantum state preparation that extends the concept of frustration-free Hamiltonians to stochastic dynamics. The protocol drives many-body systems into highly entangled target states, common dark states of all measurement projectors, through minimal local unitary corrections that realize an absorbing-state dynamics without post-selection. We show that relaxation to the target state is governed by emergent transport of nonlocal charges, such as singlet excitations in SU(2)-symmetric dynamics. While measurement-feedback annihilates compatible charge configurations, both measurement and scrambling unitaries induce charge transport and thus determine the convergence time. Mapping a baseline model of SU(N) SWAP measurements with

local corrections to a solvable absorbing random walk yields a runtime scaling $t \sim L^z$ with transport exponent $z = 2$.

TT 75.3 Thu 10:00 HÜL/S186

Quantum typicality approach to energy flow between two spin-chain domains at different temperatures — LAURENZ BECKEMEYER¹, •MARKUS KRAFT¹, MARIEL KEMPA¹, DIRK SCHURICHT², and ROBIN STEINIGEWEG¹ — ¹University of Osnabrück, Department of Mathematics/Computer Science/Physics, D-49076 Osnabrück, Germany — ²Institute for Theoretical Physics, Utrecht University, 3584CC Utrecht, The Netherlands

We discuss a quantum typicality approach to examine systems composed of two subsystems at different temperatures. While dynamical quantum typicality is usually used to simulate high-temperature dynamics, we also investigate low-temperature dynamics using the method. To test our method, we investigate the energy current between subsystems at different temperatures in various paradigmatic spin-1/2 chains, specifically the XX chain, the critical transverse-field Ising chain, and the XXZ chain. We compare our numerics to existing analytical results and find a convincing agreement for the energy current in the steady state for all considered models and temperatures.

[1] Beckemeyer et al. arXiv:2507.23439

TT 75.4 Thu 10:15 HÜL/S186

Revisiting boundary-driven method for transport: Finite-size effects and the role of system-bath coupling — •MARIEL KEMPA¹, MARKUS KRAFT¹, SOURAV NANDY², JACEK HERBRYCH³, JIAOZI WANG¹, JOCHEN GEMMER¹, and ROBIN STEINIGEWEG¹ — ¹University of Osnabrück, Osnabrück, Germany — ²Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ³Wrocław University of Science and Technology, Wrocław, Poland

Understanding transport in interacting quantum many-body systems is a central challenge in condensed matter and statistical physics. Numerical studies typically rely on two main approaches: Dynamics of linear-response functions in closed systems and Markovian dynamics governed by master equations for boundary-driven open systems. While the equivalence of their dynamical behavior has been explored in recent studies, a systematic comparison of the transport coefficients obtained from these two classes of methods remains an open question. Here, we address this gap by comparing and contrasting the dc diffusion constant \mathcal{D}_{dc} computed from the aforementioned two approaches. We find a clear mismatch between the two, with \mathcal{D}_{dc} exhibiting a strong depen-

dence on the system-bath coupling for the boundary-driven technique, highlighting fundamental limitations of such a method in calculating the transport coefficients related to asymptotic dynamical behavior of the system. We trace the origin of this mismatch to the incorrect order of limits of time $t \rightarrow \infty$ and system size $L \rightarrow \infty$, which we argue to be intrinsic to boundary-driven setups.

TT 75.5 Thu 10:30 HÜL/S186

Synchronized Aharonov-Bohm Motifs via Engineered Dissipation — ●CHRISTOPHER WÄCHTLER and GLORIA PLATERO — ICM-SCIC, Madrid, Spain

The interplay between external gauge fields and lattice geometry can induce extreme localization dynamics through complete destructive interference. We show that combining this flux-induced localization with engineered dissipation leads to robust spin synchronization in rotationally symmetric spin geometries, referred to as Aharonov-Bohm motifs, with cyclic symmetries of any order. The synchronized dynamics is independent of initial conditions and features entanglement among spins within each motif. We further demonstrate that multiple motifs can fully synchronize when coupled, which is achieved by applying additional collective dissipation acting on all intra-motif spins. These results reveal a direct connection between flux-induced localization, dissipative engineering, and collective quantum synchronization.

TT 75.6 Thu 10:45 HÜL/S186

Krylov space dynamics of ergodic and dynamically frozen Floquet systems — ●LUKE STASZEWSKI¹, ASMI HALDAR², PIETER CLAEYS¹, and ALEXANDER WIETEK¹ — ¹Max Planck Institute for the Physics of Complex Systems, Dresden — ²Laboratoire de Physique Theorique - IRSAMC, Toulouse

In isolated quantum many-body systems periodically driven in time, the asymptotic dynamics at late times can exhibit distinct behavior such as thermalization or dynamical freezing. Understanding the properties of and the convergence towards infinite-time (nonequilibrium) steady states however remains a challenging endeavor. We propose a physically motivated Krylov space perspective on Floquet thermalization which offers a natural framework to study rates of convergence towards steady states and, simultaneously, an efficient numerical algorithm to evaluate infinite-time averages of observables within the diagonal ensemble. The effectiveness of our algorithm is demonstrated by applying it to the periodically driven mixed-field Ising model, reaching system sizes of up to 30 spins. Our method successfully resolves the transition between the ergodic and dynamically frozen phases and provides insight into the nature of the Floquet eigenstates across the phase diagram. Furthermore, we show that the long-time behavior is encoded within the localization properties of the Ritz vectors under the Floquet evolution, providing an accurate diagnostic of ergodicity.

15 min. break

TT 75.7 Thu 11:15 HÜL/S186

Chaotic many-body quantum dynamics, spectral correlations, and energy diffusion — ●DOMINIK HAHN and JOHN CHALKER — Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford OX1 3PU, United Kingdom

We present results on the quantum dynamics of a minimal model with spatial structure and local interactions. The model features a time-independent Hamiltonian, in contrast to the widely studied quantum circuits, and is analytically tractable in the limit of large local Hilbert space dimension and weak intersite coupling. In this regime, we show that the energy dynamics are governed by a classical master equation exhibiting diffusive behavior. Furthermore, we demonstrate that the spectral form factor can be expressed exactly in terms of the solution to this master equation, demonstrating how the linear ramp emerges at long times, while locality gives rise to an additional enhancement at short times.

TT 75.8 Thu 11:30 HÜL/S186

Dissipative diffusion in quantum state preparation — ●TIM POKART¹, LUKAS KÖNIG¹, SEBASTIAN DIEHL², and JAN CARL BUDICH^{1,3,4} — ¹Institute of Theoretical Physics, Technische Universität Dresden — ²Institut für Theoretische Physik, Universität zu Köln, 50937 Cologne, Germany — ³Würzburg-Dresden Cluster of Excellence ct.qmat, 01062 Dresden, Germany — ⁴Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany

Dissipative quantum protocols that engineer a desired state as their dark state provide a powerful route to preparing quantum many-body states. We investigate a number conserving variant of such a dissipative protocol which is able to stabilize a topologically nontrivial phase. We show that the protocol admits a unique and stable dark state. Furthermore, we find that the cooling is diffusive in nature, supported by both analytical arguments and numerical simulations.

TT 75.9 Thu 11:45 HÜL/S186

First principles simulation of spin diffusion using dynamic mean-fields — ●TIMO GRÄSSER¹, MATTHIAS ERNST¹, and GÖTZ S. UHRIG² — ¹Institute of Molecular Physical Science, ETH Zurich, 8093 Zurich, Switzerland — ²Condensed Matter Physics, TU Dortmund University, 44227 Dortmund, Germany

The transfer of a globally conserved polarization among a homogeneous spin ensemble is called spin diffusion and one of the most important phenomena in the broad field of magnetic resonance. Describing spin diffusion theoretically is a notoriously difficult task due to the large number of spins involved. We use a description through dynamic mean-fields (dubbed spinDMFT [1]) to derive an effective model for spectral spin diffusion. The approach is benchmarked for two crystalline test samples, malonic acid and dipotassium α -D-glucopyranose-1-phosphate dihydrate, yielding a remarkable agreement with experimental data and requiring only little computational effort. This strongly supports the use of spinDMFT, which may be extended in future works to understand spin diffusion in dynamic nuclear polarization (DNP) experiments [2].

[1] T. Gräßer et al., Phys. Rev. Research 3, 043168 (2021), DOI 10.1103/PhysRevResearch.3.043168

[2] J. Eills et al., Chem. Rev. 123, 1417 (2023), DOI 10.1021/acs.chemrev.2c00534

TT 75.10 Thu 12:00 HÜL/S186

Simulating universal long-time dynamics in integrable quantum spin chains — ●ANGELO VALLI¹, CATALIN PASCU MOCA², MIKLOS ANTAL WERNER³, MARTON KORMOS¹, DORU STICLET⁶, BALAZS DORA¹, ZIGA KRAJNİK⁴, TOMAZ PROSEN⁵, and GERGELY ZARAND¹ — ¹Budapest University of Technology and Economics, Budapest (Hungary) — ²University of Oradea, Oradea (Romania) — ³Wigner Research Centre for Physics, Budapest (Hungary) — ⁴New York University, New York (USA) — ⁵University of Ljubljana, Ljubljana (Slovenia) — ⁶National Institute for R&D of Isotopic and Molecular Technologies, Cluj-Napoca (Romania)

We introduce a novel tensor-network approach to calculate cumulants of the full counting statistics to unprecedentedly long times. We investigate spin-transfer in quantum spin chains, where the superdiffusive transport with dynamical exponent $z=3/2$ has been conjectured to fall within the Kardar-Parisi-Zhang (KPZ) universality class of classical interface growth. Recent experimental evidence on quantum simulators challenged this hypothesis. Our results extend far beyond the experimental timescales and provide unambiguous evidence that spin transfer in integrable quantum spin chains is indeed incompatible with KPZ universality. However, spatio-temporal fluctuations of the spin analogue of surface roughness exhibit a self-similar Family-Vicsek (FV) scaling, relating roughness, growth, and dynamical exponents in all transport regimes and across models with $SU(N)$ symmetry. Our results shed light on how classical universal scaling laws extend to the quantum many-body realm.

TT 75.11 Thu 12:15 HÜL/S186

Few-body structures of Quantum impurity problems in the Heisenberg picture — ●MAXIME DEBERTOLIS — University of Bonn

Quantum impurity problems are known to exhibit a simplified representation of their ground state or for quench protocols when an optimized single-particle basis is chosen. This work extends the study of single-particle rotations tailored to operators in the Heisenberg picture. We present the concept of natural super-orbitals for many-body operators, defined as the eigenvectors of the one-body super-density matrix associated with a vectorized operator. These objects are related to measures of non-Gaussianity of operators associated to the occupations of the natural super-orbitals. We perform a numerical investigation of the natural super-orbitals corresponding to both the time-evolution operator and a time-evolved local operator in the t-V model and in a quantum impurity model using tensor network simulations. In the quantum impurity model, occupations of the natural orbitals for both operators decay exponentially at all times. More surprisingly, the non-Gaussianity of the local operator saturates in time.

This indicates that only a small number of orbitals contribute significantly to quantum correlations, enabling a compact matrix-product-operator representation. This framework opens the door to future research that leverages the compressed structure of operators in their natural super-orbital basis, enabling for instance the computation of out-of-time-order correlators in large interacting systems over extended time scales.

TT 75.12 Thu 12:30 HÜL/S186

Propagating the Hierarchical Equations of Motion (HEOM) using the Multi-Configurational Time-Dependent Hartree method (MCTDH) — •LUISA R. GREYER¹, UWE MANTHE², SAMUEL L. RUDGE¹, and MICHAEL THOSS¹ — ¹Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg im Breisgau, Deutschland — ²Theoretische Chemie, Fakultät für Chemie, Universität Bielefeld, Universitätsstr. 25, 33615

Bielefeld, Deutschland

The Hierarchical Equations of Motion (HEOM) are a powerful, numerically exact approach for simulating the time evolution of an open quantum system. Over the past decade, several tensor-train- and tensor-network-based approaches have been suggested and realized to make the HEOM applicable to ever larger model systems [1,2].

In this contribution, we build upon the existing twin-space formulation of the HEOM [2] and introduce a novel approach employing the Multi-Configurational Time-Dependent Hartree method (MCTDH) [3] for the time propagation of the HEOM. We demonstrate the applicability of the resulting HEOM+MCTDH method by presenting electron transport calculations for a nanojunction model, for which fully quantum results have not been available previously.

[1] Q. Shi *et al.*, J. Chem. Phys. **148**, 174102 (2018).

[2] Y. Ke *et al.*, J. Chem. Phys. **156**, 194102 (2022).

[3] H.-D. Meyer *et al.*, Chem. Phys. Lett. **165**, 73 (1990).

TT 76: Focus Session: Curvilinear magnetism: Magnetics with nanoscale curved geometries (joint session MA/TT)

The behaviour of any physical system is determined by the order parameter whose distribution is governed by the geometry and topology of the physical space of the object, in particular its dimensionality and curvature. Specifically, spin textures, static and dynamic magnetic responses become sensitive to bends and twists in physical space. In this respect, curvature effects emerged as a novel tool to tailor magnetic properties and responses relying on geometric deformations. In magnetism, coupling between geometry of a magnet and magnetic order parameter brings about novel responses of curved thin films, nanowires and nanoparticles and enforces topological constraints on the number and type of magnetic solitons living in a curved space. Curvatures can force a geometry-driven local interactions like Dzyaloshinskii-Moriya interaction (DMI) and anisotropy as well as novel non-local chiral symmetry breaking effects, which were confirmed experimentally using electron holography studies of magnetic cap-shaped structures. Advances in experimental techniques (fabrication and tomographic characterization) allow validating theoretically predicted effects and apply them for functional devices as was demonstrated with geometrically twisted 3D racetracks. Recent highlights of the community include experimental proof of curvature stabilised skyrmions, explorations of curvilinear altermagnets, tailoring magnetic solitons in curvilinear 2D magnets, curvilinear magnetoelectrics, use of curvilinear magnetic architectures to tune superconducting transport, and magnetoionic manipulation of magnetic states in nanostructures to name just a few representative topics, which will be covered at the focused symposium.

Organizers: Denys Makarov, d.makarov@hzdr.de; Paola Gentile, paola.gentile@spin.cnr.it

Time: Thursday 9:30–13:00

Location: POT/0151

Invited Talk

TT 76.1 Thu 9:30 POT/0151

2D and 3D racetracks: Interplay of geometric and magnetic chiralities — •STUART PARKIN — Max Planck Institute for Microstructure Physics, Halle (Saale), Germany — Martin Luther University Halle-Wittenberg

Magnetic Racetrack Memory (RTM) is a unique memory-storage device that relies on the current driven motion of multiple domain walls along magnetic conduits that can be arranged either horizontally (2D) or vertically (3D). It has great potential as a high performance, non-volatile memory that has enormous data storage capacity compared to today's memory technologies. Atomically engineered 2D magnetic racetracks in the form of synthetic antiferromagnets allow for very high current induced motion of nanoscopic chiral domain walls[1]. Recently we have shown that 2D RTM can be scaled to dimensions that are technologically relevant with widths of just ~50 nm[2]. 3D racetracks would allow for the highest density memories. Using a state-of-the-art multi-photon super-resolution lithography system we form 3D scaffolds of arbitrary shapes on which the racetracks can be subsequently deposited. We discuss 3D racetracks that are formed with clockwise and anticlockwise chiral twists and curved cross-sections. The interplay between the geometrical chirality and the spin chirality of the individual domain walls allows for domain wall diode devices [3]. [1] S. S. P. Parkin, S.-H. Yang, Nat. Nanotechnol. 2015, 10, 195. [2] J.-C. Jeon, A. Miglierini, J. Yoon, J. Jeong, S. S. P. Parkin, Science 2024, 386, 315. [3] A. M. A. Farinha, S.-H. Yang, J. Yoon, B. Pal, S. S. P. Parkin, Nature 2025, 639, 67.

Invited Talk

TT 76.2 Thu 10:00 POT/0151

Combined MFM/KPFM at the Ultimate Sensitivity Limit for Probing Curvature-Engineered Micromagnetic States

— •EMILY DARWIN¹, RESHMA PEREMADATHIL PRADEEP^{1,2}, LUCA BERCHIALLA³, DANIEL ROTTHARDT^{1,2}, ALES HRABEC³, and HANS HUG^{1,2} — ¹Empa, Swiss Federal Laboratories for Materials Science and Technology, 8600 Dübendorf, Switzerland — ²Department of Physics, University of Basel, 4056 Basel, Switzerland — ³Paul Scherrer Institut PSI, 5232 Villigen, Switzerland

Curved substrates offer a promising route for tailoring the magnetic properties of multilayer systems, potentially stabilizing topologically non-trivial spin textures such as skyrmions. However, local variations in surface inclination can significantly affect growth conditions, altering crystallographic orientation or even disrupting the multilayer architecture.

In this study, we investigate a Pt/Co/Ru multilayer deposited on a polymer substrate patterned with nanoscale semispherical bumps using a combined single-pass Magnetic Force Microscopy (MFM) and Frequency-Modulated Kelvin Probe Force Microscopy (FM-KPFM) technique. Our system achieves unprecedented sensitivity to both magnetic and electrostatic interactions. We find that steep, near-vertical walls at the perimeter of hemispherical features locally disorder the multilayer stack, resulting in distinct changes in the contact potential difference. This disruption facilitates magnetic flux return and enables the formation of circular magnetic domains aligned with the external magnetic field on the dome tops.

Invited Talk

TT 76.3 Thu 10:30 POT/0151

Curvilinear magnetism in superconducting spintronics —

•SOL JACOBSEN — Center for Quantum Spintronics, Norwegian University of Science and Technology NTNU, Trondheim, Norway

Replacing semiconductor-based computational components with superconducting elements can give an energy saving of two orders of magnitude. To harness this, we need precise control of the interaction between superconducting and magnetic components. Geometric curvature controls the superconducting transition by affecting spin relaxation and precession in superconductor-magnet heterostructures [1]. To functionalize this in devices, we can dynamically alter the curvature by inducing bending-strain. This can for example lead to electrically controlled superconducting spin-valves, current-reversal, and chirality-dependent ground states in triplet-SQUIDs [1-3]. In this presentation, I will discuss how real-space geometric curvature provides new pathways for manufacturing and controlling the interaction between superconductivity and magnetism in wires and thin films, and anticipate future developments in the field.

[1] Salamone et al, Phys. Rev. B 104 (2021) L060505; 105, (2022) 134511. [2] Salamone et al, Appl. Phys. Lett. 125 (2024) 062602. [3] Skarpeid et al, J.Phys.:Condens.Matter, 36 (2024) 235302.

15 min break

Invited Talk

TT 76.4 Thu 11:15 POT/0151

Advanced Control of Magnetic Nanostructures via Metasurface Engineering and Voltage-Driven Functionalities — •ANNA PALAU — Institut de Ciència de Materials de Barcelona (ICMAB-CSIC)

Understanding and manipulating magnetic micro- and nanostructures are fundamental to advancing technologies in data storage, spintronics, and magnetic sensing. Magnetic metasurfaces have recently attracted significant interest for their ability to locally configure magnetic field distributions and overcome limitations of traditional magnetic imaging techniques. In this work, we demonstrate how metasurfaces enable precise control of vortex motion, coercive fields, and saturation behaviour in magnetic nanostructures without altering their intrinsic anisotropy [1]. We show that metasurfaces can overcome magnetic field constraints in X-ray Photoemission Electron Microscopy (XPEEM), enabling high-resolution imaging of magnetisation states under conditions previously inaccessible. Additionally, we explore electric-field-driven ionic migration as a complementary route for voltage-controlled, non-volatile modulation of magnetic and superconducting properties [2], highlighting new opportunities for energy-efficient control and advanced characterisation. [1] Barrera et al. ACS Nano 19, 10461 (2025), [2] Güntel et al. Small 24(1908) (2025), Spasojević et al. Nat. Commun. 16, 1990 (2025)

Invited Talk

TT 76.5 Thu 11:45 POT/0151

Magnetic tomography of noncollinear spin textures in curvilinear geometries — •SANDRA RUIZ-GOMEZ — ALBA Synchrotron, Barcelona, Spain

Three-dimensional nanomagnetic systems offer a unique platform for discovering and controlling complex spin textures. Recent advances in 3D nanofabrication, magnetic characterization techniques, and micromagnetic modeling are now enabling precise control of curvature, torsion, and geometry at the nanoscale, opening new routes for engineering spin textures in three-dimensional architectures.

In this talk, I will present our latest results on how geometrical design and 3D architecture can be exploited to tailor the energy landscape of domain walls, manipulate their topological properties, and guide their motion from straight nanowires to more complex curved cylindrical and tubular geometries. By combining state-of-the-art fabrication techniques with high-resolution imaging and theoretical analysis, we identify how curvature can be harnessed to stabilize complex spin textures, enabling deterministic control over their dynamics.

Overall, this work highlights how 3D nanomagnetism can be leveraged to access new regimes of topological control, with implications for next-generation spintronic devices, robust information carriers, and reconfigurable magnetic architectures.

TT 76.6 Thu 12:15 POT/0151

Transferred magnetic nanomembranes for curvilinear magnetism and spintronics — •OLHA BEZSMERTNA¹, OLEKSANDR

PYLYPOVSKIY¹, RUI XU¹, MYKOLA VINNICHENKO², ANDREA SORRENTINO³, DANIEL WOLF⁴, AXEL LUBK⁴, PETER FISCHER^{5,6}, and DENYS MAKAROV¹ — ¹Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — ²Institute for Ceramic Technologies and Systems IKTS, 01277 Dresden, Germany — ³Alba Light Source, MIS-TRAL beamline, Cerdanyola del Vallès 08290, Spain — ⁴Leibniz Institute for Solid State and Materials Research, 01069 Dresden, Germany — ⁵University of California, Santa Cruz, United States — ⁶Lawrence Berkeley National Laboratory, Berkeley, United States

The functionality of the magnetic nanomembranes can be extended through controlled transfer processes and geometric design. We show that advanced giant magnetoresistive thin films can be reliably transferred onto various substrates using green chemistry, preserving their structural integrity and magnetic performance, thus enabling mechanically conformal devices for applications where low weight, flexibility, and durability are essential [1]. With the developed technique, we demonstrate fabrication of curvilinear hierarchical magnetic nanotemplates and their subsequent transfer to an appropriate handling support enabling high-resolution transmission microscopy investigations (electron- and x-ray-based) of the impact of geometric curvature on complex magnetic states [2].

References: [1] Bezsmertna et al. Adv. Funct. Mater. 35, 2502947 (2025). [2] Bezsmertna et al. Nano Lett. 24, 15774 (2024).

TT 76.7 Thu 12:30 POT/0151

Magnetic solitons in spherical maghemite nanoshells —

•OLEKSANDR V. PYLYPOVSKIY¹, GASPARE VARVARO², DAVIDE PEDDIS^{2,3}, PRIYANKA MISHRA⁴, CARMINE AUTIERI⁴, FILIPP N. RYBAKOV⁵, DENIS D. SHEKA⁶, and DENYS MAKAROV¹ — ¹Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany — ²CNR-Istituto di Struttura della Materia, 00015 Roma, Italy — ³Università degli Studi di Genova, 1-16146 Genova, Italy — ⁴International Research Centre Magtop, Institute of Physics, Polish Academy of Sciences, 02668 Warsaw, Poland — ⁵Uppsala University, Uppsala SE-751 20, Sweden — ⁶Taras Shevchenko National University of Kyiv, 01601 Kyiv, Ukraine

Topology of the shape of magnetic nanoarchitecture makes a major impact on global properties of its magnetic textures [1,2]. Here, we present a fabrication of maghemite spherical shells and a theoretical analysis of magnetic solitons they host in equilibrium. The ferrimagnetic shells with a radius and shell thickness of about 4 nm and 1.4 nm have a radial easy axis that favors skyrmionic textures. Their ground state corresponds to a 3D onion state with the change of the radial component of magnetization at the equator. In this presentation, we will also report on the localization of magnetic solitons on spherical shells.

[1] V. P. Kravchuk et al., PRB **94**, 144402 (2016); [2] O. M. Volkov, O. V. Pylypovskiy et al., Nat. Commun., **15**, 2193 (2024).

TT 76.8 Thu 12:45 POT/0151

Coherent Spin Waves in Curved Ferromagnetic Nanocaps of a 3D-printed Magnonic Crystal — •KILIAN LENZ¹, HUIXIN GUO², MATEUSZ GOLEBIEWSKI³, RYSZARD NARKOWICZ¹, JÜRGEN LINDNER¹, MACIEJ KRAWCZYK³, and DIRK GRÜNDLER² —

¹Inst. of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany — ²School of Engineering, Institute of Materials, Laboratory of Nanoscale Magnetic Materials and Magnonics, École Polytechnique Fédérale de Lausanne, Switzerland — ³Institute of Spintronics and Quantum Information, Adam Mickiewicz University, Poznań, Poland

In this work we present ferromagnetic resonance measurements and simulations of a 3D magnonic crystals embedded in an on-chip microresonator. It was realized by two-photon lithography of a 3D woodpile structure and atomic layer deposition of a 30-nm-thin Ni film. Operated near 14 and 24 GHz, the microresonator output revealed numerous coherent magnons with distinct angular dependencies reflecting the underlying face-centered cubic lattice. The micromagnetic simulations show that some of the edge modes are localized at the curved nanocaps and that they remain robust against changes of the field orientation. These cap modes exhibit an unexpected phase evolution. The findings advance the development of functional microwave circuits with 3D magnonic crystals and strengthen their visionary prospects for edge-dominated magnon modes.

TT 77: Topical Talk Bibes (joint session O/TT)

Time: Thursday 9:30–10:15

Location: TRE/PHYS

Topical Talk

TT 77.1 Thu 9:30 TRE/PHYS

Oxide interfaces as platforms for emergent quantum phenomena — ●MANUEL BIBES — Laboratoire Albert Fert, CNRS, Thales, U. Paris-Saclay, Palaiseau (France)

Oxide surfaces and heterointerfaces host electronic phases that emerge from the combined effects of broken inversion symmetry, orbital reconstruction, and electrostatic boundary conditions. In this overview, I will discuss how two-dimensional electron gases (2DEGs) formed at oxide surfaces and interfaces give rise to large and tunable spin-orbit interactions, interfacial magnetism, and ferroic control of transport properties.

The focus will be on Rashba-type spin-orbit coupling in oxide 2DEGs

and its interplay with ferromagnetism and ferroelectricity, leading to effects such as electrically tunable Anomalous Hall effect, spin and orbital Edelstein effects, and spontaneous non-reciprocal charge transport. Angle-resolved photoemission spectroscopy (ARPES) and X-ray photoelectron spectroscopy (XPS) play a central role in elucidating the electronic structure, orbital character, and electrostatic landscape underlying these phenomena, and in establishing clear links between interface chemistry, symmetry breaking, and transport behavior.

Finally, I will discuss how these engineering 2DEGs enables new routes toward low-power spin-orbitronic and ferroelectric device concepts compatible with silicon technology. The talk will highlight open challenges and opportunities at the interface between surface science, correlated electron physics, and oxide electronics.

TT 78: Quantum Dots and Point Contacts (joint session TT/HL)

Time: Thursday 11:00–12:45

Location: HSZ/0101

TT 78.1 Thu 11:00 HSZ/0101

Mapping dissipation in a quantum dot junction — ●JOHANNES HÖFER¹, SUBHOMOY HALDAR², VILLE MAISI², HERVÉ COURTOIS¹, and CLEMENS B. WINKELMANN^{1,3} — ¹Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 25 rue des Martyrs, Grenoble, France — ²NanoLund and Solid State Physics, Lund University, 22100 Lund, Sweden — ³Univ. Grenoble Alpes, CEA, Grenoble INP, IRIg-Pheliqu, Grenoble, France

Characterization of quantum devices relies primarily on electrical properties. It is usually assumed that all parts of the device remain at the same temperature, but the inevitable presence of local dissipation can lead to significant deviations and degrade device performance [1].

Here, we present simultaneous measurement of the current through a quantum dot junction as well as the dissipation generated by the current. To this end, we thermally isolate the drain contact of an epitaxially defined quantum dot in an InAs nanowire. The electron temperature is measured via the zero-bias conductance of a Josephson junction [2]. Due to the energy-selective transport through a single quantum level, we can tune the dissipation solely with a gate voltage, while keeping both the current and voltage across the dot constant.

The presented device enables future investigations of local dissipation in nanoscale devices, e.g. for mitigation of detrimental heating effects, as well as implementations of proposed experiments in the field of quantum thermodynamics.

[1] S.G.J. Philips et al., *Nature* 609 (2022) 919

[2] B. Karimi, & J.P. Pekola, *Phys. Rev. Applied* 10 (2018) 054048

TT 78.2 Thu 11:15 HSZ/0101

Lindblad-based linear response of hybrid semiconductor-superconductor devices — ●TOBIAS KUHN, RAFFAEL L. KLEES, and MONICA BENITO — Augsburg University, Augsburg, Germany

The field of hybrid semiconductor-superconductor quantum dots is pushing towards the development of functional devices that harness the advantages of both worlds. Their complexity calls for a complete theoretical framework to understand responses to different probe fields and dissipation induced by the environment. We present a Lindblad-based linear response formalism, built upon the framework introduced in Ref. [1]. It captures not only the inherently multi-level nature of these devices but also their probe-readout flexibility and non-unitary effects of the finite-frequency response. We exemplify the framework using quantum dot based Kitaev chain setups which are promising candidates for topologically protected qubits [2,3].

[1] L. Peri, M. Benito, C. J. B. Ford, and M. F. Gonzalez-Zalba, *npj Quantum Inf* 10, 1 (2024)

[2] M. Leijnse and K. Flensberg, *Phys. Rev. B* 86, 134528 (2012)

[3] D.M.Pino, R.S.Souto, R.Aguado, *Phys. Rev. B* 109, 075101 (2024)

TT 78.3 Thu 11:30 HSZ/0101

Dynamics of strong correlations of a hybrid quantum dot system with superconducting and ferromagnetic electrodes — ●ANTONI JANKIEWICZ, KACPER WRZEŚNIEWSKI, and IRENEUSZ WEYMANN — Institute of Spintronics and Quantum Information, Adam

Mickiewicz University, Poznań, Poland

We theoretically explore the non-equilibrium dynamics of a quantum dot coupled to superconducting and ferromagnetic electrodes. This hybrid setup offers a rich platform to investigate the interplay between strong correlations, superconductivity, and ferromagnetism at the nanoscale. To perform the analysis we employ the numerical renormalization group and its time-dependent extension. These methods enable us to capture the subtle nature of dynamical quantum phase transitions induced by abrupt changes in Hamiltonian parameters, known as quantum quenches. Such transitions are crucial for understanding the stability and evolution of many-body states in response to external perturbations.

The aim of this work is to examine the competition between the superconducting pairing and the dot's spin. For that, we determine the time dependence of key observables, including the dot's spin and the on-dot pairing correlations. We demonstrate that these quantities reveal the competing character of correlations as they oscillate in counter-phase. Furthermore, we also analyze the dynamical quantum phase transitions in the system by determining the Loschmidt echo and the return function, which provide direct measures of the system's sensitivity to quenches.

TT 78.4 Thu 11:45 HSZ/0101

Tunneling resonances through periodically driven quantum dots — ●JAN MATHIS GIESEN, DANIEL WEBER, and SEBASTIAN EGERT — RPTU University Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany

We consider a general setup of transport through a time-periodically driven quantum dot using Floquet theory. An analytic non-equilibrium solution of the problem is developed which allows the analytic prediction and analysis of the tunneling amplitudes as a function of frequency, driving amplitude, and energy levels on the dot. One main result is the discovery of a previously unknown resonant switching effect, where a very small control signal on a weakly connected quantum dot can induce perfect transmission. This opens the door for the design of novel efficient nano-electronic devices. The results are also relevant for corresponding setups using magnonic systems, photonic waveguides, or ultra-cold gases in optical lattices.

TT 78.5 Thu 12:00 HSZ/0101

Spectroscopic-imaging Coulomb blockade microscopy — JUNHO BANG¹, BYEONGIN LEE¹, HANKYU LEE¹, ●JIANFENG GE², and DOOHEE CHO¹ — ¹Department of Physics, Yonsei University, Seoul 03722, Republic of Korea — ²Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

We use scanning tunneling microscopy (STM) to directly visualize Coulomb blockade (CB) phenomena in the double-barrier tunnel junction formed between the STM tip and crystalline indium nanoislands on semiconducting black phosphorus. Spatially resolved tunneling spectra reveal bias-dependent dispersions of CB peaks across individual nanoislands. Strikingly, the trajectories of CB peaks exhibit two-fold asymmetries: (i) their curvatures reverse sign across a nonzero bias

offset, and (ii) the trajectories lack mirror symmetry about this bias offset. Simulations based on orthodox theory faithfully reproduce both asymmetries, which we trace to work-function mismatches at (i) the island-tip and (ii) the island-substrate interfaces, respectively. These results establish spectroscopic-imaging Coulomb-blockade microscopy as a quantitative probe of junction parameters, offering a pathway for diagnosing and optimizing single-electron charge sensors relevant to quantum-computing architectures.

TT 78.6 Thu 12:15 HSZ/0101

Electromigrated palladium nano-contacts: formation of atomic contacts and non linear current-voltage characteristics — ●SAMANWITA BISWAS¹, THOMAS HULTZSCH¹, MARCEL STROHMEIER², ELKE SCHEER², and REGINA HOFFMANN-VOGEL¹ — ¹Institute of Physics and Astronomy, University of Potsdam — ²Department of Physics, University of Konstanz

We investigate the electronic transport properties of atomic-size Pd contacts fabricated by electromigration (EM) of lithographically defined nano-constrictions, at room temperature in different environments. In particular we study changes in the conductance upon EM with a focus on possible shell effects [1]. By systematic analysis of a large number of data sets in the conductance range up to $\sim 10G_0$ (with the conductance quantum $G_0 = 2e^2/h$), we identify preferential conductance values and compare these with the ones expected for shell closure in multivalent metals. For contacts with $G \lesssim 5G_0$, the current-voltage characteristics often become nonlinear on a scale of few 100mV; we discuss this observation with respect to structural changes

during the thinning process of EM. By monitoring the smallest conductances, we often identify a decrement of resistance inside a cycle, opposite to the overall trend, indicating the transition to the ballistic regime. Our results suggest that metallic few atomic contacts of Pd, despite being more reactive than noble metals, can be stabilized even at room temperature.

[1] Mares & van Ruitenbeek, Phys. Rev. B 72, 205402 (2005)

TT 78.7 Thu 12:30 HSZ/0101

Readout of multi-level quantum geometry from electronic transport — ●RAFFAEL L. KLEES and MÓNICA BENITO — Institute of Physics, University of Augsburg, D-86159 Augsburg, Germany

The quantum geometric tensor (QGT) of a quantum system in a given parameter space captures both the geometry of the state manifold and the topology of the system [1]. While the local QGT elements have been successfully measured in various platforms, the challenge of detecting them in electronic transport systems — such as tunnel or molecular junctions — has yet to be resolved. To fill this gap, we propose a measurement protocol based on weak and resonant parameter modulations [2], and theoretically demonstrate how the local QGT in such systems can be directly probed from changes of the tunnel conductance [3]. This approach enables the measurement of both geometrical and topological features of quantum states in a broad class of transport-based quantum systems.

[1] M. Kolodrubetz *et al.*, Phys. Rep. **697**, 1 (2017)

[2] T. Ozawa and N. Goldman, Phys. Rev. B **97**, 201117(R) (2018)

[3] R. L. Klees and M. Benito, arXiv:2508.08239 (2025)

TT 79: Correlated Magnetism – Transport

Time: Thursday 11:30–12:45

Location: HSZ/0103

TT 79.1 Thu 11:30 HSZ/0103

Spin Dynamics Approach to Thermal Hall Conductivity — ●IGNACIO SALGADO-LINARES^{1,2}, ALEXANDER MOOK³, LÉO MANGEOLLE^{1,2}, and JOHANNES KNOLLE^{1,2,4} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, TQM, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ³Department of Physics, Johannes Gutenberg University Mainz, 55128 Mainz, Germany — ⁴Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom

In recent years, the thermal Hall effect has emerged as a powerful tool for probing topological phenomena of magnetic systems. At low temperatures, the thermal Hall transport of long-range ordered magnets can be described in the framework of linear spin-wave theory (LSWT). However, how to treat regimes with increased thermal fluctuations or non-linearities beyond LSWT is an outstanding question. Therefore, within this project, we developed a novel numerical technique to extract the thermal Hall transport properties, which intrinsically includes non-linear effects. In particular, we use semi-classical spin dynamics simulations to compute thermal currents in the Kitaev model in a field. The results are expected to shed new light on the topological thermal transport in Kitaev spin liquid candidate materials.

TT 79.2 Thu 11:45 HSZ/0103

Extrinsic contribution to bosonic thermal Hall transport — ●LÉO MANGEOLLE^{1,2} and JOHANNES KNOLLE^{1,2,3} — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — ³Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom

Bosonic excitations like phonons and magnons dominate the low-temperature transport of magnetic insulators. Similar to electronic Hall responses, the thermal Hall effect (THE) of charge neutral bosons has been proposed as a powerful tool for probing topological properties of their wavefunctions. For example, the intrinsic contribution of the THE of a perfectly clean system is directly governed by the distribution of Berry curvature. However, disorder is inevitably present in any material and its contribution to the THE has remained poorly understood. Here we develop a rigorous kinetic theory of the extrinsic side-jump contribution to the THE of bosons. We show that the extrinsic THE is always relevant for bosonic systems and can be of the

same order as the intrinsic one but sensitively depends on the type of local imperfection. We study different types of impurities and show that a THE can even arise as a pure impurity-induced effect in a system with a vanishing intrinsic contribution. We discuss the importance of our results for the correct interpretation of THE measurements and provide a ready-to-use formula for comparison to experimental data.

TT 79.3 Thu 12:00 HSZ/0103

Giant thermopower changes due to secondary gradients of electronic properties — ●ULRIKE STOCKERT^{1,2,4}, JUDITH GRAFENHORST¹, SARAH KREBBER³, KRISTIN KLIEMT³, CORNELIUS KRELLNER³, and ELENA HASSINGER^{4,1,2} — ¹Technische Universität Dresden, 01062 Dresden, Germany — ²MPI for Chemical Physics of Solids, 01187 Dresden, Germany — ³Physikalisches Institut, Goethe-Universität Frankfurt, 60438 Frankfurt/M, Germany — ⁴Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The diffusion thermopower S_{diff} of conventional metals and semiconductors is typically small, being of the order of 10-100 $\mu\text{V/K}$. It arises from changes of the number and velocity of mobile charge carriers with temperature T due to the energy dependence of the density of states and the T dependence of the Fermi distribution. In simple models for the thermopower, these changes are assumed to be weak, and the materials behave homogeneous. However, if electronic properties as the chemical potential or the charge-carrier mobility exhibit strong T dependencies, any temperature gradient induces also significant gradients of these properties. In our presentation we will show that such a secondary gradient of the electrical conductivity σ may induce giant values of the diffusion thermopower. Using a simple drift-diffusion model and allowing explicitly for gradients of σ , we are able to predict the correct magnitude, shape, and field dependence of the thermopower. Our results open a new route to large thermopower values via gradients of electronic properties.

TT 79.4 Thu 12:15 HSZ/0103

Observation via spin Seebeck effect of macroscopic magnetic transport from emergent magnetic monopoles — ●NAN TANG¹, JOSEF WILLISHER², STEPHAN GLAMSCH³, AISHA AQEEL³, LUDWIG SCHEUCHENPFLUG¹, MICHAEL SCHULZE⁴, CHRISTOPH LIEBALD⁵, DANIEL RYTZ⁵, CHRISTO GUGUSCHEV⁴, MANFRED ALBRECHT³, RODERICH MOESSNER², and PHILIPP GEGENWART¹ — ¹Experimentalphysik VI, Universität Augsburg, Augsburg, Germany — ²Max-Planck-Institut für Physik komplexer Systeme, Dresden, Ger-

many — ³Experimentalphysik VI, Universität Augsburg, Augsburg, Germany — ⁴Leibniz-Institut für Kristallzüchtung (IKZ), Berlin, Germany — ⁵EOT GmbH-Coherent, Idar-Oberstein, Germany

Magnetic monopoles, elusive in high-energy physics, have been realised as emergent quasiparticles in solid-state systems, where topological defects act as effective magnetic charges. They have been proposed in diverse platforms, including skyrmion lattices, chiral magnets, soft ferromagnets, and artificial nanomagnets, yet their role in magnetic transport has remained unconfirmed. Here, we demonstrate such transport via the spin Seebeck effect in the insulating pyrochlore $\text{Dy}_2\text{Ti}_2\text{O}_7$. A thermal gradient applied perpendicular to a [111]-oriented magnetic field yields a spin Seebeck voltage showing a dominant peak at monopole proliferation, alongside a secondary feature and frequency-dependent behavior. These results establish a direct link between monopole dynamics and magnetic transport in an insulator and provide a route to probing fractionalized excitations and spintronic functionalities.

TT 79.5 Thu 12:30 HSZ/0103

Unconventional Magnetotransport and Magnetic Anisotropy in van der Waals Ferromagnet Fe_4GeTe_2 — ●RIJU PAL^{1,2,3},

JOYAL J. ABRAHAM^{1,2}, BUDDHADEB PAL³, SUCHANDA MONDAL⁴, PRABHAT MANDAL^{3,4}, ATINDRA NATH PAL³, BERND BÜCHNER^{1,2,5}, VLADISLAV KATAEV¹, and ALEXEY ALFONSOV¹ — ¹Leibniz IFW Dresden, D-01069, Germany — ²Institute for Solid State and Materials Physics, TU Dresden, D-01062, Germany — ³S. N. Bose National Centre for Basic Sciences, Kolkata, 700106, India — ⁴Saha Institute of Nuclear Physics, Calcutta, 700064, India — ⁵Würzburg-Dresden Cluster of Excellence ctd.qmat, Dresden, D-01062, Germany

Magnetic van der Waals (vdW) materials, with their intrinsic two-dimensionality and tunable exchange interactions, magnetocrystalline anisotropy, and electron correlations, are promising candidates for realizing non-trivial magnetic states. Combining transport measurements and electron spin resonance (ESR) spectroscopy, we studied the quasi-2D vdW ferromagnet Fe_4GeTe_2 , which has a near-room-temperature $T_C \sim 270\text{K}$ and an unusual spin-reorientation transition near $T_{SR} \sim 120\text{K}$. Transport experiments reveal two electronic transitions near T_{SR} and $T_Q \sim 40\text{-}50\text{K}$ marked by sign reversal in Hall effect and magnetoresistance. ESR study further quantifies the non-trivial temperature evolution of magnetic anisotropy, with characteristic temperatures coinciding with those found in transport studies, indicating strong magneto-electronic coupling relevant for spintronic applications.

TT 80: Focus Session: High-Temperature Superconductivity in Hydride Materials at High Pressures (joint session TT/DS)

Superconductors with record transition temperatures up to 250 K have been discovered and confirmed in hydride materials at high pressures over the last decade, enabled by major advances in both computational and experimental approaches. Density functional theory, combined with structure search algorithms and machine learning methods, enables high-throughput predictions of novel high-pressure phases. Ab initio microscopic theories, including Eliashberg theory and superconducting density functional theory, successfully predict transition temperatures of identified phases, with several predictions now confirmed experimentally. The synthesis of novel hydrides has revealed the importance of including hydrogen quantum fluctuations in theoretical predictions. Experimentally, advances in high-pressure synthesis techniques have enabled the preparation of novel hydride phases, while electrical transport measurements, tunneling spectroscopy, and magnetic studies have established a strong body of evidence for superconductivity by probing zero resistance, the superconducting gap, and magnetic response. This focus session will emphasize these breakthroughs, highlight ongoing challenges in both experiment and computation, and provide an outlook for finding high-temperature superconductors at lower and ambient pressures.

Coordinators: Philipp Gegenwart (Universität Augsburg), Matthias Vojta (TU Dresden)

Time: Thursday 15:00–18:45

Location: HSZ/0003

Topical Talk TT 80.1 Thu 15:00 HSZ/0003
Computational searches for conventional high temperature superconductivity — ●CHRIS PICKARD — University of Cambridge

First principles methods for the prediction of the structure of materials have delivered a powerful tool for generating candidate structures for comparison with experimental analytical methods. Early studies focused on the exotic properties and structures of relatively simple systems, typically the elements and binary compounds. The promise of discovering materials with extreme properties relies on the ability of screen a wide variety of compounds.[1] I will reflect on why ab initio random structure searching (AIRSS) is particularly suited to these challenges, focussing on the dramatic acceleration that ephemeral data derived potentials (EDDPs) afford,[2] and their role in the uncovering of Mg_2IrH_6 as a feasible ambient pressure high temperature superconductor.[3]

[1] A.M.Shipley, M.J.Hutcheon, R.J.Needs, Ch.J.Pickard, Phys. Rev. B 104, 054501 (2021)

[2] Ch.J.Pickard, Phys. Rev. B 106, 014102 (2022)

[3] K.Dolui, L.J.Conway, Ch.Heil, T.A.Strobel, R.Prasankumar, Ch.J.Pickard, Phys. Rev. Lett. 132, 166001 (2024)

Topical Talk TT 80.2 Thu 15:30 HSZ/0003
High-pressure synthesis of hydrides and their characterisation by single-crystal X-ray diffraction — ●NATALIA DUBROVINSKAIA¹ and LEONID DUBROVINSKY² — ¹Material Physics, University of Bayreuth; Bayreuth, Germany — ²Bayerisches Geoinstitut, University of Bayreuth, Germany

The sulfur-hydrogen, lanthanum-hydrogen, and yttrium-hydrogen systems have attracted significant interest following reports of near-ambient-temperature superconductivity in some of their high-pressure phases. Here, we present single-crystal X-ray diffraction studies of these systems, supported by density functional theory calculations, which reveal an unexpected chemical and structural diversity in S, La, and Y hydrides synthesised at 50–200 GPa. Syntheses were carried out in diamond anvil cells by laser heating S, La, LaH₃, or Y together with hydrogen-rich precursors-ammonia borane or paraffin oil. The arrangements of heavy atoms in newly formed phases were determined from SCXRD data, while hydrogen contents were estimated using empirical relationships and ab initio calculations. Our study also uncovers the formation of previously unreported metal allotropes, carbides, and ternary compounds at high pressure. The complex phase diversity, variable hydrogen stoichiometries, and metallic nature of these high-pressure hydrides, as revealed by theory, highlight the challenges in identifying the superconducting phases and understanding electronic transitions in materials synthesised under extreme conditions.

Topical Talk TT 80.3 Thu 16:00 HSZ/0003
Electrical Transport Studies in bulk and thin-film hydride high-temperature superconductors — ●SVEN FRIEDEMANN¹, SAM CROSS¹, OWEN MOULDING¹, ISRAEL OSMOND¹, XIAOJIAO LIU², ANNETTE KLEPPE², OLIVER LORD³, and JONATHAN BUHOT¹ — ¹HH Wills Physics Laboratory, University of Bristol, UK — ²Diamond Light Source Ltd., Didcot, UK — ³School of Earth Sciences, University of Bristol, UK

Superconductivity is not restricted to low temperatures! Indeed, transition temperatures up to 260 K have been demonstrated by multiple groups in H_3S , LaH_{10} , and YH_9 , at very high pressures. This is a success story of both theory and experiment. Theory has mastered accurate predictions of new superconductors and has been crucial to guide experimental efforts. Experiments have mastered many technical challenges. Together, these efforts open pathways to realise higher transition temperature at low pressures.

We present combined structural and electrical transport studies of hydride high- T_c superconductors based on our development of *in situ* synthesis, x-ray diffraction, and transport measurements in diamond-anvil pressures cells including thin-film methods for electrodes and superconducting samples. We present the characterisation of clean-limit superconductivity in H_3S and the discovery of the new superconductor La_4H_{23} . We demonstrate superconductivity in thin films of LaH_{10} with a $T_c = 250$ K consistent with bulk LaH_{10} . Our results open new avenues to study hydride high- T_c superconductors with thin-film methods.

15 min. break

Topical Talk

TT 80.4 Thu 16:45 HSZ/0003

Near room-temperature conventional superconductivity in hydrogen-rich compounds at high pressures: Experimental evidences — ●VASILY MINKOV — Max Planck Institute for Chemistry, Mainz, Germany

The pioneering discovery of superconductivity in hydrogen sulfide (H_3S) with a record T_c of 203 K at 150 GPa by M. Erements et al. had a profound impact on the field. It validated the concept of high- T_c conventional superconductivity in hydrides and triggered an intense wave of research. Subsequent studies revealed that other hydrides - such as LaH_{10} and YH_9 - exhibit T_c values approaching 250 K, bringing the field closer than ever to room-temperature superconductivity. Despite the experimental challenges associated with micrometer-sized samples confined in diamond anvil cells, superconductivity in these compounds has been demonstrated using multiple independent techniques. Electrical four-probe measurements provide clear resistive transitions, while recent advances in high-pressure magnetometry enable direct detection of magnetic field screening and flux expulsion. We have further developed a method to probe trapped magnetic flux in hydrides at high pressure. The distinct behavior of trapped flux generated under ZFC and FC conditions provides strong evidence for superconductivity. Furthermore, the recent adaptation of electron tunneling spectroscopy to extreme pressures offers microscopic insight into the pairing mechanism and enables direct characterization of the superconducting gap structure in the high-temperature hydride superconductors.

Topical Talk

TT 80.5 Thu 17:15 HSZ/0003

Predictive T_c Calculations in Hydride Superconductors — ●CHRISTOPH HEIL — Institute of Theoretical and Computational Physics, Graz University of Technology, Graz, Austria

The discovery of high- T_c superconductivity in compressed hydrides has sparked a surge of theoretical predictions, yet reported critical temperatures for identical structures can differ by tens of Kelvin or more. These discrepancies reflect differences in how lattice dynamics, electronic structure, and Coulomb repulsion are treated. In this talk, we will present first-principles workflows designed to make T_c calculations both more transparent and more predictive.

We combine anharmonic lattice dynamics with full-bandwidth isotropic and anisotropic Migdal-Eliashberg calculations (IsoME and EPW) that retain the full electronic density of states, and we incorporate Coulomb repulsion via screened interactions obtained from first principles rather than an empirical μ^* . This framework allows us to systematically compare different approximation levels and to quantify how each approximation affects T_c .

Using case studies from high-pressure hydrides, we will demonstrate when simplified treatments remain adequate and when anharmonic effects, full-bandwidth electrons, and first-principle determination of Coulomb screening become essential for quantitative accuracy. I will provide practical guidelines for reliable, reproducible T_c predictions and discuss how rigorous superconductivity calculations complement crystal-structure prediction efforts in the search for new superconductors.

TT 80.6 Thu 17:45 HSZ/0003

^1H -NMR investigations of bulk superconductivity in superhydrides using Lenz lenses — ●F. BÄRTL^{1,2}, D. ZHOU³,

T. HELM¹, S. LUTHER¹, H. KÜHNE¹, J. WOSNITZA^{1,2}, and D. SEMENOK³ — ¹HLD-EMFL, HZDR, Dresden — ²IFMP, TUD, Dresden — ³HPSTAR, Beijing

The discovery of near-room-temperature superconductivity at ultra-high pressures in superhydrides has kindled intensive research activities in the past years. However, the need to use diamond-anvil cells (DACs) for the synthesis and study of such superconductors limits the number of available experimental techniques. Nuclear magnetic resonance (NMR) spectroscopy is a key technique to study the bulk properties of superconducting materials, but it usually requires sample masses of several milligrams. Here, we present our ^1H NMR measurements of several superhydride preparations, using Lenz lenses, which act as magnetic-flux transformers in the NMR experiment and enable the investigation of samples with masses in the microgram range in the sample chamber of DACs. We observe several features that evidence the bulk nature of the superconducting transition in the superhydrides, the most prominent being the suppression of the ^1H nuclear spin-lattice relaxation rate $1/T_1 T \propto D(E_F)^2$. Furthermore, we report on the systematic occurrence of a rate enhancement in the regime of the superconducting transition, which is reminiscent of a Hebel-Slichter-like peak.

TT 80.7 Thu 18:00 HSZ/0003

Above-room-temperature superconductivity in substituted LaH_x superhydride — ●STANLEY TOZER and AUDREY GROCKOWIAK — Leibniz-Institut für Festkörper- und Werkstofforschung Dresden, 01069 Dresden, Germany

We have synthesized a higher order La-based superhydride with initial superconducting transition temperature of 294 K that, when heated, morphed into a higher order system with a T_c^{onset} of 556 K and a transition width of approximately 120 K [1]. The x-ray and the electrical transport data support one another with regard to the pressure measured, and the inhomogeneous nature of the synthesis that resulted in a substituted higher order La-based superhydride in close proximity to FIBed electrodes with a broad multi-phase, irreversible transition and non-zero background resistance below T_c . The electric leads embedded in our 'crucible' probe a pathway through this inhomogeneous growth, a very small portion of which is the superconductor of interest. We have used informed growth to reproduce the initial result in a range of pressures lower than allowed for the binary LaH_{10} . A multi-probe approach is being implemented to address growth-to-growth variations and follow the transformation of the initial 294 K superconductor. This will provide an understanding of this new class of superconductor that begs the question as to the upper limit of superconductivity in the superhydrides and whether BCS theory can describe them.

[1] A.D. Grockowiak et al., Electronic Materials 2, (2022)

[2] doi.org/10.3389/femat.2022.837651

TT 80.8 Thu 18:15 HSZ/0003

Search for Room-temperature Superconductivity in the La-Sc-H System — ●DMITRII V. SEMENOK¹, IVAN A. TROYAN², DI ZHOU¹, and VIKTOR V. STRUZHKIN^{1,3} — ¹Center for High Pressure Science & Technology Advanced Research, Bldg. 8E, 10 Xibeiwang East Rd, Beijing, 100193, China — ²private — ³Center for High Pressure Science & Technology Advanced Research, 1690 Cailun Rd, Bldg 6, Shanghai 201203, China

One of the highlights of 2025 in the field of hydride superconductivity was the announcement of the experimental discovery of room-temperature superconductivity in the fully ordered ternary polyhydride $\text{P6}/\text{mmm-LaSc}_2\text{H}_{24}$ at around 260 GPa [1]. We performed a DFT analysis of intermetallic compound formation in the La-Sc system with a view to modifying the synthetic procedure, and calculated parameters of the superconducting state of the isostructural $\text{P6}/\text{mmm-La}_3\text{H}_{24}$ and $\text{P6}/\text{mmm-Sc}_3\text{H}_{24}$ at 300 GPa. Attempts to experimentally reproduce the synthesis of $\text{LaSc}_2\text{H}_{24}$ from the LaSc_2 alloy (with a careful selection of the homogeneity region of this alloy's composition) at 264-280 GPa have not yet resulted in the detection of any traces of superconductivity between 255 K and 295 K in the corresponding hydride. In my report, I will show the results of additional experimental attempts to reproduce [1], planned for January-February 2026.

[1] Y. Song et al., arXiv: 2510.01273 (2025).

TT 80.9 Thu 18:30 HSZ/0003

Computational modeling of disordered hydride superconductors — ●PEDRO NUNES FERREIRA¹, LUIZ TADEU FERNANDES ELEN², and CHRISTOPH HEIL¹ — ¹Institute of Theoretical and Computational Physics, Graz University of Technology, NAWI Graz, 8010,

Graz, Austria — ²Departamento de Engenharia de Materiais, Escola de Engenharia de Lorena, Universidade de São Paulo, Lorena, Brazil

Designing and optimizing novel hydride superconductors requires methods that accurately treat realistic chemical disorder. In this talk, I will present an ab initio thermodynamic framework, the extended generalized quasichemical approximation (EGQCA), tailored to the modeling of superconducting alloys, especially high- T_c superhydrides. EGQCA enables the prediction of any computationally accessible prop-

erty, such as T_c and electron-phonon coupling, as a function of composition using only a small set of supercell calculations, making it particularly well suited for complex hydrogen-rich materials. I will illustrate its capabilities with applications to high- T_c superhydrides at high pressure, as well as defective hydrides stabilized at ambient pressure. Finally, I will discuss how EGQCA opens the door to high-throughput design and screening of disordered superconductors, with the potential to significantly advance hydride superconductivity research.

TT 81: Correlated Electrons: Other Materials

Time: Thursday 15:00–17:15

Location: HSZ/0101

TT 81.1 Thu 15:00 HSZ/0101

Built-in Electric-Field-Driven Rashba Spin-Orbit Interactions in $\text{AlO}_x/\text{Sr}_{1-x}\text{Ca}_x\text{TiO}_3$ Interfaces — ●JANINE GÜCKELHORN¹, SERGI PLANA-RUIZ^{2,3}, GYANENDRA SINGH¹, SAUL ESTANDIA RODRIGUEZ¹, ROGER GUZMAN¹, FERNANDO GALLEGOS⁴, LUIS M. VICENTE-ARCHE⁴, JOAQUIM PORTILLO⁵, THANOS GALANIS⁵, MANUEL BIBES⁴, JAUME GÁZQUEZ¹, and GERVAZI HERRANZ¹ — ¹Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra, Spain. — ²Scientific & Technical Resources, Universitat Rovira i Virgili, Tarragona, Spain. — ³LENS-MIND, Department of Electronics and Biomedical Engineering, Universitat de Barcelona, Spain. — ⁴Laboratoire Albert Fert, CNRS, Thales, Université Paris Saclay, France. — ⁵NanoMEGAS SPRL, Brussels, Belgium.

Two-dimensional electron gases (2DEGs) at oxide interfaces exhibit strong Rashba spin-orbit coupling (SOC), arising from broken inversion symmetry and the resulting built-in electric field. However, the microscopic origin of Rashba SOC remains under debate. Density functional theory points to two key mechanisms as origin: polar lattice displacements and electric-field-driven orbital polarization. We show that the Rashba coefficient in $\text{AlO}_x/\text{Sr}_{1-x}\text{Ca}_x\text{TiO}_3$ 2DEGs increases significantly with Ca substitution, which enhances polarizability and induces ferroelectricity. Separating lattice and electrostatic effects reveals that modest structural changes accompany a near-tenfold rise in the built-in field. Our results demonstrate that nonlinear polarizability, not just structural asymmetry, dictates Rashba SOC strength, establishing polarizability as a key control of SOC in oxide 2DEGs.

TT 81.2 Thu 15:15 HSZ/0101

Non-quasiparticle states at a ferromagnetic oxide interface — DYLAN JONES^{1,2}, ANDREAS ÖSTLIN^{1,2}, and ●LIVIU CHIONCEL^{1,2} — ¹Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — ²Augsburg Center for Innovative Technologies, University of Augsburg, 86135 Augsburg, Germany

We propose a minimal tight-binding model for the electronic interface layer of the $\text{LaAlO}_3/\text{SrTiO}_3$ heterostructure with oxygen vacancies. In this model, the effective carriers are subject to oxygen vacancy-induced magnetic impurities. Both the effects of random on-site potentials and Zeeman-like exchange interactions between correlated carriers and magnetic impurities are taken into account. By applying the combined coherent potential approximation (CPA) and dynamical mean field theory (DMFT) for a ferromagnetic state, we analyze how magnetic impurities generate incoherent non-quasiparticle spectral weight near the Fermi level and introduce a low-energy scale that is expected to be relevant for electronic transport at the interface.

TT 81.3 Thu 15:30 HSZ/0101

Transport properties of the metal to insulator transition in Ca_2RuO_4 nanoflakes — ●ROMAN HARTMANN¹, ROSALBA FITTIPALDI³, ANTONIO VECCHIONE³, ELKE SCHEER¹, and ANGELO DI BERNARDO^{1,2} — ¹FB Physik, Universität Konstanz, Konstanz, Germany — ²Dipartimento di Fisica, Università di Salerno, Fisciano, Italy — ³CNR-Spin, Salerno, Italy

The Mott insulator calcium ruthenate Ca_2RuO_4 (CRO) has attracted considerable attention due to its insulator to metal transition (IMT) with a transition temperature of 357 K (insulating below, metallic above) and the ability to trigger the IMT using pressure, current or an electric field of just 40 V/cm [1,2]. Unfortunately, stress from a structural transition (orthorhombic to tetragonal) during the IMT combined with an increase in unit cell volume [1] generally breaks bulk crystals.

To overcome this limitation we have developed a method to fabricate

sub-micron CRO flakes from bulk single crystals (despite it not being a layered material) that we can contact using standard lithographic and thin film techniques.

In these flakes we can reversibly trigger the IMT thousands of times by passing current without breaking the sample. The robustness of the devices enables us to switch at high frequencies paving the way for potential applications and enabling us to gain further insight into the nature of the IMT [3].

[1] F. Nakamura et al., Sci. Rep. 3, 2536 (2013)

[2] R. Okazaki et al., JPSJ 82, 103702 (2013)

[3] V. K. Bhartiya et. al., arXiv:2504.17871 (2025)

TT 81.4 Thu 15:45 HSZ/0101

Many body effects in Li-ion cathode materials: how Coulomb interactions drive the redox profile — ●FRANCESCO CASSOL and SILKE BIERMANN — CPHT, Ecole Polytechnique, Palaiseau, France

In the last decades, a rising demand for energy storage has spurred consistent efforts into the design of high energy density cathode materials.

Crystallizing in layered structures, these compounds alternate lithium and transition-metal oxide planes, facilitating Li mobility during charge and discharge. Most of the battery properties are intimately related to the electronic structure, which governs the cyclic charge redistribution via oxidation and reduction of transition metal ions.

In this talk, we investigate the effects of Coulomb interactions on the corresponding redox mechanism upon delithiation, focusing on complex Li-based alloys studied within the dynamical mean-field theory (DMFT). Our results reconcile the charge profile with experiments and emphasize the importance of many-body effects for an accurate description of battery compounds.

15 min. break

TT 81.5 Thu 16:15 HSZ/0101

Separating magnetic bulk and surface properties of Czochralski-grown FeSi — ●GILLES GÖDECKE¹, PHILIPP HERRE¹, MARKUS ETZKORN^{2,3}, MUSFIRA AQEEL^{2,3}, ALEXANDER FRANTZ⁴, DIRK BAABE⁴, STEFAN SÜLOW¹, and DIRK MENZEL^{1,2} — ¹Institut für Physik der Kondensierten Materie, TU Braunschweig, Germany — ²Laboratory for Emerging Nanometrology, TU Braunschweig, Germany — ³Institut für Angewandte Physik, TU Braunschweig, Germany — ⁴Institut für Anorganische und Analytische Chemie, TU Braunschweig, Germany

The narrow-gap semiconductor FeSi has been extensively discussed regarding its low-temperature electronic transport and magnetic properties, ranging from Kondo-insulating behavior to the emergence of conducting and magnetic surface states. We present resistivity measurements on FeSi single crystals grown by the Czochralski method. To separate bulk and surface contributions, the sample thickness is continuously decreased by polishing. In addition, we conduct magnetization measurements of FeSi powder samples with decreasing grain sizes prepared by ball milling. The increase of the surface-to-volume ratio leads to enhanced surface contributions in the conductivity and magnetization. The results enable us to distinguish between the electrical and magnetic bulk and surface contributions and further estimate the dimensions of the surface states.

TT 81.6 Thu 16:30 HSZ/0101

Flat phonons in Eu_2AuGe_3 — ●ALEKSANDR SUKHANOV¹, OLEG UTESOV², ARTEM KORSHUNOV³, VINICIUS FREHSE¹, and MAREIN RAHN¹ — ¹Experimental Physics VI, Center for Electronic Correla-

tions and Magnetism, University of Augsburg, 86159 Augsburg, Germany — ²Center for Theoretical Physics of Complex Systems, Institute for Basic Science (IBS), Daejeon, Korea, 34126 — ³Donostia International Physics Center (DIPC), Paseo Manuel de Lardizabal, 20018 San Sebastian, Spain

We employed inelastic x-ray scattering (IXS) to study the lattice dynamics in a single crystal of Eu_2AuGe_3 (orthorhombic, space group $Fmmm$). Within its crystal structure, a structural motif consisting of one Au atom and three Ge atoms plays a special role. Its atomic displacements can be effectively mapped out to the well known electronic cross-stitch model, which is a toy model for the electronic flat bands. We show that the same simple model can be applied to predict a flat phonon mode in Eu_2AuGe_3 . In our experimental IXS spectra, we resolve the flat mode and show that it softens on cooling and leads to a charge density wave transition. Our first-principle calculations of the lattice dynamics further support the experimental findings.

TT 81.7 Thu 16:45 HSZ/0101

Tuning through a tetragonal collapse in $\text{Ca}_{1-x}\text{Sr}_x\text{Co}_2\text{As}_2$ single crystals investigated by thermal expansion — ●SVEN GRAUS¹, ADRIAN VALADKHANI², N. S. SANGEETHA¹, MARKUS GARST³, ROSER VALENTI², ANDREAS KREYSSIG¹, and ANNA E. BÖHMER¹ — ¹Experimental Physics IV, Ruhr University Bochum, Bochum, Germany — ²Institute for Theoretical Physics, Goethe University Frankfurt, Frankfurt am Main, Germany — ³Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

$\text{Ca}_{1-x}\text{Sr}_x\text{Co}_2\text{As}_2$ crystallizes in the tetragonal ThCr_2Si_2 -type structure and undergoes a rare substitution-driven crossover from a collapsed tetragonal to an uncollapsed tetragonal structure. The resulting rich magnetic and electronic phase diagram provides an interesting platform to investigate the complex interplay between lattice, magnetic and electronic degrees of freedom.

High-resolution thermal-expansion measurements reveal strong

anisotropy between in-plane and out-of-plane directions and identify a critical region near $x \approx 0.48$, where the thermal expansion coefficients α_a/T and α_c/T diverge at low temperatures. Analysis of the temperature dependence of the c/a ratio shows an accumulation of entropy in this region. The thermal-expansion behavior is well captured by a simple model of a pressure-tuned Van Hove singularity which is supported by density-functional theory calculations.

We acknowledge support from the Deutsche Forschungsgemeinschaft (DFG) under CRC/TRR 288 (Project A02).

TT 81.8 Thu 17:00 HSZ/0101

Synthesis of CsMn_2P_2 single crystals and study of their low temperature properties — ●MARTIN KOSTKA, ASHIWINI BALODHI, MATTHIAS KROLL, N. S. SANGEETHA, SVEN GRAUS, MAIK GOLOMBIEWSKI, ANDREAS KREYSSIG, and ANNA E. BÖHMER — Experimental Physics IV, Ruhr-University Bochum, Bochum, Germany

CsMn_2P_2 is an intriguing material because it exhibits unusual dynamic magnetic behavior not present in other AMn_2P_2 compounds, likely related to a mixed $\text{Mn}^{2+}/\text{Mn}^{3+}$ valence state and enhanced magnetic fluctuations [1]. However, the synthesis of CsMn_2P_2 single crystals is a challenge due to the high reactivity of Cs, the high vapor pressure of Cs and P, and the high melting point of Mn. We succeeded in optimizing the growth conditions for reproducible synthesis of ~ 1 mm sized CsMn_2P_2 single crystals by systematically studying various growth techniques. The resulting samples were characterized by x-ray diffraction, electron microscopy, energy-dispersive x-ray spectroscopy, and electrical-transport measurements. The electrical resistance shows multiple intriguing phase transitions. However, it is sample dependent and varies with synthesis parameters. A relation with the lattice parameter c is observed.

We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG) under CRC/TRR 288 (Project A02).

[1] F. Hummel, Magnetism and superconductivity in layered manganese and iron pnictides, Diss. LMU (2015)

TT 82: Cryogenic Detectors and Sensors

Time: Thursday 15:00–16:30

Location: HSZ/0103

TT 82.1 Thu 15:00 HSZ/0103

2D germanium-based micro-bolometers for quantum information readout — ●JULIUS WERNER, MARTINA TRAHMS, JOHANNES HÖFER, FREDERIC GUSTAVO, JEAN-LUC THOMASSIN, CLEMENS WINKELMANN, and BORIS BRUN — Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Pheliqs, Grenoble, France

We develop and investigate micron-scale bolometers based on a two-dimensional hole gas (2DHG) in a Ge/SiGe semiconducting heterostructure. Such devices have promising applications for quantum sensing and the readout of quantum communication signals. The high-transparency interfaces formed between germanium and superconducting aluminum leads allow using the proximity Josephson effect in the 2DHG for thermometry, which is sensitive down to 50 mK. To enable time-resolved thermometry and bolometry with MHz-bandwidth operation, the Josephson inductance is read out via its contribution to a radio-frequency resonant circuit. We present a full thermal balance investigation of the 2DHG-based bolometer at millikelvin temperatures, allowing us to determine the thermal equilibration mechanisms at play and showcase the potential of the Ge 2DHG for quantum heat-detector applications.

TT 82.2 Thu 15:15 HSZ/0103

High-Resolution Spectroscopy of Muon Induced X-ray Emission on a Prehistoric Human Tooth using Metallic Magnetic Calorimeters — ●HENDRIK HADENFELDT, ANDREAS ABELN, DANIEL HENGSTLER, DANIEL KREUZBERGER, ANDREAS REIFENBERG, DANIEL UNGER, ANDREAS FLEISCHMANN, LOREDANA GASTALDO, and CHRISTIAN ENSS — Kirchhoff-Institute for Physics, Heidelberg University, Germany

High-resolution X-ray spectroscopy of muonic atoms provides a powerful tool for probing nuclear and elemental properties. Muon-induced X-ray emission (MIXE), developed at the Paul-Scherrer-Institute (PSI), enables non-destructive elemental analysis. Using metallic magnetic calorimeters (MMCs), we aim to improve the precision of MIXE measurements of light muonic atoms. MMCs are low-temperature photon

detectors operated at a few tens of mK. When a photon is absorbed, its energy causes an increase in the temperature of the absorber. This temperature increase leads to a change in magnetization of a paramagnetic Ag:Er sensor, which is then read out by SQUID magnetometers. In this talk, a newly developed MMC detector setup for high-resolution muonic X-ray spectroscopy used during beamtime at PSI is presented. The detector achieved an unprecedented energy resolution of better than 50 eV full width at half maximum (FWHM) at photon energies around 120 keV. Data collected during measurements performed on a prehistoric human tooth have been analyzed to demonstrate the applicability of this detector technology to non-destructive elemental analysis.

TT 82.3 Thu 15:30 HSZ/0103

High resolution measurement of the ^{65}Zn spectrum with magnetic microcalorimeters (MMCs) — ●MICHAEL PAULSEN¹, PHILIPP RANITZSCH^{2,3}, JÖRN BEYER¹, ALEXANDER GÖGGMANN², SEBASTIAN KEMPF^{4,5}, KARSTEN KOSSERT², OLE NÄHLE², CONSTANTIN SCHUSTER^{1,2}, MARIA SIDOROVA^{1,2}, and MATHIAS WEGNER^{5,4} — ¹Physikalisch-Technische Bundesanstalt (PTB) Berlin — ²PTB Braunschweig — ³DLR e.V., Hamburg — ⁴IMS, Karlsruhe Institute of Technology (KIT) — ⁵IPE, KIT

MMCs have proven to be among the best spectrometers for beta transitions and electron capturing (EC) radionuclides. To achieve a high energy resolution, the sensor and absorber heat capacities are kept as low as possible. Thus, the absorber dimensions are very small, yet simultaneously large enough to ensure that a sufficient detection efficiency is achieved. This is challenging when studying EC radionuclides, such as ^{65}Zn since the emission energies range from 0 to over 1 MeV for high-intensity gamma rays. We present a high-resolution spectrum of ^{65}Zn featuring K , L and M peaks below 10 keV. For the β^+ branch ($E_{\text{max}} = 329.9$ keV), additional complications arise. Each emitted positron typically annihilates with an electron in the absorber and generates gamma rays with a combined energy of 1022 keV. These additional events cannot be time resolved by the detector due to the

very short lifetimes of the positrons (~ 100 ps). This yields a distorted beta spectrum with a substantial number of counts above E_{\max} . We consider how this relates to the issue of detector efficiency and how to unfold such spectra using Monte-Carlo based simulation methods.

TT 82.4 Thu 15:45 HSZ/0103

A novel dilution refrigerator based microwave impedance microscopy — •YIZHOU WEI and BERTHOLD JACK — The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

Microwave Impedance Microscopy (MIM) is an advanced imaging technique that offers remarkable sensitivity in detecting spatial variations of the electric conductivity with a spatial resolution of between 10 and 100 nanometers. This makes it a powerful tool for investigating 2D materials, especially in the context of topological and many-body physics of moiré materials. Despite its scientific potential, several technical challenges hinder the broader application of MIM for the study of quantum materials at cryogenic temperatures. Major issues are the pervasive noise introduced by dry cryogenic systems, particularly due to the pulse tube, and the thermalization of the microscopy module to temperatures below 100 mK. To address these challenges, we have designed and realized a novel MIM system that is both noise-resistant and capable of operating at ultra-low temperatures. In this talk, we will present key design considerations as well as first results from test measurements that validate the performance of our experimental setup.

We gratefully acknowledge funding by the Croucher Foundation (Grant No. CIA22SC02).

TT 82.5 Thu 16:00 HSZ/0103

Detecting single itinerant microwave photons by stroboscopic measurement — •HANNA ZELLER¹, LUKAS DANNER^{1,2}, MAX HOFHEINZ³, CIPRIAN PADURARIU¹, JOACHIM ANKERHOLD¹, and BJÖRN KUBALA^{1,2} — ¹ICQ and IQST, Ulm University, Ulm, Germany — ²German Aerospace Center (DLR), Institute of Quantum Technologies, Ulm, Germany — ³Institut Quantique, Université de Sherbrooke, Sherbrooke, Québec, Canada

Josephson-photonics devices have predominantly been used to create microwave radiation in a process where a Cooper pair tunneling across a dc-biased Josephson junction creates photonic excitations in a mi-

crowave cavity connected in series. In scenarios where incoming photons are required to enable Cooper pair transfer and trigger subsequent photon emission, their use as amplifiers [1] or single (microwave-) photon detectors [2] has also been investigated.

Here, we present a scheme utilizing a Josephson-photonics device with two cavities as a microwave detector of itinerant photons, where the Josephson-photonics effect implements a stroboscopic projective measurement. Using recently developed techniques to describe the incidence of generic traveling pulses of quantized radiation onto a quantum device [3,4], we optimize the device and find promising performance numbers.

[1] R. Albert, et al. Phys. Rev. X **14**, 011011 (2024).

[2] L. Danner et al., arXiv:2510.08030

[3] A. H. Kiilerich et al., Phys. Rev. Lett. **123**, 123604 (2019).

[4] A. H. Kiilerich et al., Phys. Rev. A **102**, 023717 (2020).

TT 82.6 Thu 16:15 HSZ/0103

Vortex Energy Barriers in Meandering Superconducting Nanowires: Controlling Jitter in SNSPDs via magnetic field and bias currents — •CARLOS ALBERTO DIAZ LOPEZ¹, JOACHIM ANKERHOLD¹, BJÖRN KUBALA^{1,2}, and CIPRIAN PADURARIU¹ — ¹Institute of Complex Quantum Systems, University of Ulm, Ulm, Germany — ²German Aerospace Center (DLR), Ulm, Germany

We present a theoretical and computational study of vortex dynamics in meandering superconducting nanowires (e.g., SNSPDs). Building upon established methods for computing vortex energies in non-conventional geometries, our work incorporates the effect of screening currents induced by an external magnetic field. We calculate the total Gibbs free energy landscape to determine sets of parameters (B_z , I_{bias}) to engineer a tunable energy barrier for vortex crossing events. We seek barriers high enough to suppress spontaneous vortex-crossing (the mechanism underlying dark counts and timing jitter) yet remain low enough to permit crossing upon localized perturbations (e.g., a hotspot following single-photon absorption).

This analytical approach is benchmarked against a heuristic approach via simulations of the generalized time-dependent Ginzburg-Landau (gTDGL), performed using the open-source package pyTDGL. Our findings offer a design principle for optimizing operating conditions of SNSPDs to achieve maximal timing resolution and dark-count suppression.

TT 83: Topology: Quantum Hall Systems

Time: Thursday 15:00–18:30

Location: HSZ/0105

TT 83.1 Thu 15:00 HSZ/0105

Many-body Euler topology — •AXEL FÜNFHAUS¹, TITUS NEUPERT², THILO KOPP³, and ROSER VALENTÍ¹ — ¹Goethe Uni Frankfurt, Frankfurt am Main, Germany — ²University of Zurich, Zurich, Switzerland — ³University of Augsburg, Augsburg, Germany

Chern insulators exhibit an anomalous nonzero Hall conductivity due to a spontaneous breaking of time-reversal symmetry. To identify non-trivial topology in their time-reversal symmetric many-body spectra, we identify many-body Euler numbers as a counterpart to many-body Chern numbers. Exemplarily, we perform calculations in a topological Hubbard model that can realize Chern and fractional Chern insulating phases. Furthermore, we lay out a classification scheme to realize different topological phases using symmetry indicators in analogy to topological band theory.

TT 83.2 Thu 15:15 HSZ/0105

Topological signatures in the electrostatics of Chern junctions — •ROBIN DURAND^{1,2}, PASCAL SIMON¹, and ION GARATE² — ¹Laboratoire de Physique des Solides, Université Paris-Saclay, CNRS, Orsay 91405, France — ²Département de physique, Institut quantique and Regroupement Québécois sur les Matériaux de Pointe, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1, Canada

Electrostatic control in topological materials is a key challenge for next-generation electronic and quantum devices. We investigate how topological properties, especially Berry curvature and Chern number, reshape electrostatic equilibrium in Chern-insulator junctions under magnetic field. We show that Berry curvature corrections to the modified Landau quantization significantly modify both the built-in potential and the intrinsic chemical-potential profile at the junction.

Using a Landau-level framework combined with a semiclassical expansion, we derive an analytical expression revealing that the built-in potential becomes directly governed by spectral asymmetry, and therefore by the Chern number on each side. Large-scale tight-binding simulations of the half-BHZ model validate this prediction quantitatively.

Our results show that topological properties can directly influence electrostatic profiles in Chern junctions. By linking the built-in potential to spectral asymmetry and Chern number, we reveal how Berry curvature affects charge redistribution and electrostatic equilibrium at topological interfaces.

TT 83.3 Thu 15:30 HSZ/0105

Non-Hermitian topology of transport in the quantum Hall phases in graphene — •RAGHAV CHATURVEDI^{1,2}, EWELINA M. HANKIEWICZ², JEROEN VAN DEN BRINK¹, and ION COSMA FULGA¹ — ¹Leibniz Institute for Solid State and Materials Research, IFW Dresden, Germany — ²Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-Universität Würzburg, Germany

Signatures of non-Hermitian topology can be realized in a conventional quantum Hall device connected to multiple current sources. These signatures manifest as robust current-voltage characteristics, dictated by the presence of a nontrivial, non-Hermitian topological invariant of the conductance matrix. Chiral edge states are believed to be responsible for this non-Hermitian response, similar to how they lead to a quantized Hall conductivity in the presence of a single current source. Here, we go beyond this paradigm, showing that multiterminal conductance matrices can exhibit non-Hermitian topological phase transitions that cannot be traced back to the presence and directionality of a boundary-localized chiral mode. By performing quantum transport simulations in the quantum Hall regime of graphene, we find

that when the chemical potential is swept across the zeroth Landau level, unavoidable device imperfections cause the appearance of an additional non-Hermitian phase of the conductance matrix. This highlights graphene as an ideal platform for the study of non-Hermitian topological phase transitions, and is a first step towards exploring how the geometry of quantum devices can be harnessed to produce robust, topologically-protected transport characteristics.

TT 83.4 Thu 15:45 HSZ/0105

Superconducting Beam Splitting of Quantum Hall Edge States for HOM Interference — ●MAXIME JAMOTTE¹, TOM MENEI¹, ALEXANDER ZYUZIN², MANOHAR KUMAR², and THOMAS L. SCHMIDT¹ — ¹University of Luxembourg, Luxembourg, Luxembourg — ²Aalto University, Aalto, Finland

Electron interferometers have proven to be important tools for characterizing the exchange statistics of quantum Hall edge states. Moreover, it has recently become possible to proximitize quantum Hall edge states using superconductors. This opens a new avenue for interferometers based on the particle-hole degree of freedom. We propose a Hong-Ou-Mandel interferometer in which an s-wave type-II superconductor is located between two graphene systems in a magnetic field, with chiral edge states serving as the interferometer arms. Local and crossed Andreev processes hybridize electron and hole edge excitations, producing delocalized electron-hole pairs. Using a microscopic tight-binding Bogoliubov-de Gennes model, we simulate the injection of subgap electrons and compute anti-bunching probabilities and current cross-correlations, revealing how normal and Andreev processes shape the interferometric signatures of this new hybrid geometry.

TT 83.5 Thu 16:00 HSZ/0105

Plasma mapping for the Moore-Read state in ideal Chern bands — ●QI HU¹, SARANYO MOITRA¹, INTI SODEMANN VILLADIEGO¹, and VICTOR GURARIE² — ¹Institut für Theoretische Physik, Universität Leipzig, 04103 Leipzig, Germany — ²Department of Physics, CB390, University of Colorado, Boulder, Colorado 80309, USA

We construct an improved short distance regularization of the plasma mapping for the Moore-Read fractional quantum Hall state and also extend it from Landau levels to Aharonov-Casher ideal Chern bands, which are relevant in moire materials. This allows us to map correlations of the Moore-Read wave-function onto those of a classical statistical plasma with two components which in addition are coupled to a non-uniform neutralizing background. We exploit this to understand not only the universal topological properties of the Moore-Read state but also other details of their correlation functions. We will discuss the possibility of a phase transition from the plasma into novel dielectric states that can occur when the effective magnetic field in the Chern band becomes increasingly non-uniform.

TT 83.6 Thu 16:15 HSZ/0105

Universal Transport Theory for Paired Fractional Quantum Hall States in the Quantum Point Contact Geometry — ●ESLAM AHMED¹, RYOI OHASHI², YUKIO TANAKA¹, and KENTARO NOMURA² — ¹Nagoya University, Nagoya, Japan — ²Kyushu University, Fukuoka, Japan

Even-denominator fractional quantum Hall (FQH) states can be viewed as topological superconductors of composite fermions, supporting a charged chiral mode and $|C|$ neutral Majorana modes set by the Chern number C . Distinguishing the many competing paired phases remains an open problem. We develop a unified theory of transport through a quantum point contact (QPC) for arbitrary C by analyzing quasiparticle and electron tunneling within the edge CFT $SO(|C|)_1 \otimes U(1)$. Using an instanton expansion, we show that strong quasiparticle tunneling is dual to weak electron tunneling for all even-denominator states. This duality yields universal scaling dimensions and identifies a stable insulating fixed point. The resulting transport exponents provide experimentally accessible signatures capable of distinguishing different paired FQH states.

TT 83.7 Thu 16:30 HSZ/0105

Quantum Hall Effect without Chern Bands — ●BENJAMIN MICHEN¹ and JAN CARL BUDICH^{1,2} — ¹TU Dresden, 01062 Dresden, Germany — ²MPIPKS, 01187 Dresden, Germany

The quantum Hall effect was originally observed in a two-dimensional electron gas forming Landau levels when exposed to a strong perpendicular magnetic field and was later generalized to Chern insulators

without net magnetization. In this talk, further extending the realm of the quantum Hall effect, we report on the robust occurrence of an integer quantized transverse conductance at the onset of disorder in a microscopic lattice model, all bands of which are topologically trivial (zero Chern number). We attribute this phenomenon to the energetic separation of nonquantized Berry fluxes within those bands. Adding disorder then nudges the system into a quantum Hall phase from an extended critical regime obtained by placing the Fermi energy within a broad window inside a trivial band. This natural integer-rounding mechanism manifests as the mobility-gap-induced quantization of a nonuniversal Hall conductance. Our results are corroborated by numerical transport simulations and the analysis of two complementary topological markers.

15 min. break

TT 83.8 Thu 17:00 HSZ/0105

Hollow Topological Matter and Dual Fractional Quantum Hall Effect — ●RAM MUMMAVARAPU and ROMAN-PASCAL RIWAR — Peter Gruenberg Institute, Theoretical Nanoelectronics, Forschungszentrum Juelich, D-52425 Juelich, Germany

The Integer Quantum Hall Effect (IQHE) at filling factor m and the Fractional Quantum Hall Effect (FQHE) at $1/m$ are commonly viewed as distinct phases of matter. We propose various chiral/non-chiral heterostructures that effectively pin m co-propagating IQHE edge states to a synchronised single mode. This setup thus realizes the Dual Fractional Quantum Hall Effect (DFQHE), a phase where fractionalization is reversed, that is, fundamental excitations retain integer electric charge but carry fractional magnetic flux. While the transconductance remains integer quantized, the edge correlations nonetheless exhibit anyonic power-law scaling. We show that this is a physical manifestation of Hollow Topological Matter: due to pinning, the edge no longer corresponds to the original physical bulk, but rather to a virtual bulk that may be bosonic or fermionic independent of the microscopic exchange statistics.

TT 83.9 Thu 17:15 HSZ/0105

Fractional Statistics in Anyon Colliders: A Keldysh-Instanton Approach — ●JULIAN KÄLBER, MATTHIAS THAMM, FELIX PUSTER, and BERND ROSENOW — Universität Leipzig

The observation of fractional statistics in fractional quantum Hall (FQH) systems remains a central goal of modern condensed-matter physics. In recent collider-type experiments, dilute anyon beams are injected through quantum point contacts (QPCs) into unbiased edges, and signatures of anyonic exchange statistics are extracted from current cross-correlations. A quantitative description of these experiments, however, requires an accurate treatment of the QPCs, which act as dynamical tunnelling gates and introduce non-equilibrium effects that are not captured by simple Poissonian models.

In this work we develop an approximation scheme that incorporates the QPC dynamics within the Keldysh formalism. From the full action we derive an effective tunnelling action and obtain real-time instanton solutions of the free chiral-edge theory. The resulting non-equilibrium prefactor for tunnelling-operator correlation functions has the same structure as the Poissonian averaging employed in dilute-beam models, it reproduces the correct long-time asymptotics, and naturally generates oscillatory short-time features absent in previous treatments. Using this formalism we calculate a generalized Fano factor for a balanced anyon collider. The predicted values agree with theoretical expectations and with experimental measurements in the limit of small QPC transparencies, and remain consistent with experimental results at finite transparencies.

TT 83.10 Thu 17:30 HSZ/0105

From hidden order to skyrmions: Quantum Hall states in an extended Hofstadter-Fermi-Hubbard model — FABIAN J. PAUW¹, ULRICH SCHOLLWÖCK¹, NATHAN GOLDMAN^{2,3}, SEBASTIAN PAECKEL¹, and ●FELIX A. PALM² — ¹LMU Munich & MCQST, Munich, Germany — ²Université Libre de Bruxelles, Brussels, Belgium — ³Laboratoire Kastler Brossel, Collège de France, Paris, France

The interplay between topology and strong interactions gives rise to a variety of exotic quantum phases, including fractional quantum Hall (FQH) states and their lattice analogs - fractional Chern insulators (FCIs). Such topologically ordered states host fractionalized excitations, which for spinful systems are often accompanied by ferromagnetism and skyrmions. Here, we study an extended Hofstadter-

Hubbard model of spinful fermions on a square lattice. Using DMRG simulations, we demonstrate the emergence of a spin-polarized 1/3-Laughlin-like FCI phase, characterized by a quantized many-body Chern number, a finite charge gap, and hidden off-diagonal long-range order. In contrast to systems at filling factor $\nu=1$, we do not find skyrmionic excitations upon doping, thereby disentangling spin physics and topological order. The diagnostic toolbox presented in this work, based on local densities, correlation functions, and spin-resolved observables, is directly applicable in quantum gas microscopy experiments. Our results open new pathways for experimental exploration of FCIs with spin textures in both ultracold atom and electronic systems.

TT 83.11 Thu 17:45 HSZ/0105

The fate of the Laughlin state in ideal Chern bands — ●SARANYO MOITRA and INTI SODEMANN VILLADIEGO — Universität Leipzig, Leipzig, Germany

Ideal Chern bands are believed to be crucial to realizing the recently discovered fractional quantum Hall states at zero magnetic field. However, the nature of even the most archetypical Laughlin states and its competition with other phases remains poorly understood in this setting. We rigorously demonstrate that the Laughlin wave-function in ideal Chern bands is unstable to a novel gapless dielectric phase. Even the celebrated filling 1/3 state crystallizes into a correlated phase with continuously tunable power-law exponents, and quasiparticles with fractional charges varying smoothly below $e/3$. Remarkably, this state remains gapless without spontaneous symmetry breaking, exemplifying a form of beyond-Goldstone gaplessness. Our results bridge the physics of fractional quantum Hall and Coulomb gases, and we will discuss potential implications of this finding for moiré materials and its possible connections to critical states in other settings.

TT 83.12 Thu 18:00 HSZ/0105

Parafermions emerging from spin-polarized $\nu = 2/3$ fractional quantum Hall state — ●STEFFEN BOLLMANN¹, ANDREAS HALLER², JUKKA I. VÄYRYNEN³, THOMAS L. SCHMIDT², and ELIO J. KÖNIG⁴ — ¹Max Planck Institute for Solid State Research, Stuttgart, Germany

— ²University of Luxembourg, Luxembourg — ³Purdue University, West Lafayette, Indiana, USA — ⁴University of Wisconsin*Madison, Madison, Wisconsin, USA

We study the theoretical realization of Z_3 parafermions in the spin-polarized $\nu = 2/3$ fractional quantum Hall (FQH) state, motivated by recent experimental advances in materials such as rhombohedral graphene or twisted MoTe₂. We discuss how parafermions can emerge in FQH-superconductor heterostructures, unlike earlier proposals that rely on spin-unpolarized systems. Disorder-induced backscattering of FQH edge states drives the system toward the Kane-Fisher-Polchinski fixed point, where the edge theory decouples into a charged mode carrying charge $2e/3$ and an electrically neutral mode. Inter-edge interactions in the neutral sector lead to a strong-coupling regime that gaps the neutral modes entirely. This reduction leaves an effective low-energy description governed by lattice parafermion modes.

TT 83.13 Thu 18:15 HSZ/0105

Quantized and nonquantized Hall response in topological Hatsugai-Kohmoto systems — ●THIBAUT DESORT, MARK OLIVER GOERBIG, and CORENTIN MORICE — Laboratoire de physique des solides, Université Paris-Saclay, Orsay, France

The Hall conductivity of insulators is well-known to be quantized, including in interacting systems [1]. The Hatsugai-Kohmoto (HK) interaction [2], a type of Hubbard model diagonal in reciprocal space, is now widely studied in the context of topology, owing to the fact that its eigenstates, eigenenergies and Green's functions can be computed exactly. Using the Kubo formula, it is possible to access the Hall conductivity which has, even in the presence of the HK interaction, been reported to be quantized because it coincides with a Chern number [3]. In this work, using Zeeman fields, we lift the many-body degeneracy induced by the Hatsugai-Kohmoto interaction in the topological Kane-Mele model. This selects specific states within the ground-state manifold that reveal a surprising non-quantized Hall response.

[1] Q. Niu, D. J. Thouless, Y.-S. Wu, Phys. Rev. B 31, 3372 (1985)

[2] Y. Hatsugai, M. Kohmoto, J. Phys. Soc. Jap. 61, 2056 (1992)

[3] P. Mai, B. E. Feldman, P. W. Phillips, Phys. Rev. 5, 013162 (2023)

TT 84: 2D Materials: Electronic structure, excitations, etc. III (joint session O/HL/TT)

Time: Thursday 15:00–17:45

Location: HSZ/0204

TT 84.1 Thu 15:00 HSZ/0204

Linearized augmented plane waves for low-dimensional materials — ●ANDRIS GULANS, ERNEST JANSONS, and JANIS UZULIS — University of Latvia, Riga, Latvia

We address the challenge of efficient yet highly precise density-functional theory calculations of low-dimensional materials and present a set of tools and algorithms specific to linearized augmented plane waves (LAPW) that is implemented in the electronic-structure code **exciting**. First, we discuss our iterative eigensolver compatible with local and hybrid functionals. It is an extension of Davidson's algorithm and does not require explicit Hamiltonian construction while overcoming difficulties associated with high condition numbers. The second important ingredient is the adaptively compressed exchange that represents the non-local (screened) Fock exchange via a low-rank approximation. This approach enables computational complexity as low as $O(N^3 \log N)$ floating-point operations (FLOPs) with N being the number of atoms. It is a novel feature in hybrid functional calculations using LAPW as the standard approaches require $O(N^4)$ FLOPs. Finally, we introduce a cylindrical cutoff for the Coulomb interaction for handling the $q = 0$ singularity.

TT 84.2 Thu 15:15 HSZ/0204

Graphene-Enabled Mott–Metal Transition in Silicon Dangling Bonds — ●NICLAS TILGNER¹, SIHEON RYEE², ZAMIN MAMIYEV¹, PHILIP SCHÄDLICH¹, CHRISTOPH TEGENKAMP¹, TIM O. WEHLING², and THOMAS SEYLLER¹ — ¹Institute of Physics, Chemnitz University of Technology, Germany — ²I. Institute of Theoretical Physics, University of Hamburg, Germany

Controlling emergent electronic phases in materials with strong Coulomb interactions remains a central challenge in condensed matter physics. Adatom lattices on semiconducting surfaces provide prototypical platforms for exploring such correlated phenomena. Recent

advances have facilitated the synthesis of 2D Mott insulators in proximity to graphene (N. Tilgner et al 2025 2D Mater. 12 045022). Here, we demonstrate that alkali adsorption on a graphene/Si/SiC(0001) heterostructure – where the Si layer hosts correlated dangling bonds – enables controlled charge transfer to the Mott insulator. Beyond a critical carrier concentration, we observe a sudden collapse of the Mott gap, indicating a transition to a correlated metallic phase. Our results point to a finite proximity coupling between the Mott layer and graphene, as recently suggested by a theoretical study (N. Witt et al 2025 arXiv:2503.03700), which gives rise to nonlocal dynamical screening beyond simple electrostatics and provides a natural pathway for the observed phase transition.

TT 84.3 Thu 15:30 HSZ/0204

From self-consistent DFT+DMFT to the two-particle level: Magnetic phase diagram of X:SiC(111) — ●LUKAS BONGARDT^{1,2}, NIKLAS ENDERLEIN³, GIORGIO SANGIOVANNI⁴, PHILIPP HANSMANN^{3,5}, and HENRI MENKE¹ — ¹Max Planck Computing and Data Facility — ²Technical University of Munich — ³FAU Erlangen — ⁴Universität Würzburg — ⁵University of Iceland, Reykjavík

Recently we have proposed a novel and versatile platform to realize a two-band Hubbard model with massless Dirac fermions and flat bands hosting strong correlations by depositing three different species of transition-metal adatoms on semiconductor surfaces (arXiv:2410.17165). Using state-of-the-art DFT+DMFT calculations we investigated the spectral properties of X:3C-SiC(111) ($X = \text{Ti, V, Cr}$). Due to the presence of well-defined Dirac cones and flat bands, indicating the potential for realizing topological and correlated phases, we identify transition-metal adatoms on SiC as a possible platform for exploring the interplay of correlations, topology, and magnetism in two-dimensional materials.

In this work, we explore the magnetic phase diagram of these sys-

tems within DMFT by calculating the generalized two-particle vertex and using it to solve the Bethe-Salpeter equation for the generalized susceptibility. This gives us a fully orbital-, spin-, and most importantly momentum-dependent susceptibility which carries the information about the ordering wave vector and is experimentally accessible through various techniques.

TT 84.4 Thu 15:45 HSZ/0204

Cr 3d Orbital Hybridization and Electronic Structure in the Layered Magnetic Semiconductor CrPS₄ — •LASSE STERNEMANN¹, DAVID MAXIMILIAN JANAS¹, RICHARD LEVEN¹, ESHAN BANERJEE², JONAH ELIAS NITSCHKE¹, MARCO MARINO¹, LEON BECKER³, AHMET CAN ADEMOGLU¹, FRITHJOF ANDERS¹, STEFAN TAPPERTZHOFFEN³, and MIRKO CINCHETTI¹ — ¹TU Dortmund University, Department of Physics, 44227 Dortmund, Germany — ²Department of Materials, Imperial College London, London, SW7 2AZ, United Kingdom — ³TU Dortmund University, Department of Electrical Engineering and Information Technology, 44227 Dortmund, Germany

Despite its promising spintronic and magneto-optical characteristics, the electronic band structure of the van der Waals magnetic semiconductor CrPS₄ is still unknown. Here, we report angle-resolved photoemission spectroscopy measurements of its band structure in the paramagnetic and antiferromagnetic phase, complemented by DFT+U calculations. Theoretical results reveal dominating Cr 3d and S 3p contributions to the valence band and a ligand-to-metal charge-transfer band gap. Crystal field split Cr 3d orbitals display distinct hybridization regimes with S 3p orbitals: t_{2g} orbitals are only weakly affected by hybridization, while e_g states experience a 4 eV anti-bonding/bonding splitting with S-mixing relaxing dipole selection rules, otherwise darkening optical *d-d* transitions. These findings establish the ground state electronic and orbital structure of CrPS₄ and provide essential benchmarks for understanding its optical and magnetic responses.

TT 84.5 Thu 16:00 HSZ/0204

Spectroscopic Investigation of the Ni Valence States in NiTe₂ — •TASSAPHON TIRASUTT¹, SHENG-HUAI CHEN¹, ALEXANDER C. KOMAREK¹, CHUN-FU CHANG¹, YU-CHIEH KU², PO-YU CHO³, CHUN SUM BRIAN PANG⁴, MIZUKI FURO⁵, NAOKI ITO⁵, ULRICH BURKHARDT¹, SIMONE G. ALTENDORF¹, ATSUSHI HARIKI⁵, and LIU HAO TJENG¹ — ¹Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ²National Yang Ming Chiao Tung University, Hsinchu, Taiwan — ³National Synchrotron Radiation Research Center, Hsinchu, Taiwan — ⁴The University of British Columbia, Vancouver, Canada — ⁵Osaka Metropolitan University, Osaka, Japan

Nickel-based transition metal compounds exhibit a wide range of properties arising from the strongly correlated *d* electrons. In this study, we investigate NiTe₂, a layered transition-metal dichalcogenide with reported type-II Dirac semimetallic properties. While its topological nature has been the focus of interest, the fundamental question of the properties of the Ni ions in NiTe₂ has rarely been discussed. We address this issue using soft X-ray core-level and valence-band photoelectron spectroscopy, as well as Ni-*L*_{2,3} absorption spectroscopy, combined with a theoretical approach using LDA+DMFT. Our findings provide insights into the Ni 3d occupation and degree of correlation of the Ni in a metallic ligand bath of the NiTe₂ system.

TT 84.6 Thu 16:15 HSZ/0204

TMDC surfaces as scattering targets in spin-polarization detectors: A case study of MoS₂ — •CHRISTOPH ANGRICK¹, ANNIKA HENRIKSEN¹, NICOLE EDOSA¹, ANDRE REIMANN¹, MORITZ EWERT^{2,3}, LARS BUSS^{2,3}, JENS FALTA³, JAN INGO FLEGE^{2,3}, and MARKUS DONATH¹ — ¹University of Münster, Germany — ²Brandenburg University of Technology Cottbus-Senftenberg, Germany — ³University of Bremen, Germany

Spin-polarization detectors are employed in photoemission experiments to reveal the spin texture of electronic states. One well-proven approach is based on the VLEED process, where the spin-dependent electron reflection from targets influenced by exchange and/or spin-orbit interaction is used. The suitability of a target must be investigated beforehand [1,2]. In this talk, a first impression of TMDC-based detectors is given [3]. The spin-dependent electron reflectivity of spin-orbit-influenced MoS₂ is measured over a wide range of incident energies and angles for the following samples: a single layer of MoS₂ on Au(111) and cleaved MoS₂ single-crystal surfaces. On the basis of the resulting maps for the electron reflectivity, Sherman function, and figure of merit, promising features of MoS₂ for use in spin-polarization

detection are discussed.

[1] Thiede *et al.*, Phys. Rev. Applied **1**, 054003 (2014).

[2] Angrick *et al.*, J. Phys.: Condens. Matter **33**, 115001 (2020).

[3] Angrick *et al.*, Phys. Rev. B, accepted for publication (2025).

TT 84.7 Thu 16:30 HSZ/0204

Efficient GW calculations for metals from an accurate ab initio polarizability: the case of doped MoS₂ monolayer — •GIACOMO SESTI¹, PINO D'AMICO¹, ALBERTO GUANDALINI², CLAUDIA CARDOSO¹, ANDREA FERRETTI¹, and DANIELE VARSANO¹ — ¹CNR-NANO, Modena, Italy — ²Università di Roma La Sapienza, Roma, Italy

Many-body perturbation theory in the GW approximation has proved very successful for the calculation of quasiparticle (QP) band structures of semiconductors. QP corrections are less significant in metals and are typically disregarded for the computational cost involved. Also, GW calculations of metals suffer of specific methodological challenges to properly treat the screening. This is typically solved under the addition of a Drude term, that however is inadequate at low dimensionalities¹. Further, even for metals, QP corrections become more relevant at lower dimensionalities.

Here, we present GW calculations of QPs for doped MoS₂ monolayer showing excellent agreement with experimental ARPES measurements². Such an unprecedented agreement has been possible thanks to the W-av method, which combines a Monte Carlo integration with interpolation approaches. This technique originally developed for 2D semiconductors³ is here extended to the metallic case.

1) Champagne *et al.* NanoLett. **23**, 10 (2023)

2) Liu *et al.* PRL. **122** (2019)

3) Guandalini *et al.*, npj Computational Materials, **9** (2023)

TT 84.8 Thu 16:45 HSZ/0204

Ultrafast Momentum Dependent Relaxation Dynamics in TbTe₃ — •FLORIAN DENIZER¹, NOAH MEYER^{2,3}, ANISHA SINGH³, IAN R. FISHER³, UWE BOVENSIEPEN¹, ZHI-XUN SHEN^{2,3}, and PATRICK S. KIRCHMANN² — ¹Fakultät für Physik, Universität Duisburg-Essen — ²Department of Physics, Applied Physics and Stanford Synchrotron Radiation Laboratory, Stanford University — ³Geballe Laboratory for Advanced Materials, Departments of Physics and Applied Physics, Stanford University

Rare-earth tritellurides (RTe₃) form charge density waves (CDW) due to electronic instabilities at the Fermi-surface, because of an anisotropy of the crystal lattice between the two major in-plane crystal axes *a* and *c*. Unoccupied electronic states can be populated by ultrafast laser excitation. Electronic relaxation and coherent vibrational modes including the amplitude mode have been investigated by time and angle resolved photoelectron spectroscopy (*tr*-ARPES). Among the manifold of laser-driven processes, the one that is responsible for the electronic instability has not yet been identified. With this objective in mind we perform a *tr*-ARPES experiment on TbTe₃ and investigate the momentum transfer along the *a*- and the *c*-axis as a function of excitation strength. At sufficiently low pump fluence below *F* = 0.3 mJ/cm² we identify (quasi-)elastic scattering in the vicinity of the Fermi surface. In the talk we will discuss isotropic defect-induced elastic scattering and directed quasi-elastic scattering determined by the nesting vector. Funding through the DFG within SFB 1242 and through the DOE is gratefully acknowledged.

TT 84.9 Thu 17:00 HSZ/0204

Unconventional Topological Superconductivity in CrCl₃/NbSe₂ heterostructures — •SOUVIK DAS¹, BENJAMIN ZHOU^{2,3}, ANSHUMAN PADHI¹, JING-RONG JI¹, NICLAS HEINSDORF^{2,3}, PRAJWAL RIGVEDI¹, TIANZHE CHEN¹, WEIBIN LI⁴, PIERLUIGI GARGIANI⁴, MANUEL VALVIDARES⁴, MARCEL FRANZ^{2,3}, BANABIR PAL¹, and STUART S.P. PARKIN¹ — ¹Max Planck Institute of Microstructure Physics, Halle, Germany — ²Quantum Matter Institute, University of British Columbia, Vancouver, Canada — ³Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada — ⁴ALBA Synchrotron Light Source, Barcelona, Spain

Topological p-wave superconductors can host non-Abelian particles useful for fault-tolerant quantum computing. Here we report experimental evidence of unconventional topological superconductivity in a heterostructure of monolayer, in-plane ferromagnetic CrCl₃ islands on superconducting NbSe₂. STM measurements show that, despite CrCl₃ being ferromagnetic, the interfacial superconducting gap is more robust against out-of-plane magnetic fields than the s-wave gap of NbSe₂, indicating unconventional pairing. We also find enhanced zero-energy

states along CrCl₃ island edges, consistent with the presence of edge modes. Theory suggests these features arise from an intrinsic helical p-wave state stabilized by interfacial Rashba spin-orbit coupling. This demonstrates a new route to create topological superconductivity via interface engineering.

TT 84.10 Thu 17:15 HSZ/0204

Structural and Electronic Properties of CrSBr Nanoribbons: Insights from First-Principles Calculations — •DANIIL KRUKLINSKII, MAHDI GHORBANI-ASL, and ARKADY KRASHENINNIKOV — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Experiments show that exfoliated CrSBr flakes naturally form nanoribbons along a specific crystallographic direction, and similar structures can be fabricated using an electron beam in the TEM as a cutting tool. Here, we employ density functional theory calculations to systematically investigate the stability as well as electronic and magnetic properties of CrSBr nanoribbons. Our results indicate that nanoribbons oriented along one of the two major crystallographic directions are the most stable under typical growth and exfoliation conditions and remain semiconducting, exhibiting pronounced electron-hole separation between the VBM and CBM. In contrast, nanoribbons in the perpendicular direction display a substantially reduced band gap due to strongly localized edge states. Both orientations retain strongly spin-polarized band-edge states near the Fermi level and show only a weak dependence of the band gap on ribbon width. Using *ab initio* molecular dynamics simulations, we further demonstrate that electron-beam irradiation with energies of at least 200 keV can facilitate the fabrication of nanoribbons directly from pristine monolayer CrSBr, favouring the formation of diagonal nanoribbons. These diagonal ribbons are metallic, in contrast to the monolayer, and host a high density of majority-spin

edge states, giving rise to pseudo-half-metallic transport.

TT 84.11 Thu 17:30 HSZ/0204

Band-selective coherent phonon-driven band renormalization in 1T-MoTe₂ — •CARL JENSEN¹, CHRISTOPHER EMEIS², STEPHAN JAUERNIK¹, PETRA HEIN¹, FABIO CARUSO², and MICHAEL BAUER^{1,3} — ¹Institute of Experimental and Applied Physics, Kiel University, 24098 Kiel, Germany — ²Institute of Theoretical Physics and Astrophysics, Kiel University, 24098 Kiel, Germany — ³Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, 24118 Kiel, Germany

Understanding the coupling between coherent phonons and the electronic system is crucial for controlling nonequilibrium properties in solids. Here, we investigate mode- and band-selective electron-phonon coupling in centrosymmetric 1T-MoTe₂ using time- and angle-resolved photoemission spectroscopy combined with frequency-domain analysis (FDARPES). Femtosecond near-infrared pulses excite coherent Ag-symmetric phonon modes at 2.34 THz, 3.34 THz, and 3.86 THz, which manifest as oscillatory modulations in photoemission intensity and binding energy across the valence bands. Pixel-wise Fourier analysis, based on a recently developed methodology [1], reveals pronounced band selectivity with distinct coupling strengths for different electronic states and phonon modes, enabling the evaluation of band-renormalization amplitudes in the few-meV range. *Ab initio* calculations using DFT/DFPT qualitatively reproduce the experimentally observed coupling patterns and relative trends, demonstrating the capability of combined experimental and theoretical approaches to resolve ultrafast electron-phonon interactions in quantum materials.

[1] N. Gauthier, H. Soifer, J.A. Sobota, H. Pfau, E. J. Sie, A. M. Lindenberg, Z.-X. Shen, P. S. Kirchmann, Rev. Sci. Instrum. 96 (2025)

TT 85: Superconductivity: Yu-Shiba-Rusinov and Andreev Physics

Time: Thursday 15:00–17:15

Location: CHE/0089

TT 85.1 Thu 15:00 CHE/0089

Tip-gated quantum phase transition via valence change in a single Yu-Shiba-Rusinov impurity — •XINGSEN CHEN¹, JUNYI ZHANG², and HAO ZHENG¹ — ¹Tsung-Dao Lee Institute, Shanghai Jiao Tong University, Shanghai, China — ²Johns Hopkins University, Baltimore, USA

We report the real-space visualization of a quantum phase transition driven by a valence change in a single magnetic impurity coupled to a superconductor. Using a scanning tunneling microscope on a proximitized Bi₂Te₃/NbSe₂ substrate, we employ tip-induced band bending to precisely gate the energy level of a single Fe-based impurity cluster across the Fermi energy.

This tuning induces the formation of Yu-Shiba-Rusinov states inside the superconducting gap. Their evolution and zero-energy crossing signal a quantum phase transition. By correlating the YSR state transition with a concurrent high-energy valence transition, we identify the mechanism as a single-electron valence change of the Fe impurity (Fe²⁺/Fe³⁺), rather than conventional Kondo screening. Theoretical modelling using a multi-orbital Anderson impurity model confirms that the transition is governed by resonant hybridization and charge fluctuations at the mixed-valence point.

Our work establishes tip-gating as a powerful method for in-situ control of atomic-scale quantum phases and reveals a distinct mechanism for quantum phase transitions in superconducting hybrids.

TT 85.2 Thu 15:15 CHE/0089

Rare-earth spin chains on superconducting Nb(110) surface — •YU WANG¹, ARTEM ODOBESKO¹, and MATTHIAS BODE^{1,2} — ¹Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — ²Wilhelm Conrad Röntgen-Center for Complex Material Systems (RCCM), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Coupled Yu-Shiba-Rusinov (YSR) states in 1D magnetic chains can yield topologically protected edge modes. While well explored for 3d transition metals, studies on 4f-shell rare-earth metals (REMs) remain scarce. Owing to their localized and shielded 4f orbitals, REMs such as Ce, Eu, Gd, Tb, and La provide a promising platform for weakly hybridized magnetic chains on superconductors.

We present a comparative study of YSR excitations in REM adatoms and chains on Nb(110). Building on previous Gd results [1-2], we extend the analysis to Tb and other REM chains along [110] and [001]. Spectra reveal orientation-dependent edge behavior: [110] chains host trivial end states, whereas [001] chains show zero-bias features consistent with non-trivial edge modes. The results highlight the impact of 4f magnetism on YSR band formation and topological superconductivity.

[1] Y. Wang *et al.*, arXiv:2506.19514 (2025)

[2] Y. Wang *et al.*, arXiv:2311.09742 (2023)

TT 85.3 Thu 15:30 CHE/0089

Yu-Shiba-Rusinov spectroscopy of triangular molecular trimer on superconducting surface — •VLADISLAV POKORNÝ¹, MARTIN ŽONDA², and CHAO LI^{3,4} — ¹FZU - Institute of Physics, Czech Academy of Sciences, Na Slovance 2, 182 00 Prague 8, Czech Republic — ²Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, 121 16 Prague 2, Czech Republic — ³Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland — ⁴Institute of Atom Manufacturing, Nanjing University, Suzhou 215163, China

We present a study of a molecular trimer constructed from tetrabromotetraazapyrene molecules deposited on a superconducting Pb(111) surface in a triangular geometry. Scanning tunneling spectroscopy reveals a pair of split Yu-Shiba-Rusinov (YSR) states within the superconducting gap as a result of the spinful nature of the molecules [1]. The system is described using a superconducting three-impurity Anderson model with a single superconducting bath. The model is solved using the numerical renormalization group technique, which provides a quantitative description of the experimental result, revealing the doublet nature of the ground state as a result of the intersite capacitive coupling and explains the behavior of the YSR states. We also briefly discuss the possible source of the peak splitting.

[1] C. Li *et al.*, arXiv:2508.05575 (2025).

TT 85.4 Thu 15:45 CHE/0089

Stochastic resonance realized with a superconducting magnetic impurity state — •PHILIPP MAIER¹, BJÖRN KUBALA^{1,2}, JOACHIM ANKERHOLD¹, and CIPRIAN PADURARIU¹ — ¹Institute for

Complex Quantum Systems and IQST, Ulm University — ²German Aerospace Center (DLR), Ulm

The phenomenon of stochastic resonance (SR) was originally studied in the context of climatic changes and has since been observed in a variety of classical and quantum systems. Here, we theoretically investigate the emergence of SR in superconducting junctions to infer the rates of quantum electronic tunneling processes [1, 2].

We focus on a system where one electrode hosts a Yu-Shiba-Rusinov (YSR) state – a discrete bound state within the superconducting gap induced by the magnetic exchange interaction between a magnetic impurity and its superconducting host.

Applying the framework of full counting statistics (FCS), we demonstrate that SR manifests as a reduction of the Fano factor and a resonance of the tunneling current. Crucially, the frequency of this resonance reveals information about the rate of microscopic electronic processes, such as the process responsible for quasiparticle-occupation parity breaking.

[1] M. Hänze et al., *Sci. Adv.* 7 (2021)

[2] T. Wagner et al., *Nat. Phys.* 15 (2019)

TT 85.5 Thu 16:00 CHE/0089

Analytical and ab-initio characterization of YSR-state binding energies under magnetic-moment misalignment — •ILIAS KLEPETSANIS^{1,2} and SAMIR LOUNIS³ — ¹Forschungszentrum Jülich & JARA, Germany — ²University of Duisburg-Essen and CENIDE, Germany — ³Martin-Luther University Halle-Wittenberg, Institut für Physik und Halle-Berlin-Regensburg Cluster of Excellence CCE Halle, Germany

Complex spin textures interfaced with superconducting surfaces give rise to a rich variety of phenomena, ranging from the emergence of intricate in-gap states –such as Yu-Shiba-Rusinov (YSR) states– to the realization of topological superconductivity hosting Majorana modes. At the core of these effects lie competing and intertwined interactions involving Cooper pairing, spin-spin coupling, and spin-orbit-driven mechanisms. In this work, we systematically and analytically identify how the binding energies of YSR states in atomic nanostructures depend on the orientation of their magnetic moments. We distinguish between different underlying mechanisms, including those that are independent of spin-orbit coupling (SOC) and those that arise from SOC-driven magnetic misalignment. Results obtained using an Anderson-impurity model coupled to the Bogoliubov-de Gennes (BdG) formalism are compared with both DFT-BdG calculations for Fe nanostructures on a superconducting BiAg₂ surface and available scanning tunnelling microscopy measurements.

– We acknowledge funding by the DFG (LO 1659/11-1; Cluster of Excellence Center for Chiral Electronics -EXC3112/1 -533767171).

15 min. break

TT 85.6 Thu 16:30 CHE/0089

Emergence of new zero modes bound to vortices in extended topological Josephson junctions — •ADRIAN REICH¹, KIRYL PIASOTSKI^{1,2}, and ALEXANDER SHNIRMAN^{1,2} — ¹Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany

We theoretically study planar Josephson junctions formed on the surface of a three-dimensional topological insulator (Fu-Kane proposal) and examine the experimentally relevant parameter regimes in which

the effective velocity of the emergent one-dimensional Majorana modes approaches zero. We show that the frequently employed Fu-Kane effective theory breaks down in this case. As parameters like the chemical potential or the width of the junction are tuned, instances of vanishing effective velocity mark the emergence of additional “Dirac cones” at zero energy and finite momentum. If the junction is subjected to an external magnetic field, Josephson vortices may then bind a number of zero modes in addition to the topological Majorana mode. The additional zero modes are “symmetry-protected” and can be lifted by a broken mirror symmetry (which is to be expected in realistic scenarios) as well as by an in-plane magnetization (or Zeeman field). We note that the ensuing presence of additional low-energy Andreev states can significantly contribute to measured quantities like the Josephson current or microwave absorption spectra.

TT 85.7 Thu 16:45 CHE/0089

Local Observation of Andreev Billiards in an In-Plane Magnetic Field — •JENS BREDE, ADRIAN GREICHGAUER, and YOICHI ANDO — University of Cologne

Quasiparticles in a normal metal can be confined by a surrounding superconductor through Andreev reflection at the N/S interface. For subgap energies, electrons are retroreflected as holes that retrace their paths, forming closed semiclassical trajectories. When their accumulated phase reaches 2π , these trajectories create Andreev bound states (ABS), observed as subgap features in the local density of states (LDOS). We probe these ABS using STM at 400 mK in the two-dimensional electron gas of the Cu(111) surface state, confined to quasi-rectangular islands by superconducting Nb. We observe a hard superconducting gap and, with increasing in-plane magnetic field, nearly periodic LDOS gap closings. The period scales roughly linearly with the island dimension perpendicular to the field direction. A simple model that incorporates the vector potential into the semiclassical trajectories qualitatively reproduces the experimental behavior.

TT 85.8 Thu 17:00 CHE/0089

Assessing effective models of double quantum dot Andreev molecules — •KACPER WRZEŚNIEWSKI¹, PETER ZALOM², TOMASZ TOMÁŠ NOVOTNÝ³, and IRENEUSZ WEYMANN¹ — ¹Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University in Poznań, Poland — ²Institute of Physics, Czech Academy of Sciences, Praha, Czech Republic — ³Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Praha, Czech Republic

We investigate the phase diagram of a parallel double-quantum-dot Andreev molecule, in which the two quantum dots are coupled to a common superconducting lead. Using the numerical renormalization group (NRG) method, we analyze the evolution of the ground state across a broad parameter space, including level detuning, superconducting gap size, lead couplings, and interdot hopping. The resulting phase diagrams exhibit singlet, doublet, and a relatively uncommon triplet ground state, the latter serving as a clear signature of strong lead-mediated interactions between the quantum dots.

To evaluate the reliability of simplified theoretical descriptions, we benchmark the applicability of several effective models, including the atomic limit and zero-bandwidth approximations. Our results reveal notable limitations of these approaches: with the exception of the extended zero-bandwidth approximation, the effective models fail to reproduce the triplet ground state. These findings provide valuable guidance for interpreting experimental data and for the design of superconducting devices based on quantum dots.

TT 86: Correlated Magnetism – Spin Liquids II

Time: Thursday 15:00–16:45

Location: CHE/0091

TT 86.1 Thu 15:00 CHE/0091

Classical spin liquids from frustrated Ising models in hyperbolic space — ●FABIAN KÖHLER¹, JOHANNA ERDMENGER², RÖDERICH MOESSNER³, and MATTHIAS VOJTA¹ — ¹Institut für Theoretische Physik und Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany — ²Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — ³Max-Planck-Institut für Physik komplexer Systeme and Würzburg-Dresden Cluster of Excellence ct.qmat, Nöthnitzer Str. 40, 01187 Dresden

Antiferromagnetic Ising models on frustrated lattices can realize classical spin liquids, with highly degenerate ground states and, possibly, fractionalized excitations and emergent gauge fields. Motivated by the recent interest in many-body system in negatively curved space, we study hyperbolic frustrated Ising models. Specifically, we consider nearest-neighbor Ising models on tessellations with odd-length loops in two-dimensional hyperbolic space. For finite systems with open boundaries we determine the ground-state degeneracy exactly, and we perform extensive finite-temperature Monte-Carlo simulations to obtain thermodynamic data as well as correlation functions. We show that the shape of the boundary, constituting an extensive part of the system, can be used to control low-energy states: Depending on the boundary, we find ordered or disordered ground states. Our results demonstrate how geometric frustration acts in curved space to produce classical spin liquids.

TT 86.2 Thu 15:15 CHE/0091

Unconventional Spin Dynamics and Supersolid Excitations in the Triangular-Lattice XXZ Model — ●RAFAEL ALVARO FLORES CALDERON¹, RÖDERICH MOESSNER², and FRANK POLLMANN¹ — ¹Department of Physics, Technical University of Munich, 85748 Garching, Germany — ²Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, D-01187 Dresden, Germany

Motivated by recent experiments, we investigate the spin-1/2 XXZ model on the triangular lattice with strong Ising anisotropy, combining large-scale numerical simulations and analytical methods to uncover unconventional spin dynamics at $T = 0$. First, we compute the dynamical spin structure factor using density matrix renormalization group (DMRG) simulations and find excellent agreement with inelastic neutron scattering data on the layered compound $\text{K}_2\text{Co}(\text{SeO}_3)_2$. The low-energy spectrum reveals a roton-like minimum at the M point, absent in linear spin-wave theory, accompanied by peak intensity and a broad continuum above it. Near the Γ point, we observe an approximately linear dispersion with vanishing spectral weight. Second, we compare multiple analytical frameworks that reproduce the observed features. Remarkably, a variational supersolid QDM wavefunction and the DMRG ground state exhibit nearly identical structure factors with pronounced transverse photon-like excitations. Together, our comprehensive theoretical and numerical analysis elucidates the microscopic origin of supersolid excitations in the XXZ triangular lattice model and their proximity to a spin liquid phase observed experimentally.

TT 86.3 Thu 15:30 CHE/0091

Magnetization-driven spinon Landau levels and ordering instabilities in a Dirac spin liquid — WEN WANG¹, ●URBAN F.P. SEIFERT², OLEG A. STARYKH³, and LEON BALENTS¹ — ¹Kavli Institute for Theoretical Physics, University of California, Santa Barbara, California 93106-4030, USA — ²Institute for Theoretical Physics, University of Cologne, Zùlpicher Str. 77a, 50937 Cologne, Germany — ³Department of Physics and Astronomy, University of Utah, Salt Lake City, UT 84112, USA

A particularly fascinating example of a quantum spin liquid is the U(1) Dirac spin liquid (DSL), which at low energies is described by emergent quantum electrodynamics (QED3), a strongly coupled conformal field theory. Motivated by recent numerical evidence for its realization in triangular lattice J1-J2 Heisenberg antiferromagnets as well as the identification of several candidate materials, we revisit the problem of the U(1) DSL in a Zeeman magnetic field. Equipped with recent numerical and field-theoretical insights into the field-induced behaviour of the QED3 low-energy theory, we analyze a microscopic (lattice) model using Gutzwiller-projected wavefunctions. We analyze how the

applied field may induce an instability towards in-plane antiferromagnetic ordering, and discuss observables that may be unique to such a field-induced state. In experiments, these may allow one to infer the presence of an underlying DSL at zero field.

TT 86.4 Thu 15:45 CHE/0091

Monopole condensation in U(1) Dirac spin liquids: AFM and VBS orders — ●JOÃO C. INÁCIO¹ and FAKHER ASSAAD^{1,2} — ¹Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, Am Hubland, 97074 Würzburg, Germany

Quantum spin liquids are states of matter where quantum fluctuations prohibit magnetic order down to zero temperature. Such states cannot be described by conventional mean-field theories. In U(1) Dirac spin liquids (DSL), the low-energy degrees of freedom are emergent gauge fields coupled to fractionalised spinon excitations. Spinons behave like Dirac fermions coupled to a compact U(1) gauge field, giving rise to QED₃. Within this framework instanton excitations of the gauge fields, i.e. monopoles, are central to understand the spin liquid state. Monopoles carry antiferromagnetic (AFM) or valence bond solid (VBS) charge leading to a Dirac mass upon their condensation, creating a large competition between different magnetic orders. We study a U(1) lattice gauge theory coupled to phonons by the means of exact fermionic quantum Monte Carlo simulations in order to understand this competition. By doing a scan over the spinon-phonon coupling (g) and the gauge field fluctuations (J) we are able to create a phase diagram where AFM, VBS and DSL phases coexist.

TT 86.5 Thu 16:00 CHE/0091

Exactly solvable spin liquids in Kitaev bilayers and moiré superlattices — ●IVAN DUTTA^{1,2}, ANAMITRA MUKHERJEE^{1,2}, ONUR ERTEN³, and KUSH SAHA^{1,2} — ¹National Institute of Science Education and Research, Jatni, 752050, India — ²Homi Bhabha National Institute, Training School Complex, Anushakti Nagar, Mumbai 400094, India — ³Department of Physics, Arizona State University, Tempe, Arizona 85287, USA

Building on the recent advancements on moiré superlattices, we propose an exactly solvable model with Kitaev-type interactions on a bilayer honeycomb lattice for both AA stacking and moiré superlattices. Employing Monte Carlo simulations and variational analysis, we uncover a rich variety of phases where the intra and interlayer Z2 fluxes (visons) are arranged in a periodic fashion in the ground state, tuned by interlayer coupling and out-of-plane external magnetic field. We further extend our model to moiré superlattices at various commensurate twist angles around two distinct twist centers represented by C3z and C6z of the honeycomb lattice. Our simulations reveal generalized patterns of plaquette values correlated with the AA or AB stacking regions across the moiré unit cell. In addition, depending on the twist angle, twist center and interlayer coupling, moiré superlattices exhibit a variety of gapped and gapless spin liquid phases and can also host corner and edge modes. Our results highlight the rich physics in bilayer and twisted bilayer models of exactly solvable quantum spin liquids.

TT 86.6 Thu 16:15 CHE/0091

N-state Potts ices as generalizations of classical and quantum spin ice — ●MARK POTTS¹, RÖDERICH MOESSNER¹, and SIDDHARTH PARAMESWARAN² — ¹Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ²Rudolf Peierls Centre for Theoretical Physics, Oxford, UK

Classical and quantum spin ice models are amongst the most popular settings for the study of spin liquid physics. N-state Potts ice models have been constructed that generalize spin ice, hosting multiple emergent U(1) gauge fields and excitations charged under non-trivial combinations of these fields. We present a general treatment of classical N-state Potts ices relating their properties to the $\text{su}(N)$ Lie algebras, and demonstrate how the properties of charged excitations in the classical model can be related to this symmetry group. We also introduce quantum generalizations of the Potts Ice models, and demonstrate how charge flavour changing interactions unique to $N > 2$ models dominate their low energy phase diagram. We further show how symmetries inherited from the $\text{su}(N)$ algebra can lead to the frustration of flux vacuum states.

TT 86.7 Thu 16:30 CHE/0091

Phases and dynamics of the quadrupolar Kitaev model — ●PARTHA SARKER and URBAN FRIEDRICH PETER SEIFERT — Institute for Theoretical Physics, University of Cologne, Zùlpicher StraÙe 77, D-50937, Köln, Deutschland

The study of multipolar exchange interactions for local spin moments ($S > \frac{1}{2}$) has rapidly expanded in recent years. A crucial inquiry in this research landscape is whether the concept of quantum spin liquid can be generalized to multipolar liquids where multipolar moments fractionalize, giving rise to novel emergent phenomena. Recently, a model involving frustrated quadrupolar interactions between local $S = 1$ moments has been numerically shown to host a deconfined phase with \mathbb{Z}_2 topological order. We investigate various phases and dynamics of this

model using a combination of mean-field and perturbative methods.

We first analytically demonstrate the existence of an extensively large set of ground states by probing the bare Hamiltonian with trivial deformations within the framework of generalized spin wave theory. The extensive degeneracy can be explained by the explicit construction of mean field ground states. These mean field ground states map to emergent electrostatics and can be divided into topological sectors in periodic boundary condition. Although perturbative analysis for anisotropic exchange coupling does not exhibit any evidence of deconfined excitations or topological ground state degeneracy, using parton analysis we can show that near the isotropic point the system hosts fractionalized gauge excitations. Finally, using parton mean field theory, we analyze the spectrum and various correlation functions.

TT 87: Many-body Quantum Dynamics II (joint session DY/TT)

Time: Thursday 15:00–16:30

Location: HÜL/S186

TT 87.1 Thu 15:00 HÜL/S186

general framework for understanding and modeling irreversibility: relaxator Liouville dynamics — ●MARTIN JANSSEN and JANOS HAJDU — Institut für Theoretische Physik, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln, Germany

Irreversibility is explained as an emergent phenomenon brought about by a separation between two characteristic time scales: the time t_s up to which relevant degrees of freedom of a system are tracked is extremely much shorter than the spectral resolution time t_e necessary to resolve the spectrum of all degrees of freedom involved. A relaxator that breaks reversibility condenses in the Liouville operator of the relevant degrees of freedom. The irrelevant degrees of freedom act as an environment. The relaxator Liouville equation is a most general equation of motion in a many body quantum system and contains memory effects and initial correlations of all degrees of freedom, generalizing the well known semi-group dynamics. Stationary states turn out to be generically unique and independent of the initial conditions and exceptions are due to degeneracies. Equilibrium states lie in the relaxator's kernel yielding a stationary Pauli master equation and a non negative entropy production rate is identified. Kinetic equations for one-particle densities are constructed as special cases and Kubo's linear response theory is generalized to relaxator Liouville dynamics. In weak coupling between system and environment the relaxator can be factorized in environmental correlations and bilinear system operators.

TT 87.2 Thu 15:15 HÜL/S186

Ground-State Exploration Driven by Thermal and Quantum Fluctuations — ●YOSHIKI HORIIKE¹ and YUKI KAWAGUCHI^{1,2} — ¹Department of Applied Physics, Nagoya University, Nagoya, Japan — ²Research Center for Crystalline Materials Engineering, Nagoya University, Nagoya, Japan

Simulated annealing provides a heuristic solution to combinatorial optimization problems. The cost function of a problem is mapped onto the energy function of a physical many-body system, and, by using thermal or quantum fluctuations, the system explores the state space to find the ground state, which may correspond to the optimal solution of the problem. Studies have highlighted both the similarities and differences between thermal and quantum fluctuations. Nevertheless, fundamental understanding of thermal and quantum annealing remains incomplete, making it unclear how quantum annealing outperforms thermal annealing. Here, we investigate the many-body dynamics of thermal and quantum annealing by examining all possible interaction networks of $\pm J$ Ising spin systems up to seven spins. Our comprehensive investigation reveals that differences between thermal and quantum annealing become prominent for particular interaction networks, indicating that the structure of the energy landscape distinguishes the two dynamics. We identify the microscopic origin of these differences through probability fluxes in state space, finding that the two dynamics are broadly similar but that quantum tunnelling produces qualitative differences. (arXiv:2511.16457)

TT 87.3 Thu 15:30 HÜL/S186

Symmetry re-breaking in an effective theory of quantum coarsening — ●FEDERICO BALDUCCI¹, ANUSHYA CHANDRAN², and RODERICH MOESSNER¹ — ¹Max Planck Institute for the Physics of Complex Systems, Dresden — ²Boston University, Boston, MA

We present a simple theory accounting for two central observations in a recent experiment on quantum coarsening and collective dynamics on a programmable quantum simulator [T. Manovitz et al., Nature 638, 86 (2025)]: an apparent speeding up of the coarsening process as the phase transition is approached; and persistent oscillations of the order parameter after quenches within the ordered phase. Our theory, based on the Hamiltonian structure of the equations of motion in the classical limit of the quantum model, finds a speeding up already deep within the ordered phase, with subsequent slowing down as the domain wall tension vanishes upon approaching the critical line. Further, the oscillations are captured within a mean-field treatment of the order parameter field. For quenches within the ordered phase, small spatially-varying fluctuations in the initial mean-field lead to a remarkable long-time effect, wherein the system dynamically destroys its long-range order and has to coarsen to re-establish it. We term this phenomenon symmetry re-breaking, as the resulting late-time magnetization can have a sign opposite to the initial magnetization.

TT 87.4 Thu 15:45 HÜL/S186

Pairing-induced phase transition in the non-reciprocal Kitaev chain — ●PIETRO BRIGHI and ANDREAS NUNNENKAMP — Faculty of physics, University of Vienna, Boltzmanngasse 5, 1090, Vienna, Austria

Investigating the robustness of non-reciprocity in the presence of competing interactions is central to understanding non-reciprocal quantum matter. In this work, we use reservoir engineering to induce non-reciprocal hopping and pairing in the fermionic Kitaev chain, and reveal the emergence of a pairing-induced phase transition. The two phases appear in the spectrum of the non-Hermitian Kitaev Hamiltonian describing the dynamics of correlations, separated by an exceptional point. In the non-reciprocal phase, dynamics are characterized by directionality and slow relaxation, and the steady state supports non-reciprocal density and spatial correlations. At strong pairing, we uncover an unexpected density wave phase, featuring short relaxation times, a modulation in particle occupation and strikingly different correlation spreading depending on pairing non-reciprocity. Our work highlights the non-trivial breakdown of non-reciprocity due to superconducting pairing and invites experimental investigation of non-reciprocal fermionic systems.

TT 87.5 Thu 16:00 HÜL/S186

Harnessing spin qubit decoherence to probe strongly interacting quantum systems — MARCIN PŁODZIEN¹, ●SAMBUNATH DAS², MACIEJ LEWENSTEIN^{1,3}, CHRISTINA PSAROUDAKI⁴, and KATARZYNA ROSZAK² — ¹Institut de Ciències Fotòniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — ²Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 00 Prague, Czech Republic — ³Passeig Lluís Companys 23, 08010 Barcelona, Spain — ⁴Laboratoire de Physique de l'École Normale Supérieure, Université PSL, CNRS, Sorbonne Université, Université de Paris, 75005 Paris, France

Using a mobile qubit as a probe to study the properties of a larger quantum system is a novel technique that leverages the quantum nature of the probe, the system under study, and the interaction between them [1-3]. By analyzing qubit decoherence, one accesses to properties that are difficult to measure classically. We apply this method to the

anisotropic Heisenberg XXZ spin-1/2 chain, an archetypal example of strongly correlated system, and show that qubit dynamics encode key system parameters, including quantum phase transitions and perturbation propagation velocity [4]. This demonstrates the effectiveness of small quantum probes for exploring large quantum systems.

References: 1. F. Casola, T. van der Sar et al, Nat. Rev. Mat. 3, 17088 (2018). 2. J. F. Rodriguez-Nieva, K. Agarwal et al. Phys. Rev. B 98, 195433 (2018). 3. S. Chatterjee, J. F. Rodriguez-Nieva et al, Phy. Rev. B 99, 104425 (2019). 4. M. Płodzień, S. Das et al, Phy. Rev. B 111, L161115 (2025).

TT 87.6 Thu 16:15 HÜL/S186

Enhancing efficiency of local-information time evolution — ●MOKSH BHATEJA¹, JONAS RIGO², and MARKUS SCHMITT^{2,3} — ¹Max Planck Institute for the Physics of Complex Systems, Dresden, Ger-

many — ²Universität Regensburg, Regensburg, Germany — ³PGI-8: Forschungszentrum Jülich, Jülich, Germany

The time evolution of an initially unentangled system under the von Neumann equation generally leads to rapid entanglement growth. This poses challenges for numerical tractability. The Information Lattice framework addresses this by systematically discarding accumulated non-local information (i.e., entanglement) to maintain computational feasibility. Within the local-information time evolution (LITE) approach, we propose Rényi-2 entropy as a measure of information, eliminating the need for matrix decomposition. When combined with additional approximations, this approach significantly enhances the efficiency and scalability of simulations in terms of both system size and duration of time evolution. We demonstrate the accuracy of this method by computing high-quality diffusion coefficients and local observables for a large non-integrable system.

TT 88: Spin Transport and Orbitronics, Spin-Hall Effects II (joint session MA/TT)

Time: Thursday 15:00–17:00

Location: POT/0361

TT 88.1 Thu 15:00 POT/0361

Spin-pumping and induced magnetic polarization in permalloy/platinum heterostructures — ●VERENA NEY¹, KILIAN LENZ², FABRICE WILHELM³, RENÉ HÜBNER², FABIAN GANSS², ANDREI ROGALEV³, JÜRGEN LINDNER², and ANDREAS NEY¹ — ¹Johannes Kepler Universität Linz, Österreich — ²Helmholtz Zentrum Dresden-Rossendorf, Deutschland — ³ESRF, Grenoble, Frankreich

Spin pumping is the transfer of angular momentum across interfaces into a non-ferromagnetic material driven by the precessing magnetization of an adjacent ferromagnet. Using ferromagnetic resonance (FMR) the presence of spin pumping can be evidenced by an increase of the Gilbert damping parameter α [1]. Here we study platinum-permalloy (Pt/Py) heterostructures using temperature-dependent broadband FMR. A clear increase of α is seen in a temperature range from 10 to 300 K when Pt and Py are in direct contact. The temperature dependence of the spin-pumping contribution can be derived by comparing with an Al-sandwiched Py reference film from [2]. Surprisingly, upon insertion of a thin Al spacer layer between Pt and Py the increase in α is suppressed. X-ray magnetic circular dichroism at the Pt L₃-edge reveals a clear magnetic polarization in Pt/Py whereas it is absent when a spacer layer of only 2 nm of Al is inserted. The induced polarization of Pt can thus be associated with spin pumping, while non-polarized Pt in proximity to Py shows an almost identical $\alpha(T)$ behavior as the Py reference sample in [2].

[1] Y. Tserkovnyak Phys. Rev. Lett. **88**, 117601 (2002)

[2] V. Ney et al. Phys. Rev. Materials **7**, 124403 (2023)

TT 88.2 Thu 15:15 POT/0361

Single and double spin Hall anomalous Hall and Hanle effects in Pt/YIG and Ta/YIG bilayers — ●AKASHDEEP AKASHDEEP, DUC MINH TRAN, MATHIAS KLÄUI, GERHARD JAKOB, and TIMO KUSCHEL — Johannes Gutenberg University Mainz, Germany

Anomalous Hall effect data of heavy metal / magnetic insulator bilayers, such as Pt/Y₃Fe₅O₁₂ (YIG), are commonly explained by magnetoresistance effects that are quadratically depending on the spin Hall angle (SHA) [1-4]. This is because they usually consist of two spin Hall processes as for example valid for spin Hall magnetoresistance [1,2]. In addition, S. Zhang et al. predicted theoretically a single spin Hall process combined with interfacial spin-dependent scattering which results in a linear SHA dependence [5] not reported experimentally so far.

In this contribution, we present anomalous Hall effect results for Pt/YIG and Ta/YIG with opposite sign in SHA of Pt and Ta. Thus, we can probe even and odd SHA dependencies. For thin Pt and Ta thicknesses, we observe results that are even in the SHA which is consistent with experimental literature. However, we found an odd SHA dependence for thicker heavy metal layers which is only partially mentioned in theory. We will present the separation of the effects and discuss the impact of the SHA on the individual effect contributions.

[1] H. Nakayama et al., Phys. Rev. Lett. **110**, 206601 (2013)

[2] S. Meyer et al., Appl. Phys. Lett. **106**, 132402 (2015)

[3] S. Vélez et al., Phys. Rev. Lett. **116**, 016603 (2016)

[4] J. Li et al., Phys. Rev. B **106**, 184420 (2022)

[5] S. S.-L. Zhang, G. Vignale, Phys. Rev. Lett. **116**, 136601 (2016)

TT 88.3 Thu 15:30 POT/0361

Current-induced spin and orbital polarization in the ferroelectric Rashba semiconductor GeTe — ●SERGIO LEIVA-MONTECINOS¹, LIBOR VOJÁČEK², JING LI², MAIRBEK CHSHIEV², LAURENT VILA², INGRID MERTIG¹, and ANNIKA JOHANSSON³ — ¹Martin-Luther-Universität Halle-Wittenberg, Germany — ²Univ. Grenoble Alpes, CEA, CNRS, Grenoble, France — ³Max Planck Institute of Microstructure Physics, Halle (Saale), Germany

The Edelstein effect is a promising mechanism for generating spin and orbital polarization from charge currents in systems without inversion symmetry. In ferroelectric materials, such as Germanium Telluride (GeTe), the combination of bulk Rashba splitting and voltage-controlled ferroelectric polarization provides a pathway for electrical control of the sign of the charge-spin conversion [1, 2].

In this work [3], we investigate current-induced spin and orbital magnetization in bulk GeTe using Wannier-based tight-binding models derived from *ab initio* calculations and semiclassical Boltzmann theory. Employing the modern theory of orbital magnetization, we demonstrate that the orbital Edelstein effect surpasses its spin counterpart by one order of magnitude. Moreover, the orbital Edelstein effect remains largely unaffected in the absence of spin-orbit coupling, highlighting its distinct physical origin compared to the spin Edelstein effect.

[1] D. Di Sante *et al.*, Adv. Mater. **25**, 509 (2012).

[2] C. Rinaldi *et al.*, Nano Lett. **18**, 2751 (2018).

[3] S. Leiva-Montecinos *et al.*, arXiv:2505.21340 (2025).

TT 88.4 Thu 15:45 POT/0361

Orbital contribution to g-tensor from first-principles modern theory — ●GARIMA AHUJA¹, MIRCO SASTGES^{2,3}, DONGWOOK GO⁴, SHOBHANA NARASIMHAN¹, YURIY MOKROUSOV^{2,3}, and STEFAN BLÜGEL^{2,5} — ¹Theoretical Sciences Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, India — ²Peter Grünberg Institut, Forschungszentrum Jülich and JARA, Jülich, Germany — ³Institute of Physics, Johannes Gutenberg University Mainz, Mainz, Germany — ⁴Department of Physics, Korea University, Seoul, South Korea — ⁵Institute for Theoretical Physics, RWTH Aachen University, Aachen, Germany

The electronic g-factor, which measures how angular momentum couples to magnetic fields, is a key descriptor of magnetic behavior in solids. In crystalline materials, the orbital contribution to the g-factor can significantly modify its value. In this talk, we present a first-principles framework for computing g-factors, based on multiband perturbation theory with the DFT-Wannier approach, to reveal microscopic origins of the orbital contribution, highlighting the roles of local and non-local orbital currents. We resolve both orbital and spin responses, determine the full g-tensor, and show how interband couplings and band geometry shape the g-tensor across the Brillouin zone. g-tensor plays a key role in quantum technologies, where qubit coherence and control depend on accurate knowledge of magnetic response. We present our findings for some interesting bulk and 2D systems, offering a predictive route for engineering magnetic responses in materials relevant to quantum computing, spin-orbitronics, and spectroscopy.

TT 88.5 Thu 16:00 POT/0361

Inherent Electro-Optic Kerr Rotation — ●ERLEND SYLJUÅSEN¹, ALIREZA QAIUMZADEH¹, REMBERT DUINE^{2,3}, and ARNE BRATAAS¹ — ¹Center for Quantum Spintronics, Trondheim, Norway — ²Institute for Theoretical Physics, Utrecht University, The Netherlands — ³Department of Applied Physics, Eindhoven University of Technology, The Netherlands

Static electric-field-induced Kerr rotation of reflected light is used to probe symmetry breaking, electronic properties, and transport phenomena as the spin and orbital Hall effects. In this talk, we uncover a previously overlooked contribution to the electric-field-induced Kerr rotation, arising from the interplay of matter, the static electric field, and the magnetic component of light. This contribution remains nonzero even in isotropic nonmagnetic homogeneous materials, making this effect inherent to any such Kerr measurement. We present analytical expressions for both two-dimensional layers and semi-infinite bulk metals, and find within the relaxation-time approximation signal magnitudes directly relevant for experiments.

TT 88.6 Thu 16:15 POT/0361

Thermally Activated Spin Transport in a Multiferroic LiCu₂O₂/Pt Heterostructure — ●MATHEW JAMES, ANKITA NAYAK, ISTVÁN KÉZSMÁRKI, and AISHA AQEEL — University of Augsburg, 86159 Augsburg, Germany

Multiferroics, in which electric and magnetic orders are coupled, are potential materials for low-power spintronic devices. LiCu₂O₂ is a Type II multiferroic material known to exhibit spiral (non-collinear) spin ordering below its antiferromagnetic transition temperature, $T_N \approx 23$ K [1]. In this material, the magnetic Cu²⁺ ions form double chains along the crystallographic b-axis, resulting in a double-leg spin-ladder configuration.

In this study, we use the Spin Seebeck Effect (SSE) as an electric probe to investigate the thermally activated magnetic response of LiCu₂O₂ across different magnetic configurations. In the SSE, a temperature gradient across a magnetic insulator generates non-equilibrium magnons that carry a spin current. This spin current is converted into a measurable voltage in a heavy-metal layer deposited on top of the insulator, via the Inverse Spin Hall Effect [2]. Our preliminary results indicate that the SSE voltage is sensitive to the spiral ordering in LiCu₂O₂. References: [1] S. Park, et al., Phys. Rev. Lett., 98, 5 (2007). [2] K. Uchida et al., Nature, vol. 455, no. 7214, (2008).

TT 88.7 Thu 16:30 POT/0361

Current-induced orbital dynamics in magnetic oxides — ●MAHMOUD ZEER¹, MARJANA LEŽAIC¹, DONGWOOK GO^{1,2}, LEONID POUROVSKII³, STEFAN BLÜGEL^{1,4}, MATHIAS KLÄUI², OLENA GOMONAY², and YURIY MOKROUSOV^{1,2} — ¹Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — ²Institute

of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — ³CPHT, CNRS, École polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ⁴Institute of Theoretical Physics, RWTH Aachen University, 52074 Aachen, Germany

Magnetic oxides provide an ideal platform for exploring orbital degrees of freedom emerging from strong orbital angular momentum and spin-orbit coupling. The resulting unquenched orbital moments enable rich orbital-transport phenomena, particularly in antiferromagnetic systems. In this work, we investigate current-induced orbital dynamics in representative transition-metal oxides using first-principles calculations in both bulk and thin-film geometries. We identify sizable orbital response and highly efficient orbital-to-spin conversion mechanisms, which give rise to substantial torque components on the magnetic sublattices [1]. In addition, we analyze the contributions of dipole, quadrupole, and octupole magnetic moments to the overall orbital response. Our findings establish magnetic oxides as a promising and realistic platform for harnessing orbital degrees of freedom for next-generation spin-orbital technologies. [1] S. Krishnia, C. Schmitt, M. Zeer et al., under review.

TT 88.8 Thu 16:45 POT/0361

Disentangling angular momentum transport in ferromagnet-diamagnet structures via suspended systems — ●FIONA SOSA BARTH^{1,2}, MATTHIAS GRAMMER^{1,2}, RICHARD SCHLITZ³, TOBIAS WIMMER^{1,2}, JANINE GÜCKELHORN^{1,2}, LUIS FLACKE^{1,2}, SEBASTIAN T.B. GOENNENWEIN³, RUDOLF GROSS^{1,2,4}, HANS HUEBL^{1,2,4}, AKASHDEEP KAMRA⁵, and MATTHIAS ALTHAMMER^{1,2} — ¹Walther-Meißner-Institut, BAdW, Garching, Germany — ²School of Natural Sciences, TUM, Garching, Germany — ³Department of Physics, University of Konstanz, Konstanz, Germany — ⁴Munich Center for Quantum Science and Technology, München, Germany — ⁵RPTU Kaiserslautern-Landau, Kaiserslautern, Germany

Spintronics relies on the transfer of angular momentum between electrons and solid state excitations such as magnons and phonons. In our recent work, we demonstrate angular momentum transfer between two ferromagnetic strips on diamagnetic substrates [1]. A DC current on one of the strips is converted into a non-equilibrium magnon accumulation, which transfers angular momentum to the magnonic system of the second FM strip, detected electrically by the inverse processes. In this work, we investigate how the nature of this angular momentum transport is affected by the substrate. We first examine how SiO_x, SiN and SiN/SiO_x layers on Si substrates impact the transport response, and then study the effect in freestanding ferromagnetic strips fully decoupled from the substrate. This allows us to separate potential dipolar from phononic contributions to the coupling between the FM strips. [1] R. Schlitz et al., Phys. Rev. Lett. 132, 256701 (2024)

TT 89: Cryotechnique: Refrigeration

Time: Thursday 16:45–17:45

Location: HSZ/0103

TT 89.1 Thu 16:45 HSZ/0103

Twin low frequency stirling type Pulse Tube Cryocoolers driven by a single metal bellows compressor — ●XAVIER O. HERRMANN^{1,2}, JACK-ANDRÉ SCHMIDT^{1,2}, BERND SCHMIDT², JENS HÖHNE³, and ANDRÉ SCHIRMEISEN^{1,2} — ¹Institute of Applied Physics, Justus-Liebig University, Giessen, Germany — ²TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany — ³Pressure Wave Systems GmbH, Taufkirchen, Germany

GM-Type Pulse Tube Cryocoolers (PTC) offer cooling power at temperatures down to 2.2 K with ⁴He as a working fluid [1]. With increasing reliability of PTCs, they have become a dependable and cost-effective option for cooling sensitive sensors [2] to temperatures even below typical LHe bath cryostats. In contrast to conventional GM cryocoolers, PTC require only one moving part: the rotary valve. For critical applications with "high demand" for reliable and continuous cooling, GM-type PTC offer service intervals in excess of 3 years. In order to increase the service interval further as well as to reduce losses within the rotary valve, omitting this valve is the most effective option. In this contribution we present our current status of development of a pair of small low frequency Stirling-type PTC, derived from the two stage GM-type PTC SUSY, both driven by one metal bellows compressor.

[1] N. Jiang et al., Cryogenics 44 (2004) 809.

[2] R. Güsten et al., Nature 568 (2019) 357.

TT 89.2 Thu 17:00 HSZ/0103

Adiabatic demagnetization refrigeration to below 100 mK with frustrated Gd³⁺ compounds — ●TIM TREU, MARVIN KLINGER, FELIX KREISBERGER, ANTON JESCHE, and PHILIPP GEGENWART — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg

Adiabatic demagnetization refrigeration (ADR) is becoming increasingly important for achieving temperatures below 1 K as the global supply of helium-3 continues to tighten. Although ADR in this temperature range has long relied on paramagnetic hydrated salts, recent work shows that frustrated rare-earth oxides provide greater entropy densities and practical benefits, particularly their stability against heating and vacuum exposure [1]. In this study, we present the structural, magnetic, and thermodynamic characteristics of frustrated Gd³⁺ compounds. We evaluate their excellent ADR performance to below 100 mK and compare the results with existing literature. Also, we demonstrate on these compounds how the ADR measurement itself can be used to gain information about the heat capacity, phase transitions, phase boundaries and magnetic interactions below ³He temperatures. The work was supported by the Deutsche Forschungsgemeinschaft

(DFG, German Research 298 Foundation), Grants No. 514162746 (GE 1640/11-1) and No. TRR 360-492547816.

[1] T. Treu et al., J. Phys. Condens. Matter 37, 013001 (2025).

TT 89.3 Thu 17:15 HSZ/0103

Cooling of electrons via superconducting tunnel junctions and their arrays exhibiting nodal lines — ●LINUS ALIANI and VIKTORIIA KORNICH — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

Condensed matter physics demands experimental control over a systems' temperature. This is usually achieved by the use of commercial dilution refrigerators. However cooling to temperatures below mK is still an issue and usually phonons are cooled down instead of electrons. We therefore propose a setup, which cools *electrons via electrons*.

We consider theoretically a small current running from an electron bath through a setup based on superconducting tunneling junction(s). We employ tunneling junctions with a π phase difference in order to host nodal lines. These nodal lines and their surrounding spectrum depend on external parameters. Thus the setups' entropy is adjustable via its' dependence on their nodal lines. The high entropy of the setup forces electrons entering it to increase their entropy, thereby removing heat from the electron bath. We demonstrate the working principle of this approach by first studying the entropy of a simple superconductor-insulator-superconductor (SIS) junction and compare it to the free electron gas at chemical potential. Subsequently we modify the setup in various ways in order to introduce opportunities for fine tuning for possible experimental uses. For this we investigate su-

perconducting tunnel junctions with a ferroelectric insulator and an array of such junctions with ferroelectrics in-between.

TT 89.4 Thu 17:30 HSZ/0103

Optomechanical Cooling without Residual Heating — SURANGANA SENGUPTA¹, BJÖRN KUBALA^{1,2}, JOACHIM ANKERHOLD¹, and ●CIPRIAN PADURARIU¹ — ¹Institute for Complex Quantum Systems and IQST, Ulm University — ²German Aerospace Center (DLR), Institute of Quantum Technologies, Ulm

Resolved-sideband cooling is a standard technique in cavity optomechanics enabling quantum control of mechanical motion, but its performance is ultimately limited by quantum backaction heating. This fundamental effect imposes a limit on the minimum achievable mechanical phonon number, establishing a finite-temperature floor regardless of the applied cooling strength. We generalize the semi-classical model for optomechanical cooling to describe universal cavity Hamiltonians incorporating both passive and active nonlinearities. As a concrete demonstration, we analyze the simplest circuit optomechanical system that implements a nonlinear drive via a Josephson junction. Our analysis reveals that this active nonlinear drive can eliminate the residual heating backaction, thereby comparing favorably with alternative optomechanical cooling schemes based on passive nonlinearities [1]. By successfully overcoming the finite-temperature floor that limits conventional schemes, our method paves the way for unprecedented quantum control over mechanical systems and establishes the experimental viability of zero-heating optomechanical cooling.

[1] D. Zoepfl et al., Phys. Rev. Lett. 130, 033601 (2023).

TT 90: Quantum Impurities and Kondo Physics

Time: Thursday 17:00–18:30

Location: CHE/0091

TT 90.1 Thu 17:00 CHE/0091

Unveiling local magnetic moments in copper-oxide atomic junctions — ●MARCEL STROHMEIER¹, SAMANWITA BISWAS², WOLFGANG BELZIG¹, REGINA HOFFMANN-VOGEL², and ELKE SCHEER¹ — ¹Department of Physics, University of Konstanz, 78457 Konstanz, Germany — ²Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam-Golm, Germany

Incorporating oxygen into metallic atomic-scale junctions modifies the interatomic bonding and may even promote the formation of monoatomic chains [1]. In the specific case of copper oxide, first-principles studies have predicted the emergence of ferromagnetic ground states, attributing certain atomic configurations with spin-filtering capabilities [2]. By means of low-temperature transport measurements, we provide a series of experimental evidence indicating the presence of local magnetism in air-oxidized mechanically controllable copper break junctions. Our investigations on ultimately small contacts range from magnetotransport measurements [3] to the analysis of anomalous shot noise in the presence of strong zero-bias anomalies [4]. The analysis of the latter reveals signatures of spin-polarized currents, a finding that needs to be reconciled with the spectroscopic features being interpreted within a Kondo model [5].

[1] Thijssen et al., New J. Phys. 10, 033005 (2008)

[2] Zheng et al., J. Appl. Phys. 117, 043902 (2015)

[3] Strigl et al., Nat Commun 6, 6172 (2015)

[4] Tewari et al., Nano Lett. 18, 5217 (2018)

[5] Calvo et al., PRB 86, 075447 (2012)

TT 90.2 Thu 17:15 CHE/0091

Kondo impurities coupled to a Chern insulator — ●DAVID A. KRÜGER¹ and MICHAEL POTTHOFF^{1,2} — ¹Department of Physics, University of Hamburg, Hamburg, Germany — ²The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

We study a system consisting of two spin- $\frac{1}{2}$ impurities that are exchange-coupled to a two-dimensional Qi-Wu-Zhang Chern insulator. The interplay between the truncated Kondo effect, the truncated RKKY interaction, and the mass parameter m gives rise to a complex phase diagram comprising RKKY singlet and triplet phases, the Kondo singlet, and a partially Kondo-screened phase. Furthermore, we examine how the phase diagram depends on the coupling orbitals and the inter-impurity distance.

Using a Lanczos transformation, we map the problem to a one-dimensional chain with the impurities at the first site, which is then

solved using an adaptive natural-orbital configuration-interaction technique. We also consider fictitious local magnetic fields Zeeman-coupled to the impurity spins. The field directions form a four-dimensional base manifold $\mathcal{M} \cong \mathbb{S}^2 \times \mathbb{S}^2$. The bundle of ground states over \mathcal{M} can be topologically characterized by a Chern number that differs from the usual k -space Chern number and provides further insight into the limit of classical impurity spins.

TT 90.3 Thu 17:30 CHE/0091

Orbital-Selective Mott transition in a U(1) gauge model of the Kondo lattice: a Quantum Monte Carlo study — ●GAOPEI PAN and FAKHER ASSAAD — University of Würzburg, 97074 Würzburg, Germany

We investigate a U(1) gauge theory formulation of the dimensional mismatch Kondo model describing a spin chain on a semi-metallic surface. Using sign-problem-free determinant quantum Monte Carlo simulations, we compute the single-particle spectra, optical conductivity, and dynamical spin structure factor of the composite fermions across a wide range of parameters.

Our results reveal a clear evolution from a Kondo-screened heavy-fermion regime to a Kondo-breakdown phase where the composite fermion spectral weight collapses. Most strikingly, the zero-frequency optical conductivity displays a sharp suppression at the breakdown point, accompanied by a redistribution of spectral weight, which cannot be explained by simple band-structure effects. Instead, the data support an interpretation in terms of an orbital-selective Mott transition, where the f -sector becomes localized while the conduction c electrons remain itinerant.

Together, these findings provide unbiased numerical evidence for a gauge-fluctuation-driven Kondo breakdown and demonstrate how composite-fermion and optical conductivity can diagnose orbital-selective Mott transition in strongly correlated metals.

TT 90.4 Thu 17:45 CHE/0091

Kondo effect competing superconductivity in Van Hove systems — ●GRZEGORZ MICHAŁEK and KRZYSZTOF P. WÓJCIK — Institute of Molecular Physics, Polish Academy of Sciences, ul. M. Smoluchowskiego 17, 60-179 Poznań, Poland

Higher-order Van Hove singularities, characterized by a power-law divergence in the electron density of states near the Fermi surface, are known to boost effects of electronic correlations and in general destabilize conventional Fermi-liquid states. We investigate the influence of such singularity on the magnetic impurity in a superconductor. In

general, the Kondo effect is known to compete with superconductivity. Due to this competition, the impurity is expected to undergo a transition between the screened phase, where Kondo screening locally overcomes the superconducting pairing, and Yu-Shiba-Rusinov in-gap state formation, where impurity moment remains intact [1]. We use numerical renormalization group calculations to analyze how a singularity in the normal-state density of states influences the Kondo scale. By incorporating modified density of states into the BCS gap equation, we show the evolution of the Kondo quantum critical point with singularity exponent r .

[1] K. Satori, H. Shiba, O. Sakai, Y. Shimizu, *J. Phys. Soc. Jpn.* **61**, 3239 (1992).

TT 90.5 Thu 18:00 CHE/0091

The work distribution function of a qubit and of the Anderson impurity model — ●THEODOULOS COSTI¹, HOA NGHIEM², STEVEN CAMPBELL^{3,4}, and ANDREW MITCHELL^{3,4} — ¹Peter Günberg Institute, Research Centre Jülich, 52428 Jülich, Germany — ²Phenikaa Institute for Advanced Study, Phenikaa University, 12116 Hanoi, Vietnam — ³School of Physics, University College Dublin, Belfield, Dublin 4, Ireland — ⁴Centre for Quantum Engineering, Science and Technology, University College Dublin, Ireland

The work distribution function (WDF) of two representative quantum impurity models, the Anderson impurity model (AIM) of strongly correlated electrons, and the Ohmic spin-boson model (SBM) of a qubit coupled to an environment, is investigated within the non-perturbative time dependent numerical renormalization group (TDNRG) approach [1]. For level quenches, the zero temperature WDF, $P(W)$, exhibits a threshold behavior above the minimum work, W_{\min} , taking the form $P(W) = a|W - W_{\min}|^{-(1-\alpha_{OC})}$ where α_{OC} is the Anderson orthogonality exponent. We calculate α_{OC} analytically, finding agreement with that obtained from the TDNRG. The calculations are further validated by verifying the first three moments of the WDF and the

Crooks relation. This work demonstrates the ability of the TDNRG approach to capture the quantum thermodynamics of nanoscale quantum impurity systems for strong quenches beyond the linear response regime [1].

[1] H.T.M. Nghiem, T.A. Costi, S. Campbell, A.K. Mitchell, preprint (2025)

TT 90.6 Thu 18:15 CHE/0091

Conventional and singlet-triplet Kondo effect in radical single-molecule junctions — ●ELKE SCHEER¹, GAUTAM MITRA¹, JUETING ZHENG^{1,2}, MICHAEL DEFFNER³, KAREN SCHAEFER³, JONATHAN Z. LOW³, LUIS M. CAMPOS⁴, CARMEN HERRMANN⁴, and THEO A. COSTI⁵ — ¹Uni Konstanz, Germany — ²Xiamen Univ., China — ³Univ. Hamburg, Germany — ⁴Columbia Univ., USA — ⁵Research Center Jülich, Germany

The Blatter radical has been suggested as a building block in future molecular spintronic devices due to its expected long-spin lifetime [1]. Whether its radical character is maintained in single-molecule junctions depends on the environment [2]. For about 25% of single-molecule junctions investigated at low-temperature (4.2 K) we observe zero-bias anomalies that can be assigned to the Kondo effect and hence support the radical character. Additionally, a strong negative magnetoresistance is observed in junctions that do not reveal a zero-bias anomaly. By combining distance-dependent and magnetic-field-dependent measurements, quantum-chemical and quantum-transport calculations, we show that both observations can be consistently explained by a singlet-triplet Kondo model. [3,4].

[1] L. Ji et al., *Adv. Mater.* **32**, e1908015 (2020)

[2] J. Z. Low et al., *Nano Lett.* **19**, 2543 (2019)

[3] J. Paaske et al., *Nat. Phys.* **2**, 460 (2006)

[4] G. Mitra et al., *Chem* **11**, 102500 (2025)

TT 91: Superconductivity: Theory II

Time: Thursday 17:30–18:30

Location: HSZ/0101

TT 91.1 Thu 17:30 HSZ/0101

Superconducting length scales and currents from first principles — MITSUAKI KAWAMURA¹, TAKUYA NOMOTO², ●NIKLAS WITT³, and RYOTARO ARITA^{4,5} — ¹Yokohama National University, Japan — ²Tokyo Metropolitan University, Japan — ³JMU Würzburg, Germany — ⁴University of Tokyo, Japan — ⁵RIKEN CEMS, Japan

Superconducting length scales, namely the coherence length and the penetration depth, as well as critical currents, are central to the performance of superconductors but remain challenging to obtain from first principle calculations. While density functional theory for superconductors (SCDFT) has been widely used to predict transition temperatures, magnetic and current related superconducting properties are far less explored.

We present a fully ab initio implementation of a recently introduced method [1] within SCDFT, which gives access to superconducting length scales and depairing currents by introducing a finite-momentum pairing constraint. The approach has been integrated into the open-source superconducting-toolkit (SCTK) [2] and applied to representative elemental, alloy, and high-pressure hydride superconductors. The results demonstrate a viable route to predicting magnetic superconducting properties directly from electronic structure calculations.

[1] N. Witt et al., *npj Quantum Mater.* **9**, 100 (2024)

[2] M. Kawamura et al., *Phys. Rev. B* **101**, 134511 (2020)

TT 91.2 Thu 17:45 HSZ/0101

Cavity-control of the Ginzburg-Landau stiffness in superconductors — ●VADIM PLASTOVETS and FRANCESCO PIAZZA — Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

Confining light around solids via cavities enhances the coupling between the electromagnetic fluctuations and the matter. We predict that in superconductors this cavity-enhanced coupling enables the control of the order-parameter stiffness, which governs key length scales such as the coherence length of Cooper pairs and the magnetic penetration depth. We explain this as a renormalization of the Cooper-pair

kinetic mass caused by photon-mediated repulsive interactions between the electrons building the pair. This effect is generic for Bardeen-Cooper-Schrieffer superconductors and is most pronounced in low- T_c materials. The strength of this effect can be tuned via the length of the cavity and we estimate it to be sizable for cavities in the infrared range.

TT 91.3 Thu 18:00 HSZ/0101

Influence of Cavity-Induced Polariton Formation on Superconductivity — ●PAUL BODEWEI¹, PAUL FADLER¹, and MICHAEL A. SENTEF^{1,2} — ¹Institute for Theoretical Physics, University of Bremen/ Bremen Center for Computational Material Science — ²Max Planck Institute for the Structure and Dynamics of Matter, CFEL, Hamburg

Cavities have emerged as a powerful tool for manipulating quantum materials, leveraging vacuum fluctuations to alter fundamental material properties. Recent experiments on the organic high- T_c κ -salts report a dramatic suppression of the superfluid density when those are coupled to a cavity [1]. The prevailing hypothesis for this suppression arises from a resonant coupling between the cavity modes and infrared-active molecular phonon modes in the κ -salt. However, the microscopic mechanism by which such cavity-induced phonon/polariton coupling alters superconductivity remains unknown. To gain further understanding on this, we focus on charge-transfer κ -salts with strong electronic correlations, which are well captured by a Hubbard model [2,3]. Building on that, our goal is to understand how the emergence of cavity-mediated phonon polaritons modifies the effective interactions (e.g. spin fluctuations [4] or mediated electron pairing), and thereby to examine how and why the superconducting state is suppressed.

[1] I. Keren, T.A. Webb, S. Zhang et al., arXiv:2505.17378 (2025)

[2] M. Buzzi et al., *Phys. Rev. X*, **10**, 031028 (2020)

[3] H. Menke et al., *Phys. Rev. Lett.* **133** 136501 (2024)

[4] J. Schmalian, *Phys. Rev. Lett.*, **81**, 4232 (1998)

TT 91.4 Thu 18:15 HSZ/0101

Unraveling Quantum Effects of Flexible Molecules in Superfluid Solvents — ●KATHARINA LEITMANN¹, HARALD FORBERT^{1,2},

and DOMINIK MARX¹ — ¹Lehrstuhl für Theoretische Chemie, Ruhr-Universität Bochum, 44780 Bochum, GER — ²Center for Solvation Science ZEMOS, Ruhr-Universität Bochum, 44780 Bochum, GER

Protonated methane (CH_5^+) is a fluxional molecule whose sensitivity to its environment makes it an excellent probe for low-temperature molecular interactions. We investigate CH_5^+ microsolvation in *para*-hydrogen clusters $(p\text{H}_2)_n$ at low temperatures using two distinct simulation approaches: Ring Polymer Molecular Dynamics at 15 K to compute IR spectra and a hybrid simulation approach that combines Path Integral Molecular Dynamics for CH_5^+ and bosonic Path Integral Monte Carlo to establish Bose-Einstein statistics of the $(p\text{H}_2)_n$

quantum solvation environment, subject to bosonic exchange at 1 K.

All simulations are based on highly accurate High-dimensional Neural Network Potentials and the IR spectra are computed using a Neural Network Dipole Moment Surface, both parameterized using CCSD(T) theory. Our simulations demonstrate stable solvation of CH_5^+ at least up to $n = 12$ $p\text{H}_2$ molecules, which build the first solvation shell. We revealed that the structure of CH_5^+ is not significantly perturbed by the solvation with $p\text{H}_2$. However, we found significant fluctuations in the large amplitude motion of CH_5^+ associated with partial hydrogen scrambling as a function of cluster size n . These dynamic influences are consistently observed in the IR spectra, underscoring the robustness of our findings across different methodologies and temperatures.

TT 92: Transport – Poster

Time: Thursday 18:00–20:00

Location: P4

TT 92.1 Thu 18:00 P4

Development of a scanning NV magnetometer for quantum sensing experiments at room-temperature — •YUE YU, RICARDO JAVIER PEÑA ROMÁN, and APARAJITA SINGHA — IFMP, TU Dresden, Dresden, Germany

Nitrogen-Vacancy (NV) center based sensors are widely used because they are versatile, precise, and suitable for exploring a broad range of systems. We have previously designed NV setups capable of operating in ultra high vacuum (UHV) and cryogenic environments, which, however, are only meaningful to use with samples that mandate such extreme measurement conditions. In order to expand our measurement capabilities to room temperature (RT) systems (such as exploration of nanomagnetism in RT-stable 2D materials, antiferromagnetic / ferromagnetic spin textures, stable molecular systems) as well as to enable rapid pre-screening of both samples and NV probes prior to transferring them into the UHV cryogenic setups, we are now setting up a room-temperature-scanning-NV magnetometer. This system integrates atomic force microscopy (AFM) with optical readout of single NV centers and will feature microwave delivery directly on the AFM tip to achieve highly localized and efficient spin control. This setup will also feature piezo-controlled permanent magnets, thus enabling quantitative magnetic-field mapping with nanometer-scale spatial resolution. Together with our UHV low-temperature scanning NV magnetometer and UHV confocal microscopes, it will form a unified platform for a complete workflow across ambient, cryogenic, and UHV environments.

TT 92.2 Thu 18:00 P4

Development of an Ultra High Vacuum and Low Temperature Scanning NV Magnetometer — •SANDIP MAITY¹, RICARDO JAVIER PEÑA ROMÁN^{2,1}, DINESH PINTO^{1,3}, ISABEL PFANDER¹, KLAUS KERN^{1,3}, and APARAJITA SINGHA^{2,4} — ¹Max Planck Institute for Solid State Research, Stuttgart — ²IFMP, TU Dresden, Germany — ³Institut de Physique, École Polytechnique Fédérale de Lausanne, Lausanne — ⁴Würzburg-Dresden Cluster of Excellence (ct.qmat)

The nanoscale spatial resolution and calibration-free quantifiable magnetic field measurement capabilities of nitrogen-vacancy (NV) centers have enabled us to investigate the properties of magnetic spin textures with high magnetic sensitivity through scanning probe microscopy across a wide range of temperatures and pressure. In the poster I will be presenting the development of a scanning probe magnetometer capable of imaging magnetic textures under ultra-high vacuum and low temperature. Moreover, we have integrated commercial NV tips with a home-built tip holder equipped with an AFM amplifier and microwave excitation on the tip (not on the sample). This compact and modular probe holder allows us to have a magnetic image of any sample region without restriction. To exploit the quantifying nature of NV magnetometry using Optically Detected Magnetic Resonance, a coherent microwave (MW) delivery to the probe is mandatory. I will also present different means of delivering MW to the NV probes through different designs of the tip holders in a practical and versatile manner and how effective they are in coherently manipulating the NV spin states.

TT 92.3 Thu 18:00 P4

Advances in building a cryogenic scanning NV magnetometer — •KILIAN SROWIK^{1,2}, LOTTE BOER¹, HAYDEN BINGER¹, YOUNG-GWAN CHOI¹, AHMET ÜNAL¹, LUMINITA HARNAGEA^{2,4}, SABINE WURMEHL², BERND BÜCHNER^{2,3}, and URI VOOL¹ — ¹Max Planck In-

stitute for Chemical Physics of Solids, Dresden, Germany — ²Leibniz Institute for Solid State and Materials Research, IFW Dresden, Dresden, Germany — ³Institute for Solid State and Materials Physics, TU Dresden, Dresden, Germany — ⁴Indian Institute of Science Education and Research, Pune, India

In the last decade, the Nitrogen-Vacancy (NV) defect in diamond has emerged as an ideal quantum sensor to probe magnetic stray fields. By using a diamond nanopillar, containing a single NV center, as the tip of an atomic force microscope (AFM), it becomes possible to perform Scanning NV magnetometry (SNVM). This configuration not only enables us to measure with high spatial resolution and sensitivity, it also makes a broad temperature range accessible. While room temperature NV systems are widely used already, cryogenic NV setups still remain sparse. At the MPI CPfS, we are in the final stages of building a cryogenic SNVM setup, capable of measuring at variable temperatures down to 1.8K. This paves the way to study a multitude of interesting phenomena, like magnetic phase transitions and superconductivity. In particular, we want to focus on investigating the magnetic structure of unconventional superconductors, like the recently emerged Weyl semimetal γ -PtBi₂, reported to have superconducting surface states with a nodal superconducting gap structure.

TT 92.4 Thu 18:00 P4

On-surface spin characterisation of isolated molecules using room temperature NV magnetometry — •OLGA SHEVTSOVA^{1,2}, BERNHARD PUTZ³, ULRICH ZIENER³, and APARAJITA SINGHA^{1,2} — ¹IFMP, TU Dresden, Germany — ²Würzburg-Dresden Cluster of Excellence (ct.qmat) — ³Universität Ulm, Ulm, Germany

Molecular spins have been receiving significant attention as promising candidates for quantum technologies, offering unique advantages in stability, tunability, and scalability. In particular, our work focuses on carbon-based open-shell molecular systems - stable chlorinated trityl radicals that host an unpaired electron spin. Understanding the coherent properties of these molecular spins is a crucial step toward their integration in practical quantum applications. However, probing such properties remains challenging due to limitations in sensitivity, environmental constraints, and the invasiveness of existing techniques.

Nitrogen-Vacancy (NV) centers in diamonds can operate over a wide temperature range and provide non-invasive optical readout, making them versatile and highly suitable tools for deepening existing knowledge. In this study, we leverage NV-center-based quantum sensors to investigate both the coherent properties of molecular spins and the limits of detecting extremely low spin concentrations, potentially down to a single spin. By combining the precision of NV magnetometry with the inherent stability of open-shell systems, our work aims to provide deeper insight into their viability as stable and controllable components for future quantum technologies.

TT 92.5 Thu 18:00 P4

Probing Vortices in Superconductors with Scanning Quantum Microscope — •SREEHARI JAYARAM¹, MALIK LINGER¹, LUCAS PIPIM³, RUOMING PENG¹, RAINER STOEHR¹, MATHIAS S. SCHEURER³, JURGEN SMET², and JOERG WRACHTRUP^{1,2} — ¹3rd Institute of Physics, University of Stuttgart, Allmandring 13, Stuttgart 70569, Germany — ²Max Planck Institute for Solid State Research, Heisenbergstrasse 1, Stuttgart 70569, Germany — ³Institute for Theoretical Physics III, University of Stuttgart, Pfaffenwaldring 57, Stuttgart 70569, Germany

Magnetic dynamics at the nanoscale provide crucial insight into the behavior of superconductors. Using single-spin scanning quantum microscopy, we probe vortex dynamics in superconductors. Our measurements reveal a disordered vortex glass phase that melts near the critical temperature. Magnetic noise persists well below T_c , with a strength that increases at lower temperatures*contrary to expectations. This behavior, detected via spin decoherence, points to an intrinsic origin driven by competition between supercurrent density and thermal fluctuations. Our results establish single-spin microscopy as a powerful platform for investigating fluctuations in 2D superconductors.

TT 92.6 Thu 18:00 P4

Double galvanic access to a microwave cavity for flux-mediated optomechanics with carbon nanotubes SQUIDs —

•JULIAN SEHR, TIM ALTHUON, PHILIPP WIEDEMANN, SOPHIE KLINGEL, PHILIPP BENNETT, TINO CUBAYNES, and WOLFGANG WERNSDORFER — Karlsruher Institut für Technologie (KIT), 76131 Karlsruhe

Carbon nanotubes (CNTs) are attractive as Josephson junction weak links, offering ballistic, one-dimensional transport and the ability to electrostatically tune their carrier density and transmission. By employing two parallel Josephson junctions formed from a single carbon nanotube mechanically transferred onto the circuit after growth, we realised a superconducting quantum interference device (DC-SQUID). The device supports an induced supercurrent of up to 4 nA through a single CNT-based junction. We expect to increase the critical current by changing the superconductor of the electronic circuits from molybdenum-rhenium to niobium. Embedding such a SQUID into a non-linear microwave cavity opens up the possibility to couple the phonon modes of the CNT to cavity photons via flux-mediated optomechanical coupling. This will be realised by making the cavity galvanically accessible from both sides, while the boundaries of the resonator are defined by a filtering stage using an on-chip planar capacitance.

TT 92.7 Thu 18:00 P4

Nonlinear Nanomechanics in Suspended Carbon Nanotubes —

•PHILIPP BENNETT, SOPHIE KLINGEL, JULIAN SEHR, TIM ALTHUON, TINO CUBAYNES und WOLFGANG WERNSDORFER — Karlsruher Institut für Technologie, Karlsruhe, Germany

Suspended carbon nanotubes (CNTs) serve as a unique platform for the implementation of nanomechanical systems (NEMS), owing to their electrical, mechanical, and quantum properties in a single nanoscale object. Because of their well-defined quantum dot states and mechanical degree of freedom, suspended CNTs are attractive for studying the coupling between electronic transport and nanomechanics and as candidates for mechanical qubits.

Building a two-level phononic system at the quantum level requires a certain degree of nonlinearity. In contrast to other hybrid approaches, we rely on purely intrinsic nonlinearities, which minimizes the additional decoherence arising from external sources. The degree of intrinsic nonlinearity can be quantified via the ratio K/κ , with K being the Kerr nonlinearity and κ the decoherence rate of the resonator. Our group has recently measured the Kerr-constant for a purely mechanical system. The next step is to further reduce the decoherence rate κ . To this end, we follow two complementary strategies: enhancing CNT quality by introducing water during growth, and improving the readout by implementing an MHz-range RLC tank circuit in the dilution cryostat. These improvements are meant to boost the degree of intrinsic nonlinearity in our system, paving the way to various applications, like magnetometers for single-molecule magnets or mechanical qubits.

TT 92.8 Thu 18:00 P4

Transmission resonances for periodically driven local potentials —

•DANIEL WEBER — RPTU University Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany

We model tunneling through a quantum dot using a locally driven 1D tight-binding Hamiltonian. Using Floquet theory, we produce exact numerical results before we derive an analytic prediction of position and amplitude of transmission resonance in dependence of driving frequency, coupling strength and local energy levels. Starting with a suitable transformation of the Hamiltonian, we use a high frequency approximation to derive a valid analytical approximation for frequencies in the systems energy scales. The results can be used for the design of efficient nano-electronic devices, in photonic waveguides or can be useful for ultra-cold gases in optical lattices.

TT 92.9 Thu 18:00 P4

STM-Break Junction Measurements of Organic Dyes —

•YANNIC ALTMANN^{1,2}, RENÉ MATZDORF¹, and RÜDIGER FAUST² — ¹Institute of Physics, University of Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany — ²Institute of Chemistry, University of Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Current research in molecular electronics explores multiple ways to manipulate the conductivity of molecules inside of single-molecule junctions using external stimuli. Examples are magnetic fields [1], external forces [2], as well as electromagnetic radiation [3].

We use a LT-STM to measure the conductance of single oligo(phenylene ethynylene) molecules in STM break junction inspired experiments in two different ways: $I(z)$ -spectroscopy as well as $I(t)$ -spectroscopy. The goal of the project is to do similar measurements on organic dye molecules to study the effects of molecule excitation with visible light on the molecular conductance.

[1] G. Mitra *et al.*, Nano Letters 22, 5773 (2022)

[2] P. Zhou, *et al.*, Jo. American Chem. Soc. 145, 18800 (2023)

[3] E-D. Fung *et al.*, Nano Letters 17, 1255 (2017)

TT 92.10 Thu 18:00 P4

Vorticity as an Origin-Independent Measure of Electronic Circulation in Crystals —

•ARISTO ARDYANEIRA, LEONARD PROKISCH, MORITZ RÜBLING, and FERDINAND EVERS — Institute of Theoretical Physics, University of Regensburg, D-93053 Regensburg, Germany

Orbital angular momentum (OAM) plays a central role in the emerging field of orbitronics, but its definition in real space is problematic because it depends on the choice of origin. Common approaches - such as the atomic-centered approximation or unit-cell integration - either neglect interstitial contributions or are not uniquely defined. We propose vorticity as an alternative, origin-independent measure of the local electronic circulation. Although closely related to the experimentally accessible magnetic field, vorticity has received little attention in solid-state contexts. Using the Mandelung formulation of quantum mechanics, we derive an equation of motion for the electronic vorticity and demonstrate its direct connection to the magnetic field in a crystal. This framework provides a natural and physically transparent description of electronic spinning motion relevant for orbitronic phenomena.

TT 92.11 Thu 18:00 P4

Photogalvanic Effect as a Probe for Distinguishing type-I and type-II Semi-Dirac Systems —

•BRISTI GHOSH¹, MALAY BANDYOPADHYAY¹, and SNEHASISH NANDY² — ¹Indian Institute of Technology Bhubaneswar, Bhubaneswar, Odisha 752050, India — ²National Institute of Technology Silchar, Assam, 788010, India

The photogalvanic effect (PGE) generates a direct photocurrent under polarized light in non-centrosymmetric systems, manifesting as the linear photogalvanic effect (LPGE) or circular photogalvanic effect (CPGE) depending on light polarization. Using quantum kinetic theory within the relaxation-time approximation, we theoretically explore the PGE as a probe of quantum geometry in anisotropic type-I and type-II semi-Dirac (SD) systems. The PGE conductivity, comprising injection, shift, resonant, higher-order pole, and anomalous contributions, exhibits a pronounced enhancement in type-II systems compared to type-I. For the CPGE, both anomalous and resonant terms, arising from Fermi surface contributions, decrease with increasing chemical potential in type-I but increase in type-II systems. For the LPGE, the xxx -component of the shift conductivity in type-II SD reverses sign upon tuning the gap tuning parameter δ , while other components remain invariant, similar to type-I behavior. These contrasting CPGE and LPGE responses provide clear optical signatures distinguishing the two SD phases. The predicted effects, potentially realizable in TiO_2/VO_2 heterostructures, establish the PGE as a sensitive probe of quantum geometry and a promising route toward next-generation optoelectronic applications.

TT 92.12 Thu 18:00 P4

Intrinsic Nonlinear Magneto-Electric Hall Effect —

•SUNIT DAS and AMIT AGARWAL — Department of Physics, Indian Institute of Technology, Kanpur 208016, India

We propose a new mechanism for an intrinsic nonlinear magneto-electric Hall (MEH) response in multilayer van der Waals materials. The predicted Hall conductivity is bilinear in an out-of-plane gate electric field and the magnetic field, independent of scattering time, and can arise even in nonmagnetic systems with weak spin-orbit coupling.

This response originates from an emergent layer-orbital quantum geometry whose sign reverses with the gate field, faithfully tracking the underlying layer polarization. Our comprehensive symmetry analysis reveals that a large class of polar and chiral nonmagnetic materials can permit this magnetotransport. Using the gated bilayer as a representative platform, we demonstrate sizable MEH signals. We further show that the same layer-orbital polarizability drives a longitudinal nonlinear response in chiral materials, providing a robust probe of structural chirality. These results reveal an intrinsic nonlinear transport channel that broadens the landscape of magnetoelectric phenomena and establishes layer-orbital quantum geometry as a key tool for novel transport-based material characterization.

TT 92.13 Thu 18:00 P4

QMC study of heat transport in 2D Dirac materials — ●LUIS THREMER¹, ADRIEN REINGRUBER¹, MAKSIM ULYBYSHEV¹, and FAKHER F. ASSAAD^{1,2} — ¹Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany — ²Würzburg-Dresden Cluster of Excellence ct.qmat, Am Hubland, Würzburg, Germany

Strongly correlated systems can host varying (and often competing) scattering mechanisms, making them an ideal playground for studying their influence on various transport properties. In particular, Dirac systems can undergo a Gross-Neveu phase transition, switching from a semi-metallic to a Mott-insulating phase. Experimental evidence of this transition was long-sought and recently tentatively realised in experiments on twisted WSe₂ tetralayers. We investigate the heat transport and the behaviour of the heat conductivity across the Gross-Neveu phase transition in strongly correlated 2D Dirac materials. In particular, we focus on their dependence on the change in the nature of the low-lying excitations from electrons to antiferromagnetic spin waves, which occurs across the phase transition. For this study, we use unbiased quantum Monte Carlo and Kubo linear response theory to extract the transport coefficients from the Euclidean time correlators. We also investigate the effects of long-range Coulomb interaction on the heat transport. Since long range interaction leads to the appearance of non-local terms in the heat current, long range Coulomb interaction can potentially significantly alter the thermal-transport behaviour.

TT 92.14 Thu 18:00 P4

Curvature, Torsion, and Non-Metricity in the Continuum Theory of Lattice Defects — ●MARVIN HENKE and NIKODEM SZPAK — Fakultät für Physik, Universität Duisburg-Essen, Duisburg, Germany

The continuum theory of lattice defects provides a tractable mesoscale framework for electron transport, circumventing microscopic complexity. It maps dislocations and disclinations onto curvature and torsion within an effective Riemann-Cartan geometry. The equivalence of the two latter concepts is an ongoing debate in General Relativity. Motivated by two-dimensional systems, like graphene, we investigate the mapping of metric-induced curvature onto torsion while preserving physical aspects of the dynamics. Among them, a crucial problem with the (eigen)time scaling along the trajectories of (quasi)particles appears. Our approach to solve this problem lies in the relaxation on the standard metric compatibility condition, which introduces the non-metricity tensor as an additional geometrical object, thus opening a new opportunity to discuss deep problems of differential geometry in the context of real physical systems.

TT 92.15 Thu 18:00 P4

Magnetotransport measurements of magic angle twisted bilayer graphene — ●MONICA KOLEK MARTINEZ DE AZAGRA, SIRRI BATUHAN KALKAN, and R. THOMAS WEITZ — Georg August Universität Göttingen

Magic angle twisted bilayer graphene (MATBG) has in recent years been established as a powerful platform for exploring strongly correlated electron phenomena in two-dimensional materials [1]. The rich phase diagram of two graphene layers stacked on top of each other with a precise twist angle of 1.1° has been widely studied with a special emphasis on investigating the robust superconducting state, whose exact nature and origin have yet to be determined [2,3]. Here, we present our recent progress in the fabrication and electric characterization of high-quality, encapsulated MATBG devices, highlighting key experimental observations.

[1] Bistritzer & MacDonald, PNAS 108, 12233 (2011).

[2] Cao et al., Nature 556, 80 (2018).

[3] Cao et al., Nature 556, 43 (2018).

TT 92.16 Thu 18:00 P4

Competition of FCI and CDW in a Two-Band Model — ●MARCO SCHÖNLEBER and MARIA DAGHOFER — Institut für Funktionelle Materie und Quantentechnologien, Stuttgart, Deutschland

Fractional quantum hall physics with vanishing magnetic fields has become an increasingly important research topic in recent years due to new findings in the field of moiré materials. Experimental signatures of these phases are often observed in combination with signatures of charge ordered or other symmetry broken phases. This indicates that band mixing might play an elementary role in the complete description of this phase of matter. For this purpose, an extended Hubbard model on a triangular lattice with $\nu = 2/3$ is considered. This allows the formation of bands of non-trivial topology as well as the formation of commensurate charge density waves. The analysis is carried out by exact diagonalisation and DMRG. By varying band gap and interaction strength the topologically non-trivial FCI competes with the symmetry-broken CDW phase.

TT 92.17 Thu 18:00 P4

Chiral Kondo Lattice Emergence in Moiré Heterostructure — ●BENJAMIN HEINRICH and MARIA DAGHOFER — Institute for Functional Matter and Quantum Technologies (FMQ), University of Stuttgart

Moiré systems composed of van der Waals heterostructures provide an experimentally accessible platform to realize a wide range of strongly correlated electron phenomena. Using transition metal dichalcogenide materials, such as an AB-stacked MoTe₂/WSe₂ bilayer, gives rise to an effective multi-orbital Hubbard model on the honeycomb lattice, which can be tuned via doping and the introduction of charge transfer energy through external voltages. Including strong Ising spin-orbit coupling leads to chiral Kondo exchange between localized and itinerant electrons in different layers near half-filling [1]. To gain a better understanding of experimentally observed phenomena, including magnetic ordering, numerical modeling is performed using exact diagonalization, and finite-size effects are further reduced using the variational cluster approach.

[1] Guerci et al., Sci. Adv. 9, eade7701 (2023)

TT 92.18 Thu 18:00 P4

Simulation of charge density wave effects in the layered van der Waals material GdTe₃ — ●SHEN VAN HASSEL¹, SERGI GRYSIUK¹, and MALTE RÖSNER^{1,2} — ¹Radboud University, Nijmegen, Netherlands — ²Bielefeld University, Bielefeld, Germany

In this study, we use *ab initio* downfolding techniques to demonstrate that the Fermi surface (FS) of the undistorted rare-earth tritelluride GdTe₃ can be accurately represented by a minimal tight-binding model derived from the in-plane *p*-orbitals of the Te bilayer. To examine the effect of the charge density wave (CDW) in GdTe₃, we expand our Hamiltonian to effectively model electron-phonon interactions by assuming and testing self-energy models within the Nambu-Gor'kov space. We calculate the spectral function, which agrees well with experimental ARPES data. Our results provide a simple and effective model for simulating CDW effects in GdTe₃, paving the way for a fully *ab initio* approach applicable to a broader class of materials.

TT 92.19 Thu 18:00 P4

Ultra-Low Temperature Fast QPI on Quantum Materials — ●ALEXANDER LAFLEUR, RIAN A.M. LIGHTHART, KEVIN HAUSER, GLEB NEPLYAK, and FABIAN D. NATTERER — Department of Physics, University of Zurich, Winterthurerstrasse 190, CH-8057, Switzerland

Scanning tunneling microscopy/spectroscopy (STM/S) is a powerful experimental technique capable of elucidating the hidden nature of many quantum materials and phases. The characterization of unconventional superconductors, topological insulators, heavy-fermion systems, Kagome superconductors, and Weyl semimetals, have been broadly pushed forward by atomic resolution STM/S imaging. Yet, for many candidate quantum materials, current techniques for acquiring STM data, such as energy-dependent local density of state (LDOS) maps, fall short of the energy resolution necessary to show definitive band structure characteristics of these phases. We propose to combine ultra-low temperature STM (330 mK) with Fast Quasi-Particle Interference (Fast QPI) techniques to increase the effective hold time and energy resolutions of LDOS Maps taken on quantum materials. The Fourier transform of Fast QPI, which uses parallel spectroscopy to simultaneously measure LDOS across many channels in frequency space, allows the energy dependent LDOS to be measured in a fraction

of the time of conventional dI/dV lock-in techniques. This increase in energy resolution given the time constraints of ultra-low temperature measurements holds the potential to demonstrate new and novel ob-

servable phenomena in quantum materials and the elusive states they harbor.

TT 93: Superconductivity – Poster II

Time: Thursday 18:00–20:00

Location: P4

TT 93.1 Thu 18:00 P4

The Search for 1144 Phases under Pressure — •LEONARD ESCH, KRISTIN KLIEMT, and CORNELIUS KRELLNER — Institute of Physics, Goethe University Frankfurt, Germany

Alternative stacking of 122 Fe-based pnictides has enabled the synthesis of the 1144 phase $ABFe_4As_4$ (A = alkali, B = alkaline earth). Examples include $CaKFe_4As_4$, where a *half-collapsed* tetragonal phase emerges under pressure, and $EuRbFe_4As_4$ or $EuCsFe_4As_4$, where Eu magnetism coexists with superconductivity [1,2]. Theoretical studies predict the stability of further 1144 Fe-arsenides and an extension to phosphides ($AB(TM)_4P_4$ where TM = Fe, Ru, Co, or Ni). Notably, $CaKRu_4P_4$ has been successfully synthesised [1]. This work investigates the synthesis of other 1144 phases under high-pressure conditions, designed to support the incorporation of smaller phosphorus atoms on arsenic lattice positions. Multi-anvil presses offer precise pressure and temperature control, large sample sizes, and adaptable setups for crystal growth research. In this contribution, we present the capabilities of a multi-anvil press, the challenges encountered during sample preparation, and outline the pathway to synthesising 1144 phases. A Walker-type module, previously utilized in our laboratory, contains a 6-8 anvil configuration within a steel cylinder [3]. The choice of pressure-transmitting medium and internal configuration is crucial to achieving the desired outcome in these experiments.

- [1] B. Q. Song *et al.*, Phys. Rev. Materials **5**, 094802 (2021)
- [2] U. S. Kaluarachchi *et al.*, Phys. Rev. B **96**, 140501 (2017)
- [3] A. A. Haghighirad *et al.*, Cryst. Growth Des. **8**, 1961 (2008)

TT 93.2 Thu 18:00 P4

MBE Growth and STM/STS Characterization of Monolayer and Bilayer Sb on NbSe₂ — •ZHAO MA, RUIJUN XI, and HAO ZHENG — Shanghai Jiao Tong Univ, Tsung Dao Lee Inst, Key Lab Artificial Struct & Quantum Control, Sch Phys & Astron, Shanghai 200240, Peoples R China

Two dimensional antimony (Sb) has attracted increasing interest due to its strong spin-orbit coupling, unprecedented level of structural tunability, and potential topological phases. The atomically flat surface, weak interlayer bonding, and superconducting ground state of NbSe₂ make it an ideal substrate for epitaxial growth of Sb. Studying Sb/NbSe van der Waals heterostructures enables investigation of growth behavior, electronic reconstruction, and possible interface driven phenomena. Furthermore, the combination may be a new strategy to achieve topological superconductors. By molecular beam epitaxy (MBE), we achieve controlled growth of monolayer (1L) and bilayer (2L) Sb on NbSe₂. By STM/STS, we characterize surface morphology, atomic structure, and electronic states.

TT 93.3 Thu 18:00 P4

Superconductivity, CDW, and quasiparticle interaction in 2H-TaS₂ probed by point contacts — •OKSANA KVNITSKAYA^{1,2}, YURI NAIDYUK², and BERND BÜCHNER¹ — ¹Leibniz-Institute for Solid State Research, IFW Dresden, Dresden, Germany — ²B. Verkin Institute for Low Temperature Physics and Engineering NAS of Ukraine, Kharkiv, Ukraine

Among Ta-based dichalcogenides, metallic 2H-TaS₂ exhibits physical properties that depend on its lattice perfection, vacancies, intercalation, and external pressure, etc. TaS₂ represents a classic example of a material in which charge density wave (CDW) order and superconductivity coexist and compete. Point contacts (PCs) propose a direct method for measuring electron-quasiparticle interaction by Yanson PC spectroscopy and superconducting gap via Andreev reflection. Also the phase transitions that affect electron transport can be detected using PC as a probe. In this report, we demonstrate the first PC study of 2H-TaS₂. Firstly, we observed enhanced T_c in produced PCs, which can reach up to 7 K, instead of 1 K in the bulk, and the critical magnetic field reaches up to 5T at 2K. The nonlinear current-voltage characteristics I(V) of PC also demonstrate features associated with the CDW

transition, which is evident in dV/dI as dips symmetrically placed with respect to zero-bias voltage. Still, electron-phonon interaction features are not resolved undoubtedly in PC spectra, instead quadratic dependence of dV/dI(V) points out that the electron-electron interaction can be dominant at low biases. These preliminary results are very intriguing and give impetus to their deeper investigation.

TT 93.4 Thu 18:00 P4

Comprehensive Optimization of Structural Properties, Flux Pinning, and EXAFS-Revealed Local Structure in HgO-Engineered BiPb-2223 Superconductors — •MUSTAFA SHALABY¹, AHMED SHALABY², DUC TRAN³, AN PHAM³, LATIF KHAN⁴, and MESSOUD HARFOUCHE⁴ — ¹NCRRT, Egyptian Atomic Energy Authority, Cairo, Egypt. — ²Egyptian Russian University. Badr City, Cairo, Egypt — ³Faculty of Physics, VNU University of Science, Hanoi, Vietnam — ⁴SESAME, P.O. Box 7, Allan 19252, Jordan

A systematic investigation of HgO nanoparticle enhancement in Bi_{1.6}Pb_{0.4}Sr₂Ca₂Cu₃O_{10-δ} (BiPb-2223) HTSC, with strategic incorporation of 1-2 wt% HgO nanoparticles demonstrates an increase in high-T_c Bi-2223 phase fraction from 69% to 78% while effectively suppressing the detrimental Bi-2212 phase. Cu K-edge EXAFS analysis unveils exceptional structural stabilization, with achieved electronic structure with Cu valence states (V_{Cu}) was 3.04, 2.87, and 3.1 for pristine and HgO-doped samples respectively, maintaining the critical Cu⁺²/Cu⁺³ mixed valence configuration necessary for superconducting behaviour in the CuO₂ planes. HgO works as a structural stabilizer rather than conventional substitutional dopant, evidenced by non-uniform distribution patterns and preserved superconducting frameworks. Critical current densities reach 900 A/m² at 10 K with irreversibility fields exceeding 100,000 Oe for the pure sample, while the 2% HgO composition exhibits optimized flux pinning force characteristics with J_c = 600 A/m² at 10K.

TT 93.5 Thu 18:00 P4

From surface to bulk: Superconductivity in doped γ-PtBi₂ — •JOSH KOCHUMMACHEN OOMMEN, MANASWINI SAHOO, LUMINITA HARNAGEA, SABINE WURMEHL, ANJA WOLTER-GIRAUD, and BERND BÜCHNER — Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany

Trigonal platinum bismuthide (γ-PtBi₂) has recently attracted significant interest due to the observation of superconductivity and its topologically protected surface states. So far, superconductivity has been detected only through surface-sensitive techniques such as ARPES and STM, with no signatures observed in bulk thermodynamic measurements. However, doped polycrystalline samples show bulk superconductivity. In this work, we investigate how chemical doping modifies this behaviour by studying PtBi_(2-x)A_x (A = Te, Pd) in single crystals. Introducing the dopants transforms the system from a surface-confined superconductor into a bulk superconductor. DC and AC susceptibility measurements reveal a clear superconducting transition between 2-2.4 K, with the transition temperature T_c strongly dependent on the dopant concentration. The emergence of bulk superconductivity suggests a doping-induced structural change from a non-centrosymmetric to a centrosymmetric phase, offering an intriguing route to tune the interplay between structure and superconductivity in γ-PtBi₂. These results highlight the potential of doped γ-PtBi₂ as a platform for exploring exotic superconducting states and understanding how topological surface states evolve into bulk superconductivity.

TT 93.6 Thu 18:00 P4

Nanoscale Characterization of Superconducting NbN Thin Films — •JANINE LORENZ^{1,2,3}, SVEN LINZEN⁴, MARIO ZIEGLER⁴, GREGOR OELSNER⁴, RONY STOLZ⁴, EVGENI IL'ICHEV⁴, THOMAS SMART¹, YORGO HADDAD¹, MARC NEIS¹, PAVEL BUSHEV¹, RAMI BARENDIS¹, F. STEFAN TAUTZ^{1,2,3}, and FELIX LÜPKE^{1,5} — ¹Peter Grünberg Institut, Forschungszentrum Jülich, Germany — ²Jülich

Aachen Research Alliance (JARA), Germany — ³Institut für Experimentalphysik IV A, RWTH Aachen, Germany — ⁴Leibniz Institute of Photonic Technology, 07702 Jena, Germany — ⁵II. Physikalisches Institut, Universität zu Köln, Germany

Due to their high kinetic inductance, niobium nitride (NbN) films have recently gained attention for their application in quantum phase-slip devices. In this study, we use scanning tunnelling microscopy to investigate the spatial variation of the superconducting order parameter of NbN films grown by atomic layer deposition (ALD). Despite the increased likelihood of defect formation associated with the use of organic precursors in ALD, our measurements reveal a remarkably uniform superconducting gap, which surpasses the reported values for sputtered NbN films. We attribute this to the well controlled thickness and small grain size of ALD grown films. For a 5 nm (4 nm) NbN film grown on a silicon (sapphire) substrate, we obtain an average BCS order parameter of 2.02 meV (1.59 meV), with a standard deviation of 0.04 meV (0.05 meV). This result highlights the high homogeneity of the superconducting order parameter in ALD-grown NbN films.

TT 93.7 Thu 18:00 P4

Development of Lenz lenses for NMR of micron-sized superconductors — ●P. SWATOSCH^{1,2}, H. KÜHNE¹, F. BÄRTL^{1,2}, and J. WOSNITZA^{1,2} — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL) and Würzburg-Dresden Cluster of Excellence ctd.qmat, HZDR — ²IFMP, TU Dresden

Nuclear magnetic resonance (NMR) experiments on novel superconductors are often limited in their sensitivity when only submillimeter-sized samples are available, as in this case only a few nuclear spins contribute to the measurement signal, resulting in a low signal-to-noise ratio. One approach to solving this problem is to locally focus the high-frequency magnetic field of the NMR experiment in the sample volume. For this, structured conductor geometries in the form of Lenz lenses can amplify and shape magnetic fields through targeted eddy currents. For this purpose, we have performed comprehensive numerical simulations of the spatial distribution of electromagnetic fields. Based on geometries that have already proven useful in earlier studies [1-3], we have modeled various designs and evaluated them with respect to their field-focusing capabilities and NMR signal. The results provide a basis for the fabrication of optimized Lenz-lens geometries for highly sensitive NMR measurements of small-volume samples.

[1] Meier *et al.*, Sci. Adv. **3**, eaao5242 (2017)

[2] Schoenmaker *et al.*, Rev. Sci. Instrum. **84**, 085120 (2013)

[3] Sprengler *et al.*, PLoS ONE **12**, e0182779 (2017)

TT 93.8 Thu 18:00 P4

physical properties of the superconductor NiBi₃ — ●PO-YUAN CHENG^{1,2}, SHAN-FU CHANG^{1,2}, PANG-SHUN KUO^{1,2}, and CHIEN-LUNG HUANG^{1,2} — ¹Department of Physics, National Cheng Kung University, Tainan 701, Taiwan — ²Center for Quantum Frontiers of Research & Technology (QFort), National Cheng Kung University, Tainan 701, Taiwan

We investigate the superconducting properties of the needle-like compound NiBi₃ by electrical resistivity and specific-heat measurements down to low temperatures. Both probes reveal a superconducting transition at a critical temperature $T_c = 4$ K, with an upper critical field $H_{c2} = 4$ kOe. High-pressure resistivity measurements up to 20 GPa show that T_c decreases linearly with pressure, which is consistent with phonon-mediated superconductivity. The temperature dependence of the electronic specific-heat is well described by a single-gap s-wave model. In conclusion, these experimental results demonstrate that NiBi₃ is a conventional BCS superconductor.

TT 93.9 Thu 18:00 P4

Optical Response of Multi-orbital Superconductors: Role of Fermi Surface Topology and Geometry — ●MEGHAD YAZDANI-HAMID¹, MEHDI BIDERANG², and AKBARI ALIREZA³ — ¹Department of Physics, Bu-Ali Sina University, 65178, 016016 Hamedan, Iran — ²Department of Physics, University of Toronto, 60 St. George Street, Toronto, Ontario M5S 1A7, Canada — ³Beijing Institute of Mathematical Sciences and Applications (BIMSA), Huairou District, Beijing 101408, China

Motivated by the sensitivity of Sr₂RuO₄ to Fermi surface reconstructions under strain, we investigate how Fermi surface geometry and Van Hove singularities influence the optical Hall response and polar Kerr effect. Within a three-orbital model, we explore the impact of chemical potential and interlayer hopping on superconducting pairing and re-

sponse functions. We find that $d_{x^2-y^2}$ and $d_{x^2-y^2} + ig$ symmetries are the leading candidates for the quasi-2D orbital, while a chiral p -wave state in the quasi-1D orbitals is essential for generating an accessible Kerr angle. Increasing interlayer hopping amplifies coherence factors, producing sharp signatures in T_c and optical transport. Inter-orbital charge transfer further enhances these effects by modifying the balance between quasi-1D and quasi-2D contributions. These results provide a framework for interpreting Kerr effect experiments in multi-orbital superconductors.

[1] M. Yazdani-Hamid, M. Biderang, A. Akbari, arXiv:2501.14254

TT 93.10 Thu 18:00 P4

Resistance Measurements of SmFe_{1-x}Co_xAsO single crystal — ●ASSEM ADAM¹, NILS-TORBEN HAHN¹, THOMAS TERÖDE¹, FRANZ-MICHEL ECKELT¹, RALPH WAGNER¹, CHRISTIAN HESS^{1,2}, BERND BÜCHNER², FELIX ANGER², and SABINE WURMEHL² — ¹Fakultät für Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, Wuppertal, Germany — ²Leibniz-Institut für Festkörper- und Werkstofforschung (IFW) Dresden, 01069 Dresden, Germany

Doped SmFeAsO has been discovered in the early days of Fe-based superconductivity. However, sizeable single crystals of this material have not been available for a long time. Here, we present resistance measurements of Co-doped SmFeAsO as a function of temperature. The data reveal well defined anomalies, presumably related to the structural and magnetic transitions in this compound. The evolution upon doping is discussed.

TT 93.11 Thu 18:00 P4

Pressure-driven evolution of upper critical field and Fermi-surface reconstruction in strong-coupling superconductor Ti₄Ir₂O — ●LIFEN SHI¹, BOSEN WANG^{2,3}, and JINGUANG CHENG^{2,3} — ¹Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — ²Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China — ³School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100190, China

We report on pressure-driven evolution of the superconducting transition temperature (T_c) and upper critical field $B_{c2}(0)$ of strong-coupling superconductor Ti₄Ir₂O that possesses an unusually large $B_{c2}(0)$ at ambient pressure (AP). Our results reveal an extremely low-pressure coefficients of T_c , i.e. $dT_c/dP = -0.047$ K/GPa for $P < 15$ GPa and -0.017 K/GPa for $15 < P < 50$ GPa, presumably associated with an inherent large bulk modulus of 252 GPa. Interestingly, we find that its $B_{c2}(0)$ undergoes a smooth crossover at 35.6 GPa from well beyond to less than the Pauli paramagnetic limit $B_{pBCS}(0) = 1.84T_c$; i.e., the $B_{c2}(0) = 18.2$ T = $1.7 B_{pBCS}(0)$ at AP decreases to 5.8 T = $0.88 B_{pBCS}(0)$ at 50 GPa. The density functional calculations predicted the possible occurrence of pressure-induced Fermi-surface reconstruction for the energy bands near the K point with strong spin-orbit coupling in 31-41 GPa. The present work sheds more light on this intriguing superconductor capable of resisting to large external compression and strong magnetic fields.

TT 93.12 Thu 18:00 P4

Fluxon mass in superconductors probed by circularly polarized terahertz radiation — ●ROMAN TESAR¹, MICHAL ŠINDLER¹, PAVEL LIPAVSKÝ², CHRISTELLE KADLEC¹, and JAN KOLÁČEK¹ — ¹Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic — ²Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

We employ an original method for detecting magnetic circular dichroism in YBCO thin films using FIR/THz laser radiation. The observed dichroism is clearly related to Abrikosov vortices (fluxons). Differential transmission of left- and right-handed circular polarization arises in the superconducting state under an applied magnetic field, but vanishes at zero magnetic field and in the normal state. Fluxon dynamics can be understood within a theoretical model that incorporates the fluxon mass, the equation of fluxon motion, and the interaction with circularly polarized light. The electric field drives a supercurrent that deflects fluxons via the Magnus effect perpendicular to the current flow. The resulting cyclotron motion of fluxons affects the supercurrent and thus the transmittance. We measured circular dichroism as a function of magnetic field and temperature at several laser frequencies for two YBCO samples with distinct doping. A good agreement with theoretical predictions allowed us to estimate the effective mass of a fluxon. Nevertheless, the fluxon mass still remains somewhat controversial and

not fully resolved. The presented experimental technique is also applicable for the investigation of cyclotron resonance in semiconductors and magnon modes in magnetic materials.

TT 93.13 Thu 18:00 P4

Statistics of the local spectral gap and order parameter in disordered superconducting films — JOHANNES DIEPLINGER¹, ANIMESH PANDA¹, ●ARPAN DAS¹, FERDINAND EVERS¹, and MATTHIAS STOSIEK^{2,3} — ¹Institute of Theoretical Physics, University of Regensburg, Universitaetsstrasse 31, 93053 Regensburg, Germany — ²Department of Applied Physics, Aalto University, Otakaari 24, 02150 Espoo, Finland — ³Physics Department, Technical University of Munich, James-Frank-Str. 1, 85748 Garching, Germany

The disorder-tuned superconductor-insulator transition has been a widely studied phenomenon that highlights the interplay between superconductivity and disorder. Local fluctuations in superconducting observables are crucial for understanding related effects, such as superconducting islands and the disorder-induced enhancement of the critical temperature. Using a self-consistent Bogoliubov-de Gennes Hamiltonian, we present a study of 2D disordered superconductors, focusing on the statistics of the local spectral gap and the local order parameter. We emphasise the fact that the similarity of three energy scales - the spectral gap E_g , the order parameter Δ , and the critical temperature T_c - is a peculiarity of clean superconductors. For instance, in the presence of disorder, the mean-field T_c can increase, while the mean $\langle \Delta(T=0) \rangle$ might even decrease. Further, we analyse the flow of the distribution functions of the local order parameter and the local spectral gap as disorder changes. At large disorder, the flow of the (mean-field) distribution functions exhibits a percolation-type transition that appears to have gone unnoticed so far.

TT 93.14 Thu 18:00 P4

nematic fluctuations and electronic correlations in heavily hole-doped $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$ probed by Elastoresistance — ●FRANZ ECKELT¹, XIAOCHEN HONG^{1,2}, STEFFEN SYKORA³, VILMOS KOCSIS³, VADIM GRINENKO⁴, KUNIHIRO KIHOU⁵, CHUL-HO LEE⁵, BERND BÜCHNER³, and CHRISTIAN HESS¹ — ¹University of Wuppertal, School of Mathematics and Natural Sciences, 42097 Wuppertal, Germany — ²Department of Applied Physics and Center of Quantum Materials and Devices, Chongqing University, 401331 Chongqing, China — ³Leibniz-Institute for Solid State and Materials Research, 01069 Dresden, Germany — ⁴Tsung-Dao Lee Institute, Shanghai Jiao Tong University, Shanghai 201210, China — ⁵National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki 305-8568, Japan

We measure the elastoresistance of $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$ in the strongly hole-doped regime using longitudinal and transverse configurations. The subsequent symmetry decomposition of the elastoresistance reveals a crossover from dominant nematic fluctuations in the B_{2g} channel at low doping to a correlation-driven A_{1g} contribution that becomes visible for $x > 0.7$. Complementary multi-orbital model calculations reproduce this doping evolution and indicate that strengthened electronic correlations in the d_{xy} orbital govern the observed A_{1g} response in the heavily hole-doped regime.

TT 93.15 Thu 18:00 P4

Atomic-scale visualization of the superconducting order parameter in the misfit compound $(\text{SnS})_{1.17}\text{NbS}_2$ — DONGMING ZHAO¹, ●SHAMARITA DEB^{1,2}, DMYTRO S. INOSOV², CLAUDIA FELSER¹, SUSHMITA CHANDRA¹, and JIAN-FENG GE¹ — ¹Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — ²Technical University of Dresden, 01062 Dresden, Germany

Misfit compounds are naturally stacked heterostructures, composed of layers with distinct sublattices. Owing to the incommensurate structural modulations and interlayer coupling, they can exhibit exotic phenomena such as Ising superconductivity and charge density waves. Here, we investigate the high-quality misfit superconductor $(\text{SnS})_{1.17}\text{NbS}_2$, a non-centrosymmetric superconductor composed of alternating Sn_2 and NbS_2 layers. Utilising scanning tunnelling microscopy, we obtained atomic-resolution images that clearly resolve, for the first time, both the square lattice on the SnS layer and the hexagonal lattice on the NbS_2 layer. Scanning tunnelling spectroscopy measurements further reveal well-defined superconducting gaps on both layers. Our ongoing experiments aim to visualise its superconducting order parameter with atomic resolution and to explore possible unconventional pairing mechanisms enabled by the intrinsic structural modulations.

TT 93.16 Thu 18:00 P4

Transport properties of superconducting misfit layered compound — ●TARUSHI AGARWAL, CHANDAN PATRA, POULAMI MANNA, SHASHANK SRIVASTAVA, PRIYA MISHRA, SUHANI SHARMA, and RAVI PRAKASH SINGH — Indian Institute of Science Education & Research Bhopal

Misfit layered compounds, naturally occurring bulk heterostructures, present a compelling alternative to artificially engineered ones, offering a unique platform for exploring correlated phases and quantum phenomena. This study investigates the magnetotransport and superconducting properties of the misfit compound $(\text{PbS})_{1.13}\text{TaS}_2$, comprising alternating PbS and 1H-TaS_2 layers. It exhibits distinctive transport properties, including a prominent planar Hall effect and a fourfold oscillatory anisotropic magnetoresistance. Moreover, it shows multigap 2D superconductivity with a high in-plane upper critical field, exceeding the Pauli limit. The coexistence of multigap superconductivity and anomalous transport within the same material firmly positions misfit compounds as an ideal platform for realizing quantum effects in the two-dimensional limit of bulk crystals. This opens the door to the development of quantum devices with less complexity and enhanced tunability.

TT 93.17 Thu 18:00 P4

High pressure magnetic measurements in Cr- and U-based superconductors — ●MEGHAN MOODY¹, RAN TAO¹, MADS HANSEN¹, CALLUM STEVENS², ZHEYU WU¹, THEODORE WEINBERGER¹, ANDREJ CABALA³, MICHAL VALIŠKA³, VLADIMIR SECHOVSKÝ³, ANDREW HUXLEY², ALEXANDER EATON¹, and MALTE GROSCHE¹ — ¹Cavendish Laboratory, University of Cambridge, UK — ²School of Physics and Astronomy, University of Edinburgh, UK — ³Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Mapping the high pressure phase diagram of unconventional superconductors can provide new insights into the nature of their superconducting and magnetic states. We present recent high pressure magnetic susceptibility and SQUID magnetisation measurements in d - and f -electron superconductors, focusing on the Cr-based Kagomé system CsCr_3Sb_5 and the field-resilient U-based superconductor UTe_2 . In the former, antiferromagnetic order is suppressed under pressure, giving way to a superconducting dome that peaks around 7 K at 4 GPa. In the latter, the superconducting transition line bifurcates at a moderate pressure of about 0.3 GPa, above which two transitions are observed in susceptibility and heat capacity measurements.

TT 93.18 Thu 18:00 P4

Granularity-induced higher harmonics in the Little-Parks effect of Kagome superconductors — ●ARTEM KOKOVIN¹, DANIEL SCHULTZ¹, and JÖRG SCHMALIAN^{1,2} — ¹Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany — ²Institut für Quantenmaterialien und Technologien, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany

We develop a theoretical framework for the emergence of higher-order harmonics in the Little-Parks oscillations observed in Kagome superconductors. Motivated by recent experiments suggesting that certain Kagome compounds exhibit pronounced granularity, an effect that appears to be enhanced by the onset of charge-density-wave order, we construct a two-stage model capturing the interplay of microscopic and mesoscopic physics. On the microscopic level, we derive the effective Josephson coupling of a granular structure, including higher-harmonic contributions to the coupling. On the mesoscopic level, we analyze the magnetic-field dependence of the superconducting free energy in the presence of these Josephson couplings, demonstrating how disorder and granularity convert these Josephson interactions into higher-order Little-Parks oscillations. Our central result is that such higher harmonics naturally arise when the underlying pairing state in Kagome materials is unconventional, providing a clear diagnostic for identifying nontrivial superconducting order in this family of systems.

TT 93.19 Thu 18:00 P4

Superconductivity in Mott Altermagnets — ●ROBIN SCHLEICHER and MARIA DAGHOFER — Institute for Functional Matter and Quantum Technologies, University of Stuttgart

Earlier studies on the Hubbard model have shown that the ground state of two holes in a small cluster lattice shows d-wave symmetry. While pairing by holes doped into half-filled Hubbard models has been intensively investigated, we extend such an analysis to the

case of doped strong-coupling altermagnets. In this new approach, we investigate differences to strong-coupling antiferromagnets as well as to weak-coupling superconductivity in altermagnets. To do so, we use exact diagonalization techniques for a checkerboard model. In our case, nodes in d-wave altermagnetism do not coincide with gap nodes

expected from the Hubbard model. We discuss the extend of d-wave superconductivity and its competition with other pairing symmetries. We find altermagnetism to suppress pairing compared to antiferromagnetism. We also discuss applications to inverted Lieb lattices relevant to Mott-altermagnet materials.

TT 94: Correlated Magnetism – Low-Dimensional Systems

Time: Friday 9:30–12:00

Location: HSZ/0101

TT 94.1 Fri 9:30 HSZ/0101

The zoo of states in the 2 dimensional Hubbard model — •ROBIN SCHOLLE¹, PIETRO BONETTI^{1,2}, DEMETRIO VILARDI¹, and WALTER METZNER¹ — ¹Max Planck Institute for Solid State Research, 70569 Stuttgart — ²Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

We use real-space Hartree-Fock theory to construct a magnetic phase diagram of the two-dimensional Hubbard model as a function of temperature and doping. We are able to detect various spin- and charge order patterns including Néel, stripe and spiral order without biasing the system towards one of them. For an intermediate interaction strength we predominantly find Néel order close to half-filling, stripe order for low temperatures or large doping, and an intermediate region of spiral order. We then combine the approach with the functional renormalization group method and are able to access the superconducting regime. I will give a short summary of the method followed by a presentation of our current results and an outlook for possible further applications.

TT 94.2 Fri 9:45 HSZ/0101

Kondo-driven magnetic instability in Van Hove metals with sparse impurities — •KRZYSZTOF WÓJCIK¹, JOHANN KROHA^{2,3}, and PETER WAHL^{3,2} — ¹Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznań, Poland — ²Physikalisches Institut, Universität Bonn, Germany — ³SUPA, School of Physics and Astronomy, University of St Andrews, United Kingdom

We analyze a metal exhibiting a higher-order Van Hove singularity at the Fermi level and hosting sparse randomly distributed magnetic impurities. We show that a sharp resonance in the impurity local spectral density, characteristic of typical Kondo systems, is absent in the Van Hove-Kondo case. Despite the Kondo singlet ground state, the impurities contribute to total entropy and magnetization by affecting the available excited states, and below a critical temperature for any finite density of impurities these contributions dominate over those of the clean host, leading to hitherto unrecognized instabilities. An especially intriguing instability occurs in the case of a particle-hole asymmetric singularity, such as the one recently observed in Sr₃Ru₂O₇ [1]. In such case, despite complete Kondo screening of the impurities, the host becomes magnetically unstable due to their presence, which leads to a ferromagnetic ground state. We comment on relation to the surface magnetism observed in Sr₃Ru₂O₇.

[1] C. A. Marques *et al.*, *Sci. Adv.* **8**, eabo7757 (2022).

TT 94.3 Fri 10:00 HSZ/0101

Crystal structure, electronic structure and magnetism in the binary compounds Cr₃S₄ and Cr₃Se₄ — •HELGE ROSNER¹, SEJIN KIM¹, YURI PROTS¹, VINCENT MORANDO², OKSANA ZAHARKO², JÖRG SICHELSCHMIDT¹, MARCUS SCHMIDT¹, and MICHAEL BAENITZ¹ — ¹Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany — ²Laboratory for Neutron Scattering and Imaging, 5232 Villigen PSI, Switzerland

Cr₃X₄ (X = S, Se) crystallises in a monoclinic lattice, structurally closely related to the rhombohedral chalcogenite delafossite-like systems AgCrX₂. In contrast to these intrinsically semiconducting materials with a nonmagnetic monovalent cation site, in Cr₃X₄ the distorted triangular CrX₂ layers are separated by a formally trivalent and magnetic ion. In consequence, the interlayer distance is strongly reduced, making the system more three dimensional, and thus strongly increasing the magnetic ordering temperature. Here, we present a joint experimental and theoretical study of the binary material Cr₃X₄, including thermodynamic measurements, high resolution XRD, neutron scattering and density functional band structure calculations. Our data consistently demonstrate that the metallic systems undergo an antiferromagnetic ordering up to 160 K which is strongly coupled to

the crystal lattice. The band structure calculations show that the conduction bands originate from strongly hybridised Cr-X states with sizeable spin-orbit interaction. In a detailed comparison, we will highlight similarities and differences between Cr₃X₄ and the chalcogenite delafossites, including samples with mixed occupation on the X site.

TT 94.4 Fri 10:15 HSZ/0101

Magnetic vector phases induced by spin-nematicity in high magnetic fields for two anisotropic quasi-1D chain compounds — •STEFAN-LUDWIG DRECHSLER¹, LORENZ WOLFRAM¹, RÖSSLER ULRICH¹, KUZIAN ROMAN², KLINGELER RÜDIGER³, SKOURSKII YURI⁴, ZOGLIN ELI⁵, WOLTER-GIRAUD ANJA¹, BÜCHNER BERND¹, and NISHIMOTO SATOSHI^{1,6} — ¹IFW-Dresden, Germany — ²DIPC, San Sebastian, Spain — ³Heidelberg University, Germ. — ⁴HLD-EMFL, Dresden, Germ. — ⁵Oak-Ridge, USA — ⁶TU-Dresden

We report and analyze pulsed high-field data near quasi saturation and low-*T* thermodynamic ones for Li₂CuO₂ up to 60 T and reanalyze the organic ladder compound verdazyl β-2,3,5 (V) measured at stationary fields below 12 T [1] exhibiting both cusps in the magnetic susceptibilities χ at low-*T* pointing to field induced magnetic vector phases due to the presence of spin nematicity according to a scenario proposed in [2] making visible the otherwise difficult to detect tensorial nematic order parameter. The symmetric and/or antisymm. spin symmetry as well as a subtle interplay of ferromagnetic (FM) and anti-FM couplings are essential for the appearance of 2-magnon bound states supported by the XYZ magnetism observed for Li₂CuO₂ and the low-symmetry crystalline structure for V, resp. For the former we report specific heat data at ambient field pointing possibly to the onset of a Bose condensation below 1 K of 3-magnon bound states as suggested in [3].

[1] H. Yamaguchi *et al.*, *J. Phys. Soc. Jpn.* **87**, 043701 (2018).

[2] A. Smerald *et al.*, *Phys. Rev. B* **91**, 174402 (2015).

[3] C. Agrapdis *et al.*, *Phys. Rev. Res.* **7**, 043051 (2025).

TT 94.5 Fri 10:30 HSZ/0101

Spins in Rotation: Probing anisotropy in YbAlO₃ — •LIPSA BEHERA^{1,2}, JAVIER LANDAETA², KONSTANTIN SEMENIUK², and ELENA HASSINGER³ — ¹Dresden University of Technology, Dresden, Germany — ²Max Planck Institute for Chemical Physics of Solids — ³Karlsruhe Institute of Technology

YbAlO₃ is an example of a quasi-one-dimensional S=1/2 spin-chain system with weak Ising-like interchain coupling. It has an interesting phase diagram for H//a with an anti-ferromagnetic order below 0.9 K, a field induced longitudinal spin-density wave phase, and a transverse anti-ferromagnetic state. It enters the field polarized state at 1.15 K. Here we present magnetic AC susceptibility measurements performed under rotation at 25 mK to study how sample misalignment influences the phase diagram and critical fields. We find that rotating towards the c-axis leaves the overall phases unchanged, with only the critical fields shifting to higher values. Rotation towards the b-axis, on the other hand produces some interesting results. A splitting of the susceptibility maxima (corresponding to the transition to the fully polarized state) is observed. This suggests the presence of two independent sublattices. Some critical fields move to lower values indicating more stability in the transverse direction. These results hold the potential to highlight intriguing quasi-1D physics.

15 min. break

TT 94.6 Fri 11:00 HSZ/0101

Magnetic characterization of the spin-ladder magnet Bi₂CuO₃(SO₄) — •RODOLFO A. RANGEL HERNANDEZ¹, ALEXANDER A. TSIRLIN¹, VICTORIA GINGA¹, KIRILL POVAROV², and SERGEY ZVYAGIN² — ¹University of Leipzig, Leipzig, Germany — ²Helmholtz-Zentrum, Dresden-Rossendorf, Dresden, Germany

We present the first comprehensive magnetic characterization of $\text{Bi}_2\text{CuO}_3(\text{SO}_4)$, a spin-ladder magnet with ferromagnetic rungs and antiferromagnetic legs. Heat-capacity, susceptibility and magnetization measurements reveal characteristic signatures of a gapped low-dimensional quantum magnet. Ab initio DFT+U calculations, together with a Wannier-function analysis and quantum Monte Carlo (QMC) simulations, are used to describe the magnetism of the ladder. By fitting the experimental susceptibility with QMC, we estimate a spin-gap of $\Delta \approx 20$ K and the leading exchange couplings to be $J' \approx -208$ K (rung) and $J \approx 243$ K (leg). Additionally, electron spin resonance confirms an extrinsic nature of the susceptibility upturn at low temperatures. Our result establishes $\text{Bi}_2\text{CuO}_3(\text{SO}_4)$ as a new realization of a spin-ladder with ferro- and antiferromagnetic interactions and provide reliable microscopic parameters for future research.

TT 94.7 Fri 11:15 HSZ/0101

Symmetry-Protected Topological Phase Diagrams of Dimerized Heisenberg Ladders — TIM OBROCK and ANAS ABDELWAHAB — Leibniz Universität Hannover, Institute für Theoretische Physik, Hannover, Germany

We present symmetry-protected topological phase diagrams of unfrustrated dimerized spin- $\frac{1}{2}$ ladders with perpendicular (J_\perp) and diagonal (J_d) rung couplings, studied as a function of dimerization (δ) and inter-wire coupling strength. For two perpendicularly coupled wires, our results reproduce the established picture from previous studies: antiferromagnetic rungs yield a trivial spin-0 phase, while ferromagnetic rungs drive the system into the Haldane symmetry-protected topological phase at small $|\delta|$, with critical lines converging to the dimerized spin-1 chain limit for $J_\perp \ll -1$.

For three perpendicularly coupled wires, earlier work has shown that antiferromagnetic rungs drive a transition from trivial ($\delta > 0$) to Haldane ($\delta < 0$). Under ferromagnetic rungs, the system approaches the dimerized spin- $\frac{3}{2}$ chain limit for $J_\perp \ll -1$, exhibiting a sequence of trivial*Haldane*trivial*Haldane phases as δ evolves from 1 to -1 .

Extending beyond these previous studies, we analyze the case of two and three diagonally coupled wires. For two wires, antiferromagnetic rungs produce a Haldane region bounded by $|\delta| \approx J_d/2$, containing the exact spin-1 chain limit at $J_d = 1$ and $\delta = 0$, while ferromagnetic rungs keep the system trivial. For three diagonally coupled wires, our results reveal a phase diagram with trivial and topological phases but without an apparent spin-chain limit.

TT 94.8 Fri 11:30 HSZ/0101

Self-consistent mean-field theory and continuous unitary transformations for ordered quantum antiferromagnets with long-range interactions — MAXIMILIAN BAYER¹, DAG-BJÖRN HERING², VANESSA SULAIMAN², GÖTZ UHRIG², and KAI SCHMIDT¹

TT 95.1 Fri 9:30 HSZ/0103

Saddle-point-nesting driven formation of charge order and superconducting vortex splitting on heavily hole-doped iron-arsenide superconductors — CHI MING YIM — Tsung-Dao Lee Institute & School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China

The study of iron-arsenide superconductor $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$ (BKFA) has re-sparked considerable interest following the recent discoveries in this material of superconductivity with broken time-reversal symmetry [1], superconducting vortices with fractional flux quantum [2], and quartic states [3]. Most studies focus on its bulk properties, with much less attention paid to its surface(s). This talk reports on our recent STM/S findings on the surfaces of BKFA in its heavily-hole doped regime: On the As- surface of BKFA ($x=0.77$), we observe of a density wave order with a 2×2 spatial periodicity, with clear-cut evidence(s) confirming its charge origin. Our calculation results indicate that its formation is saddle-point nesting driven. [4]. On the K- surface of multiband superconductor KFe_2As_2 studied under an external magnetic field, we observe splitting of vortices with integer flux quantum into those with appreciably reduced conductance, demonstrating the possibility of vortex core fractionalization in a multiband superconductor [5].

[1] Grinenko et al., Nat. Phys. 17, 1254 (2021)

— ¹Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — ²Condensed Matter Theory, Technische Universität, Dortmund, Germany

We investigate the antiferromagnetic Heisenberg model on a square lattice in the presence of algebraically decaying long-range interaction. The model is first studied using a fully self-consistent mean-field treatment going beyond linear spin-wave theory. We discuss the challenges and solutions to obtain numerical results of these long-range interacting systems using functional self-consistency equations familiar to the superconducting gap equation and a parametrisation using Epstein-zeta functions to capture the long-range behaviour without truncation in the system size. In a next step we go beyond the mean-field level and apply continuous similarity transformations (CST) in momentum space. The associated flow equations are truncated in the scaling dimension to capture consistently quantum fluctuations in the ordered phase in the same manner as for the case of nearest-neighbor interactions [1]. Our aim is to understand the one-magnon dispersion at low and high energies including the fate of the characteristic roton minimum.

[1] M. Powalski, G.S. Uhrig, K.P. Schmidt, PRL 115, 207202 (2015)

TT 94.9 Fri 11:45 HSZ/0101

Electric-field-driven flat band in a distorted generalized sawtooth chain — VADIM OHANYAN^{1,2}, LUSIK AMIRAGHYAN^{1,3}, MICHAEL SEKANIA^{4,5}, and MARCUS KOLLAR⁶ — ¹Laboratory of Theoretical Physics, Yerevan State University, 1 Alex Manoogian, 0025 Yerevan, Armenia — ²CANDLE, Synchrotron Research Institute, 31 Acharyan Str., 0040 Yerevan, Armenia — ³Institute of Applied Problems of Physics, 25 Hr. Nersisyan St, Yerevan 0014, Armenia — ⁴Rechenzentrum, University of Augsburg, 86135 Augsburg, Germany — ⁵Andronikashvili Institute of Physics, Javakishvili Tbilisi State University, Tamarashvili str. 6, 0177 Tbilisi, Georgia — ⁶Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

We investigate flat magnon bands in a sawtooth chain where symmetric exchange, DM interaction, and axial anisotropy differ on each side of the triangular plaquette. When the DM terms arises from the Katsura-Nagaosa-Balatsky (KNB) magnetoelectric mechanism, the corresponding DM coefficients become functions of the electric field and the lattice geometry. This dependence is governed by two bond angles, which become inequivalent under a distortion of the triangular plaquette. We derive the conditions under which an electric field, aligned along the lattice bonds, drives the one-magnon spectrum into a flat-band regime. The distortion angle dependence of the saturation field is examined as well. We construct a mapping from flat-band solution obtained for a general DM interaction into those arising from its KNB-induced form.

TT 95: Fe-based Superconductors

Time: Friday 9:30–11:45

Location: HSZ/0103

[2] Iguchi et al., Science 380, 1244 (2023)

[3] Shipulin et al., Nat. Commun. 14, 6734 (2023)

[4] Hu et al., Nat. Commun. 18, 253 (2025)

[5] Zheng et al., Arxiv 2407.18610 (2024)

TT 95.2 Fri 9:45 HSZ/0103

Measuring Nematic Fluctuations in FeSe under Hydrostatic and Chemical Pressure — ADRIAN MERRITT¹, AMIR HAGHIGHIRAD², DMITRY REZNIK³, AYMAN SAID⁴, AHMET ALATAS⁴, ALEXEI BOSAK⁵, MICHAELA SOULIOU^{2,5}, and FRANK WEBER² — ¹Karlsruher Institut für Technologie - PHI, 76049 Karlsruhe, Germany — ²Karlsruher Institut für Technologie - IQMT, 76344 Eggenstein-Leopoldshafen, Germany — ³University of Colorado, 80309, Boulder, Colorado, USA — ⁴Advanced Photon Source, Argonne National Laboratory, 60439, Illinois, USA — ⁵European Synchrotron Radiation Facility (ESRF), 38043 Grenoble, France

Nematic correlations in iron-based superconductors have been widely studied through phonon softening measured by INS and IXS. Softening of the transverse acoustic phonons near the tetragonal-orthorhombic transition reflects growing nematic fluctuations, which also appear near the superconducting transition, highlighting the competition between nematicity and superconductivity. Our earlier IXS work on FeSe and Co-doped Ba122 showed similar behavior with and without magnetism

and across the superconducting transition, suggesting that nematicity may hinder superconductivity.

Our most recent FeSe studies examine the effects of pressure, using both hydrostatic pressure and isoelectronic chemical pressure via S substitution. Both methods introduce magnetic phases and modify the structural transition order, opening a rich, otherwise inaccessible phase diagram. We present these results and compare how nematic fluctuations evolve across the different pressure-induced phases of FeSe.

TT 95.3 Fri 10:00 HSZ/0103

Magnetic-field-induced Sarma state in atomically thin superconducting FeSe films — •WANTONG HUANG^{1,2}, YUGUO YIN¹, HAICHENG LIN¹, WEI CHEN¹, YAOWU LIU¹, LICHEN JI¹, ZICHUN ZHANG¹, XINYU ZHOU¹, XUSHENG WANG¹, YONG XU¹, LIANYI HE¹, XI CHEN¹, QI-KUN XUE¹, and SHUAI-HUA JI¹ — ¹State Key Laboratory of Low-Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084, China — ²Physikalisches Institut (PHI), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Many-body ground states of imbalanced Fermi gas have long been studied both theoretically and experimentally due to their fundamental significance in condensed matter physics, cold atom physics and nuclear physics. Among the predicted exotic phases, the Sarma state, a gapless spin-polarized superfluid, has remained experimentally elusive. Here, we report direct evidence for the Sarma state in atomically thin FeSe films using a dilution-refrigerator scanning tunneling microscope under high magnetic fields. In the bilayer and trilayer FeSe films, we observe the hallmark signature of the Sarma state: the inner Zeeman splitting coherence peaks cross the Fermi level under high in-plane magnetic fields. The angle dependent critical field exhibits a two-fold symmetry arising from the anisotropic in-plane g-factor. Moreover, our two-band model shows that the magnetic field induced Sarma phase emerges via a first-order transition at zero temperature, which evolves into a smooth crossover at finite temperature. These findings pave the way to explore the unusual physical properties and potential applications of the spin-polarized Sarma superfluid state.

TT 95.4 Fri 10:15 HSZ/0103

Coupling of Vortex Bound States as a Probe of Majorana Physics in Iron-Based Superconductors — •RAIGO NAGASHIMA¹, IKSU JANG¹, and JÖRG SCHMALIAN^{1,2} — ¹Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — ²Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

Motivated by the widespread observation of zero or near-zero vortex bound states on the surfaces of FeSe_{1-x}Te_x and related iron-based superconductors, we investigate how these states evolve and interact as the magnetic-field-induced vortex density increases. Such coupling effects provide a powerful diagnostic of the underlying nature of the bound states. We compare the behavior expected for conventional Caroli-de Gennes-Matricon (CdGM) vortex states with that arising from Majorana zero modes in two-dimensional topological superconductors. To this end, we analyze the multi-vortex problem in the Fu-Kane model and compute the resulting hybridized bound-state wave functions. Our results reveal striking and qualitative differences between the coupling patterns of CdGM states and those of Majorana modes, demonstrating that the field-induced evolution of vortex bound states offers a clear and experimentally accessible fingerprint for identifying Majorana physics in iron-based superconductors.

TT 95.5 Fri 10:30 HSZ/0103

Intertwined superconductivity and orbital selectivity in a three-orbital Hubbard model for the iron pnictides — VITO MARINO^{1,2}, ALBERTO SCAZZOLA², FEDERICO BECCA³, MASSIMO CAPONE¹, and •LUCA F. TOCCHIO² — ¹International School for Advanced Studies (SISSA), Trieste, Italy — ²Politecnico di Torino, Italy — ³University of Trieste, Italy

We study a three-orbital Hubbard-Kanamori model relevant for iron-based superconductors, using variational wave functions which explicitly include spatial correlations and electron pairing. We span the nonmagnetic sector from filling $n = 4$, which is representative of undoped iron-based superconductors, to $n = 3$, where a Mott insulating state with each orbital at half filling is found. In the strong-coupling regime, we observe spontaneous differentiation in the occupation of the d_{xz} and d_{yz} orbitals, leading to an orbital-selective state with nematic character that becomes stronger with increasing density. One of these orbitals remains half-filled for all densities, while the other

hosts (together with the d_{xy} orbital) the excess electron density. Most importantly, in this regime, long-range pairing correlations appear in the orbital with the largest occupation. Our results highlight a strong link between orbital-selective correlations, nematicity, and superconductivity, which requires the presence of a significant Hund's coupling. The interplay with magnetism is also discussed.

[1] V. Marino, A. Scazzola, F. Becca, M. Capone, and L.F. Tocchio, PRL 134, 196502 (2025).

15 min. break

TT 95.6 Fri 11:00 HSZ/0103

Predicting isostructural collapses in the ThCr₂Si₂ structure type - fast and efficient — •ADRIAN VALADKHANI¹, PAUL CANFIELD², and ROSER VALENTI¹ — ¹Goethe Universität ITP, Frankfurt am Main, Germany — ²Ames National Laboratory, Ames, USA

Isostructural collapse transitions in tetragonal ThCr₂Si₂(122) compounds strongly affect magnetism, topology, and superconductivity, yet most studies treat materials on a case-by-case basis, making the overall approach computationally inefficient. Here, we present a general, efficient framework to predict isostructural collapses across the 122 family - readily extensible to other structure types. We classify collapsibility from the ambient-pressure unit cell using a linear, supervised classifier. In addition, an ambient-pressure calibration of the density-functional-theory-based calculations anchored to the experimental structure determines both the form of collapse and the critical pressure, if it exists. We validate the method against literature data and recent work on SrCo₂P₂, and we show how the same calibration subsequently enables efficient exploration of the pressure-dependent electronic structure. Because the procedure requires minimal experimental input and fast, efficient and standard computations, it is directly transferable to other structure families where isostructural transitions or distortions occur. This establishes a practical route for screening and designing materials with collapse-tunable functionalities.

We acknowledge support by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) for funding through TRR 288 - 422213477 (project A05)

TT 95.7 Fri 11:15 HSZ/0103

Inelastic neutron scattering study of magnetic fluctuations in iron germanides YFe₂Ge₂ and LuFe₂Ge₂ — •RAN TAO¹, JIASHENG CHEN¹, STEPHEN HODGSON¹, PHILIPP NIKLOWITZ², MALTE GROSCHE¹, TRAVIS WILLIAMS³, DAVID VONESHEN³, DEVASHIBHAI ADROJA³, PAUL STEFFENS⁴, ALEXANDRE IVANOV⁴, and ANDREA PIOVANO⁴ — ¹Cavendish Laboratory, University of Cambridge, UK — ²Department of Physics, Royal Holloway, University of London, UK — ³ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, UK — ⁴Insitut Laue-Langevin, Grenoble, France

The iron-based superconductor YFe₂Ge₂ ($T_c \simeq 1.8$ K) exhibits strong electronic correlations [1,2], and a prior neutron scattering study has demonstrated enhanced magnetic fluctuations [3]. The isoelectronic and isostructural sister compound LuFe₂Ge₂ orders antiferromagnetically with $Q_F = (0,0,1)$ below $T_N \simeq 6.5$ K, and in clean crystals shows a resistive superconducting transition below 1 K.

Our inelastic neutron scattering experiments in YFe₂Ge₂ indicate that the dynamic response near Q_F deviates from the commonly assumed overdamped oscillator form and could instead best be fitted with an underdamped form. A similar response is also seen in the sister compound LuFe₂Ge₂ in the paramagnetic phase. The similarities between the two materials suggest that resonant spin fluctuations may be a more general feature in iron germanides.

[1] J. Chen et al., Phys. Rev. Lett. **125**, 237002 (2020).

[2] J. Baglo et al., Phys. Rev. Lett. **129**, 046402 (2022).

[3] H. Wo et al., Phys. Rev. Lett. **122**, 217003 (2019).

TT 95.8 Fri 11:30 HSZ/0103

Local-moment magnetism in Mn-based pnictides — •MATTEO CRISPINO¹, NIKLAS WITT¹, TOMMASO GORNI², GIORGIO SANGIOVANNI¹, and LUCA DE' MEDICI² — ¹Institut für Theoretische Physik und Astrophysik und Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany — ²LPEM, ESPCI Paris, PSL Research University, CNRS, Sorbonne Université, 75005 Paris, France

We report a comprehensive study of electronic-correlation effects in Manganese-based antiferromagnetic pnictides BaMn₂Pn₂ (Pn=P,As,Sb,Bi). Our density functional theory plus slave-spin mean-

field simulations indicate that all the compounds lie on the strong-coupling side of an itinerant-to-localized moment crossover, corresponding to the critical interaction strength for the Mott transition

in the high-temperature paramagnetic phase. We also show that the experimental Néel temperature of each compound scales with the distance from this crossover.

TT 96: 2D Materials: Stacking and heterostructures (joint session O/HL/TT)

Time: Friday 9:30–12:30

Location: HSZ/0401

TT 96.1 Fri 9:30 HSZ/0401

A new fabrication method for metal intercalated epitaxial graphene devices — •MARC BOTHE¹, STEFAN WUNDRACK^{1,2}, MARCELO JAIME¹, KLAUS PIERZ¹, FRANK HOHLS¹, RAINER STOSCH¹, HANS WERNER SCHUMACHER¹, ANDREY BAKIN², and TERESA TSCHIRNER¹ — ¹Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — ²Institut für Halbleitertechnik, TU Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig, Germany

Epitaxial graphene grown on silicon carbide is a promising platform to achieve metal intercalation. It enables the creation of two-dimensional metal layers that are encapsulated and protected by graphene. However, the use of metal intercalated graphene samples for lithographic device fabrication presents two critical challenges. First, solvents used in the lithography process lead to the deintercalation of the metal atoms. Second, the presence of lattice defects in the graphene - necessary for the intercalation process - compromises the structural and electronic integrity of the device. We present a novel fabrication method that solves these problems. In our approach, the graphene devices are first pre-structured using lithography and subsequently intercalated. This is made possible by a spatial separation on the sample between the device structures and the intercalation origin and by intercalation channels that can guide the intercalation front reliably to the devices. We demonstrate this method on gallium intercalated epitaxial graphene Hall bars that exhibit superconducting behaviour.

TT 96.2 Fri 9:45 HSZ/0401

Anisotropic Strain Observation in Naturally Occurring Buckling on Twisted Bilayer Graphene: A Nano-Raman Study — •GUSTAVO SOARES¹, RAFAEL R. BARRETO¹, RAFAEL NADAS¹, KENJI WATANABE², TAKASHI TANIGUCHI², LEONARDO C. CAMPOS¹, LUIZ G. CANCADO¹, and ANGELO MALACHIAS¹ — ¹Physics Department, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, 31270-901, Brazil — ²National Institute for Materials Science, Tsukuba, Ibaraki, 3050047, Japan

This work investigates naturally occurring buckling and its relation with anisotropic strain relaxation in twisted bilayer graphene (tBG). In the tBG system a twist angle is imposed to influence graphene structural and electronic properties. Such condition directly implies in the occurrence of biaxial in-plane strain, with usual observation of buckled/wrinkled localized regions where the tBG morphology is no longer planar. Using tip-enhanced Raman spectroscopy, we conducted high-resolution mapping to analyze variations in Raman bands associated with twist angle variation and strain effects. Our findings reveal that localized strain gradients, modulated by twist angle variations, induce deterministic buckling in graphene layers, evidencing distinct uniaxial and biaxial strain regions. Finite element modeling further supports these observations, showing that buckling can store elastic energy sufficient to overcome usual tBG-substrate adhesion forces.

TT 96.3 Fri 10:00 HSZ/0401

Kirkendall Voids in Monolayer $\text{Mo}_x\text{Ta}_y\text{S}_2$ Alloys on Au(111) — KAI MEHLICH¹, THAIS CHAGAS¹, FRANCIS H. DAVIES^{2,3}, ALESSIA BARDAZZI¹, CATHERINE GROVER¹, ARKADY V. KRASHENINNIKOV³, and •CARSTEN BUSSE¹ — ¹Department Physik, Universität Siegen, Walter-Flex-Straße 3, 57072 Siegen, Germany — ²Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — ³Department of Physics and Astronomy, University of Exeter, Stocker Road, Exeter, EX4 4QL United Kingdom

During the growth of monolayer MoS_2 - TaS_2 heterostructures, we observe the Kirkendall effect: Diffusing vacancies agglomerate in MoS_2 , forming what are commonly termed Kirkendall voids - here manifesting as holes in the 2D layer. This phenomenon has not been previously reported in systems with reduced dimensionality.

We prepare the lateral heterostructures by reactive molecular beam

epitaxy on chemically inert and weakly interacting Au(111). First, compact MoS_2 cores are grown. In a second step, TaS_2 is added in a sulfur-rich environment at elevated temperatures which promotes diffusion at the interface. The resulting heterostructures exhibit characteristic 2D Kirkendall holes surrounded by a $\text{Mo}_x\text{Ta}_y\text{S}_2$ alloy region. These findings reveal defect-mediated processes in low-dimensional systems and open new avenues for designing 2D lateral heterostructures with intricate morphologies.

TT 96.4 Fri 10:15 HSZ/0401

Designing 2D Non-van der Waals Heterostructures — •ANASTASIIA NIHEI^{1,2}, TOM BARNOWSKY^{1,2}, and RICO FRIEDRICH^{1,2} — ¹TU Dresden — ²Helmholtz-Zentrum Dresden-Rossendorf

Heterostructure interfaces created by stacking two-dimensional (2D) materials offer a pathway to realizing advanced electronic and magnetic functionalities at the nanoscale. In this work, we present a high-throughput screening of non-van der Waals (non-vdW) 2D heterostructures; including sandwich-like stacking. Non-van der Waals 2D materials can be obtained by both top-down exfoliation as well as bottom-up growth approaches of non-layered bulk crystals [1]. Our approach uses the AFLOW-Hetbuilder - a newly developed tool for stacking 2D systems based on the coincidence lattice algorithm [2-4].

We investigate interfacial binding effects across a wide range of heterobilayers [5] and sandwich-like systems, analyzing their structural, electronic, and magnetic characteristics such as hybrid interface bands and robust magnetic coupling. Furthermore, we compare the binding energetics of non-vdW and conventional vdW heterostructures. The tunable interfacial properties of non-vdW 2D heterostructures provide a versatile platform for advanced functionalities with potential applications in electronics, spintronics, and the energy sector [5].

[1] R. Friedrich *et al.*, Nano Lett. **22**, 989, (2022).

[2] D.S. Koda *et al.*, J. Phys. Chem. C **120**, 10895, (2016).

[3] <https://zenodo.org/record/4721346>.

[4] S. Divilov *et al.*, High Entropy Alloys Mater. **3**, 178 (2025).

[5] A. Nihei, *et al.*, arXiv DOI: 10.48550/arXiv.2503.12209 (2025).

TT 96.5 Fri 10:30 HSZ/0401

Second-Order Nonlinear Imaging for Probing 2D van der Waals Structures — •TAO YANG¹, BEN JOHN¹, KYOUNG P. LEE², NASIM MIRZAJANI¹, MARTIN WOLF¹, XIAOQIN LI², MARTIN THAEMER¹, ALEXANDAR PAARMANN¹, NICLAS S. MUELLER³, and ALEXANDER P. FELLOWS¹ — ¹Fritz Haber Institute, Berlin, Germany — ²University of Texas at Austin, Austin, USA — ³Freie Universität Berlin, Berlin, Germany

Twisted and stacked multi-layer architectures offer new opportunities for tailoring the electronic and optical properties of two-dimensional (2D) van der Waals materials. Reliable determination of crystal structure, stacking sequence, and twist angle is therefore crucial. Second-order nonlinear optical microscopy, including second-harmonic and sum-frequency generation (SHG and SFG, respectively), provides high sensitivity to crystal symmetry and orientation in non-centrosymmetric lattices. Recently, we employed heterodyne-detected vibrational SFG microscopy to probe the local structure of hexagonal Boron Nitride (hBN) monolayers with sub-micron resolution. By employing our developed azimuthal-scanning approach, we fully resolved the crystallographic structure and edge termination in monolayer flakes. Here, we extend these measurements to multi-layer hBN structures, using the same azimuthal-scanning approach in a newly developed SHG microscope to gain insight into their different stacking configurations. Our results highlight second-order nonlinear microscopy as a powerful tool for quantitative structural analysis in 2D materials and for future studies of moiré and twisted heterostructures.

TT 96.6 Fri 10:45 HSZ/0401

Moiré-Driven Electronic Modulations in Weakly Coupled h-BN/Graphite — •FÁBIO J. R. COSTA^{1,2,7}, DANIEL ARRIBAS², THIAGO G. L. BRITO², TIN S. CHENG³, JONATHAN BRADFORD³, AMELIA

THOMPSON³, ALEX SAYWELL³, CHRISTOPHER J. MELLOR³, PETER H. BETON³, SERGEY V. NOVIKOV³, JULIETTE PLO⁴, BERNARD GIL⁴, GUILLAUME CASSABOIS^{4,5}, LUIZ F. ZAGONEL¹, KLAUS KUHNKE², KLAUS KERN^{2,6}, and ANNA ROSLEWSKA² — ¹University of Campinas, Brazil — ²Max-Planck-Institut für Festkörperforschung, Germany — ³University of Nottingham, UK — ⁴Laboratoire Charles Coulomb, France — ⁵Institut Universitaire de France, France — ⁶EPFL, Lausanne, Switzerland — ⁷Current address: Université de Strasbourg, CNRS, IPCMS, Strasbourg, France

Van der Waals materials and their heterostructures offer exciting opportunities for next-generation nanophotonic and electronic technologies. Their electronic and optical properties can be modulated by moiré superlattices that emerge when mismatched layers are stacked together. Hexagonal boron nitride (h-BN) is a key platform in this context, yet the influence of moiré patterns on weakly interacting h-BN interfaces remains underexplored. Here¹, we use scanning tunneling microscopy to resolve large moiré superlattices in h-BN/graphite and uncover pronounced nanoscale modulations of the electronic landscape, despite their weak interlayer interactions. These findings position moiré engineering in h-BN as a powerful tool to tailor local functionalities in van der Waals heterostructures. Ref.: 1. Fábio J. R. Costa *et al.* ACS Nano 2025 19 (40), 35528-35538

TT 96.7 Fri 11:00 HSZ/0401

μ -ARPES study on the fine electronic structure of misfit layer compound (PbSe)1.16(TiSe2)2 — •HARUKI MURAMATSU¹, NATSUKI MITSUISHI^{2,3}, TEPPEI UENO⁴, KENICHI OZAWA⁵, KAYA KOBAYASHI^{4,6}, and KYOKO ISHIZAKA^{1,2} — ¹Dept. of Appl. Phys. & QPEC, Univ. of Tokyo — ²CEMS, RIKEN — ³Grad. Sch. Sci., Nagoya Univ. — ⁴Dept. of Physics, Okayama Univ. — ⁵KEK-PF — ⁶RIES, Hokkaido Univ.

Misfit layered compounds have been attracting significant attention due to their lattice mismatches and resultant two-dimensional electronic structures reminiscent of van der Waals heterostructures. One such compound, (PbSe)1.16(TiSe2)2, consists of alternating stacking of PbSe monolayers (NaCl-type, four-fold symmetry) and TiSe2 bilayers (CdI2-type, three-fold symmetry). To elucidate its electronic structure, we performed μ -ARPES measurements by carefully distinguishing the cleavage surface terminations. In the presentation, we will discuss the novel electronic states reflecting the natural incommensurate heterostructure as well as charge density wave in the buried TiSe2 bilayer.

TT 96.8 Fri 11:15 HSZ/0401

Twisted NbSe₂ heterostructures — •ALEXANDER BÄDER^{1,2}, CLARA PFISTER^{3,4}, TOBIAS WICHMANN^{1,5}, LAURA PÄTZOLD^{3,4}, TIM O. WEHLING^{3,4}, and FELIX LÜPKE^{1,2} — ¹Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich — ²II. Physikalisches Institut, Universität zu Köln — ³I. Institute of Theoretical Physics, U Hamburg — ⁴The Hamburg Centre for Ultrafast Imaging — ⁵Institut für Experimentalphysik IV A, RWTH Aachen

We fabricated monolayers (MLs) of the van der Waals material NbSe₂ that are rotated with respect to the underlying bulk NbSe₂ using our developed ultra-high vacuum (UHV) stacking technique. These heterostructures were characterized through the use of scanning tunneling microscopy and spectroscopy at a base temperature of 1.4 K. The MLs realize a variety of twist angles relative to the underlying bulk lattice, with the lowest observed twist angle being 10°. The MLs display the coexistence of charge density waves (CDW) and moiré effects: In the absence of strain, the MLs develop a 3 × 3 CDW, however the application of strain through interfacial disorder results in a 2 × 2 CDW state, supported by theoretical calculations. Compared to isolated MLs the superconducting order parameter is enhanced due to the proximity effect from the underlying bulk.

TT 96.9 Fri 11:30 HSZ/0401

band structure and charge density wave in a natural van der Waals heterostructure 4Hb-TaSe₂ — •FUMIHIKO KIMURA¹, TOMOKI MAEDA², NATSUKI MITSUISHI^{3,4}, KAZUKI OKADA², TAKUYA NOMOTO⁵, KENICHI OZAWA⁶, MASAHIRO NARITSUKA³, TETSUO HANAGURI³, SHUNSUKE KITOU⁷, YUIGA NAKAMURA⁸, TAKA-HISA ARIMA^{3,7}, TAKAO SASAGAWA², and KYOKO ISHIZAKA^{1,3} — ¹Quantum-Phase Electronics Center & Department of Applied Physics, The University of Tokyo — ²Laboratory for Materials and Structures, Science Tokyo — ³RIKEN CEMS — ⁴Graduate School of Science, Nagoya University — ⁵Department of Physics, Tokyo Metropolitan University — ⁶Institute of Materials Structure Science, High energy Accelerator

Research Organization (KEK) — ⁷Department of Advanced Materials Science, The University of Tokyo — ⁸Japan Synchrotron Radiation Research Institute (JASRI), SPring-8

4Hb-TaSe₂ is a natural van der Waals heterostructure charge density wave (CDW) material consisting of alternative stacking of monolayer 1T-TaSe₂ (Mott insulator with Star-of-David CDW) and monolayer 2H-TaSe₂ (superconductor with 3 by 3 CDW). Although transport measurements have suggested the existence of multiple CDWs, the details of the CDW and electronic structures remain unclear. In this study, we directly observed the electronic structure of 4Hb-TaSe₂ by micro-focused angle-resolved photoemission spectroscopy with careful selection of the surface terminations. We discuss the temperature dependent electronic structure with comparison to the CDW structures obtained by scanning tunneling microscopy and X-ray diffraction.

TT 96.10 Fri 11:45 HSZ/0401

Coexisting charge density waves in twisted NbSe₂ bilayers — •CHRISTOPHER TAT SHUN CHEUNG¹, ZACHARY A. H. GOODWIN², YIXUAN HAN³, JIONG LU³, ARASH A. MOSTOFI¹, and JOHANNES LISCHNER¹ — ¹Departments of Physics and Materials and the Thomas Young Center for Theory and Simulation of Materials, Imperial College London, London SW7 2AZ, U.K. — ²Institute for Functional Intelligent Materials, National University of Singapore, Singapore 117544, Singapore — ³Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom

Twisted bilayers of semiconducting transition metal dichalcogenide (TMD) monolayers have been studied extensively. In contrast, twisted bilayers composed of metallic monolayers, such as NbSe₂, remain less understood.

Monolayer NbSe₂ can host different types of charge density waves (CDWs), in which the Nb atoms move away from their high-symmetry positions. In twisted bilayer NbSe₂, identifying CDWs in relaxed structures is challenging because atomic relaxations occur both because of CDW formation and also because of the moiré pattern.

We have carried out large-scale first-principles calculations using density functional theory to study the moiré relaxations and CDWs in twisted bilayer NbSe₂. We have developed methods for revealing the CDWs, and for locally classifying the type of CDW. We find that different types of CDWs coexist in the moiré unit cell due to the interactions with strain induced by moiré relaxations [1].

[1] Cheung et al, Nano Lett. 2024, 24, 12088-12094.

TT 96.11 Fri 12:00 HSZ/0401

MicroARPES studies of contact doping of monolayer transition metal dichalcogenides by RuCl₃ — •THOMAS NIELSEN¹, EDVARD SOLBREKKEN¹, ALFRED J. H. JONES¹, ZHIHAO ZHANG¹, CHAKRADAR SAHOO¹, KENJI WATANABE², TAKASHI TANIGUCHI², JILL A. MIWA¹, SØREN ULSTRUP¹, CHRISTIAN OVERBY¹, and CHRISTIAN V-B. FOKDAL¹ — ¹Aarhus University, Denmark — ²National Institute for Materials Science, Japan

Placing van der Waals materials into contact with α -RuCl₃ has recently emerged as a method of modulating their electronic structures. The proximity to α -RuCl₃ has been observed to produce strong hole doping in the van der Waals material, and this has been established as a method to create better electrical contacts in transistor devices based on monolayer transition metal dichalcogenides (TMDs). Here, we use the microARPES endstation at the ASTRID2 synchrotron light source at Aarhus University in Denmark to study the valence bands and core levels of semiconducting monolayer TMDs in proximity to α -RuCl₃. We observe a large valence-band shift of 0.7–0.8 eV indicating strong hole doping. α -RuCl₃ is highly sensitive to the temperatures and chemicals typically used in the dry-transfer fabrication procedures of van der Waals heterostructures. How the degradation of α -RuCl₃ affects the proximity-induced doping of the TMD is discussed based on the ARPES measurements.

TT 96.12 Fri 12:15 HSZ/0401

STEM Investigation of Entropy Forbidden Ordering in CVD Grown WSe₂-MoSe₂ Alloys — •MAX BERGMANN¹, MATVEI KISLITSYN¹, JULIAN PICKER², JÜRGEN BELZ¹, ROBIN GÜNKEL¹, BADROSADAT OJAGHI DOGAHE¹, SHAMAIL AHMED¹, ANDREY TURCHANIN², and KERSTIN VOLZ¹ — ¹mar.quest | Marburg Center for Quantum Materials and Sustainable Technologies, Philipps-Universität Marburg, 35032 Marburg, Germany — ²Faculty of Chemistry and Earth Sciences, Friedrich-Schiller-Universität, 07743 Jena, Germany

2D transition metal dichalcogenides have gained significant interest due to their optoelectronic properties, which can be tailored by structural variation. However, controllable production, namely growth, of such tailored structures still remains a key challenge towards large-scale production. In this study, we show lateral heterostructures of 2D MoSe₂ and WSe₂, grown on a SiO₂ TEM grid by chemical vapor deposition, that at the interface show a highly ordered structure of W and Mo atoms at the TMD positions, as observed by scanning transmission

electron microscopy. This is in contrast to *ab initio* calculations, which ascribe unordered alloys as the preferred configuration, since entropy is the main driving force compared to formation enthalpy. We link this unexpected phenomenon to the initial nucleation of the material on a clean MoSe₂ crystal edge, present before the alloy growth, together with special precursor chemistry. Furthermore, we show *ab initio* results in conjunction with the special quasirandom structure method on the bandstructure and optical properties of this structure.

TT 97: Superconducting Diodes and Ratchets

Time: Friday 9:30–12:00

Location: CHE/0089

TT 97.1 Fri 9:30 CHE/0089

Josephson Diode Effect of All-Metallic Lateral Junctions with Interfacial Rashba Spin-Orbit Coupling — ●MAXIMILIAN MANGOLD^{1,2}, LORENZ BAURIEDL³, JOHANNA BERGER³, CHANG YU-CHENG⁴, THOMAS N.G. MEIER^{1,2}, MATTHIAS KRONSEDER³, PERTTI HAKONEN⁵, CHRISTIAN H. BACK^{1,2}, CHRISTOPH STRUNK³, and DHAVALA SURI^{1,6} — ¹School of Natural Sciences, Technical University of Munich, Garching b. Munich, Germany — ²Center for Quantum Engineering (ZQE), Technical University of Munich, Garching b. Munich, Germany — ³Department of Physics, University of Regensburg, Regensburg, Germany — ⁴Pico Group, QTF Centre of Excellence, Department of Applied Physics, Aalto University, Aalto, Finland — ⁵Low Temperature Laboratory, Department of Applied Physics, Aalto University, Espoo, Finland — ⁶Centre for Nanoscience and Engineering, Indian Institute of Science, Bengaluru, India

The Josephson diode effect (JDE) is investigated in diffusive Josephson junctions incorporating only metallic materials. We find a magnetochiral anisotropy in the JDE for devices with Fe/Pt and Cu/Pt weak links between Nb leads. The observed symmetry corresponds to Rashba spin-orbit coupling (SOC). In a simple Cu junction without a structural inversion asymmetry, the diode efficiency is finite, but field-angle independent. Our results suggest the generality of Rashba SOC for the JDE beyond the realm of high-mobility systems. Additionally, we observe an inverted hysteresis in the Fraunhofer patterns of all samples and explain it based on the critical state model of strongly pinned vortices without relying on SOC.

TT 97.2 Fri 9:45 CHE/0089

Giant anomalous Josephson effect as a probe of spin texture in topological insulators — NIKLAS HÜTTNER¹, ANDREAS COSTA¹, LEANDRO TOSI², MICHAEL BARTH¹, WOLFGANG HIMMLER¹, DMITRIY A. KOZLOV¹, LEONID GOLUB¹, KLAUS RICHTER¹, JAROSLAV FABIAN¹, DIETER WEISS¹, CHRISTOPH STRUNK¹, and ●NICOLA PARADISO¹ — ¹University of Regensburg, Germany — ²Grupo de Circuitos Cuánticos, Bariloche, Argentina

Topological-insulator surface states are chiral 2D electron systems with spin-momentum locking. Josephson junctions based on such states show nonreciprocal supercurrent features if time reversal symmetry is broken. For example, they show a finite phase at zero current, i.e., an anomalous Josephson effect. I will present φ_0 measurements on junctions with HgTe nanowires as weak link. We detect an exceptionally large anomalous phase shift in the current-phase relation. We attribute this giant φ_0 -shift to the single Fermi-surface contour of HgTe surface states, a key distinction from Rashba systems with two counteracting Fermi contours. By rotating the in-plane magnetic field, we probe the spin texture in momentum space. Interestingly, we find that the spin deviates by 19 degrees from the orientation perpendicular to the momentum. Our findings demonstrate that the anomalous Josephson effect provides a powerful and sensitive probe of the spin texture in chiral two-dimensional systems.

TT 97.3 Fri 10:00 CHE/0089

Josephson diode effect in superconducting hybrids with altermagnets — ●JANUS F. NIEBUHR, DANILO NIKOLIĆ, and MATTHIAS ESCHRIG — Institut für Physik, Universität Greifswald, Felix-Hausdorff-Straße 6, 17489 Greifswald

We present a systematic theoretical study of a ballistic Josephson junction consisting of a *d*-wave altermagnet (AM) placed between two conventional superconducting leads (S). The study is done by making use of the quasiclassical Green's function method considering two regimes of (i) a weakly and (ii) a strongly spin polarized altermagnet. The

former regime in the limit of highly transmissive S/AM interfaces allows for an analytic treatment. The resulting Josephson current-phase relation (CPR) exhibits $0 - \pi$ transitions. These significantly depend on the altermagnet's crystal orientation relative to the junction's axis by the display of a dominant second harmonic close to the transition. In the regime of strong spin polarization, the altermagnet is coupled to the superconductors via two spin-dependent interfaces, necessary for the creation of equal-spin triplets, which now entirely mediate the current. For a non-coplanar magnetization profile, a quantum-geometric phase emerges. This phase is coupled to spin and enters the Josephson CPR similarly to the phase difference. Consequently, depending on the altermagnetic crystal orientation, the CPR displays an anomalous Josephson effect, as well as a Josephson diode effect. Finally, we perform a harmonic analysis of the CPR discussing the effects in terms of the number of coherently transferred Cooper pairs across the altermagnet.

TT 97.4 Fri 10:15 CHE/0089

Field-Free Superconducting Diode and Topological FFLO States in Altermagnetic Shiba Chains — ●DIBYENDU SAMANTA and SUDEEP KUMAR GHOSH — Indian Institute of Technology, Kanpur 208016, India

The superconducting diode effect (SDE), characterized by a directional asymmetry in the critical supercurrents, typically requires external magnetic fields to break time-reversal symmetry-posing challenges for device integration. Here, we demonstrate a field-free realization of the SDE in a helical Shiba chain proximitized by a *d*-wave altermagnet. Using a self-consistent Bogoliubov-de Gennes approach, we uncover a topological Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) superconducting state hosting tunable Majorana zero modes at the chain ends. This state, stabilized by the interplay between the exchange coupling of magnetic adatoms and the induced altermagnetic spin splitting, can be tuned by an applied supercurrent. Crucially, the same FFLO phase supports strong nonreciprocal supercurrents, achieving diode efficiencies exceeding 45% without applied magnetic fields. The *d*-wave altermagnet simultaneously breaks time-reversal and inversion symmetries via momentum-dependent spin splitting, enabling both topological superconductivity and the field-free SDE in a junction-free setting. Our findings establish Shiba chain-altermagnet heterostructures as a scalable platform for supercurrent-tunable topological superconductivity and intrinsic, field-free superconducting diodes for dissipationless quantum technologies.

TT 97.5 Fri 10:30 CHE/0089

Current pulse manipulation of the superconducting diode effect in FeSe — ●ROEMER HINLOPEN¹, LINUS HOLESCHOVSKY¹, REBECCA NICHOLLS², NIGEL HUSSEY^{2,3}, CARSTEN PUTZKE¹, and PHILIP MOLL¹ — ¹Max Planck Institute for Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany — ²University of Bristol, HH Wills Laboratory, Tyndall Avenue, BS8 1TL Bristol, UK — ³High Field Magnet Laboratory (HFML-FELIX) and Institute for Molecules and Materials, Radboud University, Nijmegen 6525ED, Netherlands

The superconducting diode effect (SDE) has seen a surge in popularity in recent years for its potential technological applications. However, switching the sign of the SDE usually relies on reversing the polarity of the applied magnetic field on specifically designed device architectures which break the necessary symmetries. In this talk, we present a new means of control for the intrinsic SDE through microsecond current pulsing. We use focused ion beam (FIB) machining to create single crystalline devices of the strongly correlated nematic superconductor FeSe. We observe a clear intrinsic diode effect with efficiency up to 30 %,

which remains observable to a record applied magnetic field of 12 T. Our central result is that by sending intense microsecond current pulses through the device, we can deterministically manipulate the sign and strength of this SDE. This finding opens a new channel to control the SDE in devices and potentially realise a zero-field switchable device in the future.

15 min. break

TT 97.6 Fri 11:00 CHE/0089

Nonreciprocal Magnon Fluxonics — ●OLEKSANDR DOBROVOLSKIY — Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Braunschweig, Germany

Fluxon dynamics controls the magneto-resistive response of superconductors (S) and becomes nonreciprocal under symmetry break [1]. Magnons - the quanta of spin waves in magnetic materials - are attracting increasing attention as information carriers [2]. In my talk, I will introduce magnon fluxonics as a subdomain of superconducting spintronics. I will discuss nonreciprocal spin-wave dynamics in dipole-coupled superconductor/ferromagnet heterostructures, focusing on two effects. (i) Within the "ratchet window", the application of an AC current to S enables magnon bandgap tuning during one half-wave, while the bandgap frequencies remain constant during the other. This effect arises from the Doppler shift and the nonlinear spin-wave dispersion. (ii) At higher velocities, on the order of a few km/s, the moving vortex lattice excites magnons unidirectionally along the direction of vortex motion. This regime occurs when the wavevector (momentum) and frequency (energy) of the magnons match those of the fluxons, thereby fulfilling the Cherenkov resonance condition [3]. These results demonstrate how the well-studied superconducting diode or ratchet effects can enrich other research areas and enable new functionalities of non-reciprocal steering and unidirectional generation of spin waves.

[1] Kochan & Strunk, Nat. Electr. 8 (2025) 380.

[2] Chumak et al., IEEE Trans. Magnet. 58 (2022) 0800172.

[3] Dobrovolskiy et al., Nat. Nanotechnol. (2025).

<https://doi.org/10.1038/s41565-025-02024-w>.

TT 97.7 Fri 11:15 CHE/0089

Spin-wave-induced giant ratchet effect in superconductor-ferromagnet heterostructures — ●ANTON POKUSINSKYI and OLEKSANDR DOBROVOLSKIY — Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany

Superconducting vortex ratchets enable directed motion of magnetic flux quanta under zero time-average forces and thus act as rectifiers in superconducting circuits. Recent diode realizations exploiting asymmetric edge barriers in superconducting NbN and V/EuS microstructures have achieved ratchet efficiencies of 35-50% [1-3]. However, their tunability remains limited by fixed geometries or magnetic-field reversal, constraining scalability and dynamic control. Here, we theoretically predict a tunable giant ratchet effect in superconductor-ferromagnet heterostructures, arising from the coupling between moving fluxons and spin waves—collective precessions of spins in the ferromagnetic layer. Our modeling, based on time-dependent Ginzburg-Landau simulations under the experimental conditions of [4], demonstrates that spin-wave excitation enables dynamic control of vortex motion, offering a pathway toward reconfigurable superconducting ratchets and fluxonic devices.

[1] Ingla-Aynes et al., Nat. Electron. 8 (2025) 411

[2] Castellani et al., Nat. Electron. 8 (2025) 417

[3] Poratti et al., Small Methods e01430 (2025)

[4] Dobrovolskiy et al., Nat. Nanotechnol. (2025).

<https://doi.org/10.1038/s41565-025-02024-w>.

TT 97.8 Fri 11:30 CHE/0089

Tunable Nonreciprocity in 3D Superconductor Nanoarchitectures — ●IGOR BOGUSH and OLEKSANDR DOBROVOLSKIY — Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany

Nonreciprocity lies at the heart of superconducting diodes and ratchets, key elements for designing low-dissipative computing devices [1]. However, achieving precise control over the directionality and strength of nonreciprocity is challenging, as it requires local tuning of superconductor properties or applied stimuli. Here, we show that the geometry of curved thin superconductor membranes introduces a new degree of freedom, enabling vortex-motion synchronization [2] and nonreciprocity tunable via the magnetic field direction. In such membranes, only the component of the magnetic field normal to the surface exerts a driving Lorentz force on vortices, while the tangential component is less relevant. Using a conformal approach for time-dependent Ginzburg-Landau simulations [3], we predict that in cap-shaped superconductor membranes, the magnetic field induces effective pinning whose location can be controlled by adjusting the field direction. Even without a pinning potential, this controllable symmetry breaking induces non-reciprocal vortex dynamics and vortex ratchet behavior. These results highlight the geometry in thin curved membranes as a parameter that enhances the tunability of superconducting phenomena in rectifiers and other fluxonic devices.

[1] Plourde, IEEE Trans. Appl. Supercond. 19 (2009) 3698

[2] Bogush et al., Phys. Rev. B 111 (2025) 214510

[3] Bogush et al., Comp. Phys. Comm. 315 (2025) 109736

TT 97.9 Fri 11:45 CHE/0089

Steering of Vortex Jets in Anisotropic Pinning Fields — ●EKATERINA PRIBYTOVA¹ and OLEKSANDR DOBROVOLSKIY² — ¹Brno University of Technology, Czechia — ²Technische Universität Braunschweig, Germany

Understanding how Abrikosov vortices penetrate and move in superconductor films is crucial for fluxonics, which treats vortices as quantized information bits. So far, vortex steering was achieved for their global dynamics across the entire superconductor constriction. Here, we take a different approach of local vortex dynamics [1]: vortices are injected via an edge defect (notch) and guided through a washboard pinning potential (WPP). The resulting arrangement of vortices is a diverging jet rather than a periodic lattice. Numerical modeling via the time-dependent Ginzburg-Landau equation [2] reveals that vortex jets can be focused, deflected, and directed toward given points along the edge opposite to the notch. The underlying vortex steering mechanism is based on the competing vortex-vortex, vortex-current, and vortex-pinning interactions [1]. In return, beyond their potential for fluxonic logic gates, steered vortex jets offer a tool for probing these interactions. Specifically, the vortex jet's opening angle estimates the magnetic penetration depth, while its deflection from the current-normal direction reveals the WPP strength. These results demonstrate the predictive power of TDGL modeling for nanoengineered fluxonic circuits and complement the analytical and experimental results.

[1] Bezuglyj et al., Phys. Rev. B 105 (2022) 214507.

[2] Bishop-Van Horn, Comput. Phys. Commun. 291 (2023) 108799.

TT 98: Altermagnets

Time: Friday 9:30–11:45

Location: CHE/0091

TT 98.1 Fri 9:30 CHE/0091

Low-energy magnons in the altermagnet α -MnTe — ●KIRILL POVAROV¹, J. WOSNITZA^{1,2}, SAHANA RÖSSLER³, MARCUS SCHMIDT⁴, ALEXANDER TSIRLIN³, and SERGEI ZVYAGIN¹ — ¹Hochfeld-Magnetlabor Dresden (HLD-EMFL) and Würzburg-Dresden Cluster of Excellence ct.qmat, HZDR, Dresden — ²Institut für Festkörper- und Materialphysik, TU Dresden — ³Felix Bloch Institute for Solid State Physics, University of Leipzig — ⁴Max Planck Institute for Chemical Physics of Solids, Dresden

We report high-field electron spin resonance studies of the altermagnetic material α -MnTe in magnetic fields applied parallel to the triangular Mn²⁺ layers. We observe a single antiferromagnetic resonance (AFMR) mode, displaying isotropic behavior with $g \simeq 2.01$; very close to the free-electron value. At low temperatures the AFMR mode is remarkably sharp, but exhibits a noticeable broadening upon warming indicating the effect of magnon-magnon interactions. Based on this behavior, we estimate the strength of these interactions.

This work was supported by the DFG through the Würzburg-Dresden Cluster of Excellence on Complexity and Topology in Quantum Matter - *ct.qmat* (EXC 2147, project No. 390858490), as well as by HLD at HZDR, member of the European Magnetic Field Laboratory (EMFL).

TT 98.2 Fri 9:45 CHE/0091

Tuning the heavy fermion altermagnet candidate Ce_4Sb_3 by hydrostatic pressure — ●JULIAN KAISER¹, BIN SHEN¹, FRANZISKA WALTHER², KRISTIN KLIEMT², CORNELIUS KRELLNER², ANTON JESCHE¹, and PHILIPP GEGENWART¹ — ¹EP VI, EKM, University of Augsburg, Germany — ²Physikalisches Institut, Goethe-Universität Frankfurt, Frankfurt am Main, Germany

Altermagnets have recently attracted significant attention because they have features of both ferromagnets and antiferromagnets in a novel symmetry framework, giving rise to unconventional electronic and spin-transport phenomena previously believed to be absent in traditional collinear antiferromagnets. The heavy-fermion compound Ce_4Sb_3 has been proposed as an altermagnetic candidate with non-trivial band topology [1], making it an ideal platform for investigating the interplay among magnetism, band topology, and the Kondo effect. To probe this interplay, we performed magnetization measurements under hydrostatic pressure and established a preliminary pressure-temperature phase diagram. Our results reveal that the magnetic order in Ce_4Sb_3 is highly sensitive to pressure and can be gradually suppressed. These findings identify Ce_4Sb_3 as a tunable altermagnetic candidate in which the balance between the Kondo effect and the RKKY interaction, and thus the magnetic order, can be effectively controlled by pressure.

[1] X. He and S. Zhang, Phys. Rev. B **112**, 075138 (2025)

TT 98.3 Fri 10:00 CHE/0091

Effect of pressure on the electronic properties of the Kagome flat band metal CsCr_3Sb_5 — ●MARIA CHATZIELEFTHRIOU^{1,2}, JONAS B. PROFF¹, YING LI³, and ROSER VALENTI¹ — ¹Institute for Theoretical Physics, Goethe University Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt a.M., Germany — ²CNRS, CPHT, Ecole polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France — ³MOE Key Laboratory for Nonequilibrium Synthesis and Modulation of Condensed Matter, School of Physics, Xi'an Jiaotong University, Xi'an 710049, China

CsCr_3Sb_5 is a novel type of strongly correlated Kagome superconductor. The material shows non-Fermi liquid like behavior at high temperatures, indicating strong correlations and has an intertwined charge and spin density wave ordering below $T = 54\text{K}$. Under external pressure, this order is suppressed and a superconducting phase emerges. This phase diagram in combination with a Kagome flat band near the Fermi-level and potential altermagnetic orders has led to a plethora of theoretical and experimental studies. In this work, we perform a systematic analysis of the changes of the electronic properties induced by pressure. To this end we employ DFT+DMFT calculations revealing a complex interplay of the position of the flat bands and the strength of correlations. Our results support the predominant interpretation that pressure effectively reduces the strength of correlations by stronger hybridization between the orbitals. This finding strongly suggests that

the superconducting order is emerging due to short range fluctuations present in the system once the ordered state is suppressed sufficiently.

TT 98.4 Fri 10:15 CHE/0091

Alterelectrics: The Electric Counterpart of Altermagnets — ●VIKTOR KÖNYE¹, AMBER VISSER¹, OLEG JANSON², JEROEN VAN DEN BRINK², CORENTIN COULAIS¹, and JASPER VAN WEZEL¹ — ¹University of Amsterdam — ²IFW Dresden

Altermagnets are a new class of materials that mix features of both ferromagnets and antiferromagnets. They have spin-split bands like ferromagnets but still show no net magnetization. Their underlying symmetries also lead to unusual effects, such as a strong piezomagnetic effect and hyperbolic wave dispersion. This raises an important question: which of these behaviors actually come from magnetism, and which are simply a result of symmetry? In this work, we separate these two aspects by proposing a non-magnetic analogue of an altermagnet, built from polarized chains. These "alterelectrics" show anisotropic piezoelectricity and surface states with hyperbolic wave dispersion, demonstrated through a simple model. Instead of spin-split bands, the electronic states localize on opposite surfaces, producing strongly anisotropic, surface-dependent transport.

TT 98.5 Fri 10:30 CHE/0091

Crossed surface flat bands in three-dimensional superconducting altermagnets — YURI FUKAYA¹, BO LU², KEIJI YADA³, YUKIO TANAKA³, and ●JORGE CAYAO⁴ — ¹Faculty of Environmental Life, Natural Science and Technology, Okayama University, 700-8530 Okayama, Japan — ²Department of Physics, Tianjin University, 300354 Tianjin, China — ³Department of Applied Physics, Nagoya University, 464-8603 Nagoya, Japan — ⁴Department of Physics and Astronomy, Uppsala University, Box 516, S-751 20 Uppsala, Sweden

Superconducting altermagnets have proven to be a promising ground for emergent phenomena but their study has involved two dimensional systems. Here, we investigate three-dimensional d- and g-wave altermagnets with chiral d-wave superconductivity and show the formation of crossed surface flat bands due to the underlying symmetries. We find that these crossed flat bands appear at zero energy in the surface along z due to the superconducting nodal lines in the xy -plane, while the number of corners is determined by the crystal symmetry of altermagnets. We also show that the superconducting nodal lines give rise to Bogoliubov-Fermi surfaces, which then affect the appearance of zero-energy arcs in the surface along x . Moreover, we demonstrate that the crossed surface flat bands, surface arcs, and Bogoliubov-Fermi surfaces give rise to distinct signals in charge conductance, hence offering a solid way for their detection and paving the way for realizing higher dimensional topological phases using altermagnets.

15 min. break

TT 98.6 Fri 11:00 CHE/0091

Strongly disordered superconductor-altermagnet heterostructures — ●CHRISTIAN WIEDEMANN¹, DANILO NIKOLIĆ², MATTHIAS ESCHRIG², and WOLFGANG BELZIG¹ — ¹Universität Konstanz, Konstanz, Germany — ²Universität Greifswald, Greifswald, Germany

Similarly to ferromagnets and antiferromagnets previously [1,2], proximity systems involving superconductors (S) and a recently found class of d-wave magnetic materials known as altermagnets (AM) [3] represent promising platforms for both understanding and applications in superconducting spintronics [4]. Introducing nonmagnetic impurities to systems where superconductivity and altermagnetism coexist can reduce the effect of the altermagnetic exchange field on the critical temperature of the superconductor [5]. We investigate the interplay between the anisotropic altermagnetic influence and the isotropization caused by impurity scattering and its effect on superconductivity in an S/AM bilayer. In particular, we compute the order parameter and the free energy using the quasiclassical Green's function formalism to find stable superconducting states with a special focus on the regime of high impurity concentrations and strong altermagnetic exchange fields.

[1] A. I. Buzidn, Rev. Mod. Phys. **77**, 935 (2005)

[2] M. Eschrig, Rep. Prog. Phys. **78**, 104501 (2015)

[3] L. Šmejkal *et al*, Phys. Rev. X **12**, 040501 (2022)

- [4] S. Chourasia *et al.*, Phys. Rev. B **111**, 224503 (2025)
 [5] M.M. Vasiakin & A.S. Mel'nikov, PRB, **111**, L100502 (2025)

TT 98.7 Fri 11:15 CHE/0091

Nonlinear Sigma Model of an Insulating Altermagnet — ●PARASAR THULASIRAM^{1,2}, CHRIS HOOLEY³, and RODERICH MOESSNER¹ — ¹Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ²Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — ³Centre for Fluid and Complex Systems, Coventry University, Coventry, United Kingdom

We applied the Haldane map to derive an $O(3) \times O(3)$ nonlinear sigma model of an insulating altermagnet from a transition-metal-dichalcogenide-inspired 3D spin model. The model displays nonrelativistic spin splitting of the magnon bands and anisotropic couplings. We studied the energetics of its preferred topological defects (skyrmions and hopfions), their viability in being generated, as well as the model's behaviour under lightly frustrated couplings. We performed a renormalization analysis of the model and studied its (in)stabilities.

TT 98.8 Fri 11:30 CHE/0091

Projectively implemented altermagnetism in an exactly solvable quantum spin liquid — ●AVEDIS NEEHUS^{1,2}, ACHIM ROSCH³,

JOHANNES KNOLLE^{1,2,4}, and URBAN SEIFERT³ — ¹Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — ²Institute for Theoretical Physics, University of Cologne, 50937 Cologne, Germany — ³Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom — ⁴Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Altermagnets are a new class of symmetry-compensated magnets with large spin splittings. Here, we show that the notion of altermagnetism extends beyond the realm of Landau-type order: we study exactly solvable \mathbb{Z}_2 quantum spin-(orbital) liquids (QSL), which simultaneously support magnetic long-range order as well as fractionalization and \mathbb{Z}_2 topological order. Our symmetry analysis reveals that in this model three distinct types of “fractionalized altermagnets (AM*)” may emerge, which can be distinguished by their residual symmetries. Importantly, the fractionalized excitations of these states carry an emergent \mathbb{Z}_2 gauge charge, which implies that they transform *projectively* under symmetry operations. Consequently, we show that “altermagnetic spin splittings” are now encoded in a momentum-dependent particle-hole asymmetry of the fermionic parton bands. We discuss consequences for experimental observables such as dynamical spin structure factors and (nonlinear) thermal and spin transport.

TT 99: Quantum Chaos and Coherent Dynamics (joint session DY/TT)

Time: Friday 9:30–12:45

Location: HÜL/S186

TT 99.1 Fri 9:30 HÜL/S186

Time reversal invariance breaking in quantum chaotic scattering — ●AHMED ALDABAG, NILS GLUTH, and THOMAS GUHR — Universität Duisburg Essen

A. Aldabag, N. Gluth and T. Guhr, Universität Duisburg-Essen

Scattering theory is a key tool for the investigation of quantum systems. Often, the systems are stochastic or in a broad sense chaotic. Using Random Matrix Theory, our group recently derived the distributions of off-diagonal scattering matrix elements and cross sections with the Supersymmetry Method. We did that for the three Dyson classes which are distinguished by the presence or absence of time-reversal invariance in the system. In some important physics situations, time-reversal invariance is weakly broken. We succeeded in analytically calculating the corresponding effects on the universal behavior of the mentioned distributions. Our results provide new tools to analyze time-reversal invariance breaking in data from scattering experiments.

TT 99.2 Fri 9:45 HÜL/S186

Normalization of resonance states in chaotic scattering systems — ●FLORIAN LORENZ, JAN MÖSERITZ-SCHMIDT, and ROLAND KETZMERICK — TU Dresden, Institut für Theoretische Physik, Dresden, Germany

The normalization of resonance states in scattering systems poses a challenge due to their divergent asymptotic behavior. As a consequence, they cannot be normalized by the usual norm, but instead, by the overlap between left and right resonance states. For dielectric cavities, we demonstrate that this left-right overlap can be computed efficiently using a boundary integral, avoiding divergent integrands. This result provides a practical numerical tool for resonance state normalization. For example, this allows for exact time evolution of wave packets based on resonance states.

TT 99.3 Fri 10:00 HÜL/S186

How exceptional points conduct mode dynamics in optical microcavities — TOM SIMON RODEMUND¹, CHANG-HWAN YI², JUNG-WAN RYU², SİLE NİC CHORMAIC³, and ●MARTINA HENTSCHEL¹ — ¹Institut für Physik, TU Chemnitz, Germany — ²PCS, IBS, Daejeon, Korea — ³OIST, Okinawa, Japan

Optical microcavities confine light through total internal reflection, making them inherently open, non-Hermitian systems. Their resonances have a real and an imaginary part, both of which depend on external parameters such as the resonator geometry or the refractive index. When scanning the parameter space, resonances can coincide and when they do so in their real and imaginary part, they form an exceptional point. We illustrate their occurrence and consequences in mesoscopic optics in two examples. First, we consider two coupled

two-dimensional microcavities over coupling distances of several resonance wavelengths. Their mode dynamics is determined by a chain of exceptional points that exhibit a periodicity of approximately the wavelength [1]. The second example is a three-dimensional truncated cone. We investigate the interaction between the two mode polarizations, TE and TM, and find that the mode character changes smoothly, with TE and TM coinciding at exceptional points [2]. We confirm this behavior in phase space by generalizing the concept of Husimi functions to three dimensions. [1] C.-H. Yi, J.-W. Ryu, T.S. Rodemund, and M. Hentschel, Phys. Rev. A **112**, L031501 (2025). [2] T.S. Rodemund, S. Li, S. Nic Chormaic, and M. Hentschel, Phys. Rev. A **112**, 033528 (2025).

TT 99.4 Fri 10:15 HÜL/S186

Describing the spectral behavior around higher-order exceptional points with "periodic orbits" — ●DANIEL GROM¹, JULIUS KULLIG¹, MALTE RÖNTGEN², and JAN WIERSIG¹ — ¹Institut für Physik, Otto-von-Guericke-Universität Magdeburg, 39016 Magdeburg, Germany — ²Laboratoire d'Acoustique de l'Université du Mans, 72085 Le Mans, France

Coupled optical microrings can deliver a simple and robust scheme to generate higher-order exceptional points (EPs), where multiple eigenvalues and -modes coalesce. A feature of an EP of order n , is the high sensitivity of the eigenvalues to small perturbations. Two types of perturbations can be classified. The generic behavior, where the eigenvalue response is proportional to the n th root and the non-generic type with a different eigenvalue response.

We present a graph theoretical perspective on the spectral characterization of perturbed higher-order EPs. It turns out that specific "periodic orbits" within the graph picture of the non-chaotic system govern the eigenvalue behavior.

TT 99.5 Fri 10:30 HÜL/S186

Dynamic origin of quantum chaos signatures in the zeros of the Riemann zeta function by means of periodic orbit theory — ●ANDREAS HÖTZINGER, SEBASTIAN HÖRHOOLD, JUAN DIEGO URBINA, and KLAUS RICHTER — Institut für Theoretische Physik, Universität Regensburg, Germany

In the 90's, Berry and Keating [1] provided a qualitative, semiclassical analogy to the counting function of the nontrivial Riemann zeros, i.e. the zeros of the famous zeta function (ZF) $\zeta(s)$. Similar to Gutzwiller's trace formula they obtain a result in which the primes play the role of periodic orbits and argue that the so-called Riemann dynamics, underlying the primes, should be chaotic. It is speculated that this system is the classical limit of a Hermitian quantum Hamiltonian which has eigenvalues coinciding with the nontrivial zeros of $\zeta(1/2 + it_n)$.

Recently, a promising candidate for such a Hamiltonian has been

proposed [2], which has the potential to advance research toward a proof of the Riemann hypothesis. Based on these results, we use a related and simpler, yet non-Hermitian Hamiltonian and consider its semiclassical regime by employing methods from periodic orbit theory.

In this talk, we present our progress in the study of the classical limit of this operator and its dynamics in a complexified phase space. Through this, we hope to unveil a deeper relation between quantum chaos signatures of number theory encoded in the ZF with classical phase space structures.

- [1] M. V. Berry and J. P. Keating, SIAM Review 41.2 pp. 236-266
 [2] E. Yakaboylu, arXiv:2408.15135

TT 99.6 Fri 10:45 HÜL/S186

Semiclassical geometry of entanglement — ●MAXIMILIAN KIELER and PETER SCHLAGHECK — CESAM research unit, University of Liège, B-4000 Liège, Belgium

We propose a semiclassical perspective on entanglement in the form of a geometric Schmidt decomposition of regular states, e.g., states associated with invariant tori. Utilizing WKB quantization techniques and classical geometry, we derive the Schmidt spectrum and the corresponding Schmidt states. This framework allows for the reduction of the complexity in many-body states by decomposing them into lower-dimensional components.

15 min. break

Invited Talk

TT 99.7 Fri 11:15 HÜL/S186

Anyon dynamics in driven topologically ordered quantum systems — ●FRANCESCO PETIZIOL — Technische Universität Berlin, Institut für Physik und Astronomie, Hardenbergstr. 36, 10623 Berlin

Quantum systems with topological order exhibit long-range entanglement and host quasiparticle excitations with unconventional quantum statistics – anyons. These features make them of great interest from both fundamental and quantum-technological perspectives. Recent progress in realizing topological order in quantum simulators highlights the importance and the challenge of understanding the behaviour of such systems under non-equilibrium conditions. Focusing on Kitaev's toric code, I will discuss how external driving, either coherent or incoherent, can impact and alter anyon properties. Examples include the emergence of more complex anyon classes from simpler ones, the dynamics of entanglement under driven anyon proliferation, and opportunities for controlled anyon transport.

TT 99.8 Fri 11:45 HÜL/S186

Floquet engineering in lattice systems with a parametrically modulated parabolic potential — ●USMAN ALI¹, MARTIN HOLTHAUS¹, and TORSTEN MEIER² — ¹Institut für Physik, Carl von Ossietzky Universität, D-26111 Oldenburg, Germany — ²Department of Physics, Paderborn University, Warburger Strasse 100, D-33098 Paderborn, Germany

We present a route to Floquet engineering in lattice systems that exploits a parabolic potential to generate tunable slowly varying on-site energies. When a selected level spacing in the spectrum of the combined parabolic lattice is brought into near resonance with an external periodic drive, nonlinear resonances emerge in the classical phase space and reorganize quantum eigenstates into families of near-resonant Floquet states. Using a Mathieu-resonance approximation together with numerical Floquet calculations, we construct these states and demonstrate how resonant trap eigenstates transmute into resonance-induced effective ground states [1]. The long-time population and transport dynamics are strongly sensitive to the initial phase of the drive, providing a phase-dependent control knob for engineered tunneling and coherence. We identify parameter regimes accessible to present-day cold-atom experiments and argue that selectively populating these Floquet ground states provides a clean testbed for driven many-body and Floquet-band phenomena, enabling novel lattice dynamics inaccessible in solid-state materials [2]. References: [1] U. Ali, M. Holthaus, and T. Meier, New J. Phys. 26, 123016 (2024) [2] U. Ali, M. Holthaus, and T. Meier, Phys. Rev. Research 5, 043152 (2023)

TT 99.9 Fri 12:00 HÜL/S186

Transport through two Floquet-engineered Impurities in a One-Dimensional System: Coherent Control of Fano Resonances, BICs and Localization — ●VINCENZO BRUNO^{1,2}, AMENEH SHEIKHAN¹, ROBERTA CITRO^{2,3}, and CORINNA KOLLATH¹ — ¹Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany — ²Dipartimento di Fisica "E.R. Caianiello", Università degli Studi di Salerno and INFN, Via Giovanni Paolo II, 132, I-84084 Fisciano (Sa), Italy — ³CNR/SPIN, Fisciano (Sa), 84098, Italy

Floquet engineering has attracted considerable attention due to its ability to coherently control quantum states, finding successful applications across a wide range of fields such as quantum materials, ultracold atoms, and cavity systems. We investigate particle transport through a one-dimensional system containing two periodically driven impurities. Such a configuration is highly relevant for experimental realizations ranging from ballistic semiconductor wires and electron optics to ultracold atoms, and exhibits remarkably rich transmission properties. A central feature of this system is the emergence of Fano resonances—phenomena arising from the quantum interference between a continuum scattering path and discrete quasi-bound states. We demonstrate how drive parameters can be tuned to dynamically control these resonances. Furthermore, we reveal the existence of Bound States in the Continuum (BICs) and explore the interplay between Fano interference and cavity modes. This interplay leads to a localization mechanism where the system can be switched from a fully localized state to a regime of perfect transparency.

TT 99.10 Fri 12:15 HÜL/S186

Ruelle-Pollicott signatures of unitary quantum systems — ●SCOTT DANIEL LINZ, JIAOZI WANG, MERLIN FÜLLGRAF, and JOCHEN GEMMER — Department of Mathematics/Computer Science/Physics, University of Osnabrück, D-49076 Osnabrück, Germany

Phenomenological observations demonstrate that unitary quantum systems thermalize and equilibrate. While many concepts have been introduced to describe the equilibrium of a quantum system, the route to this state remains an area of ongoing research. A proposed step towards a general description of this behaviour is that correlation functions of chaotic quantum systems can be described by a superposition of relatively few damped oscillations, where each is weighted and assigned a complex frequency. These frequencies will be called Ruelle-Pollicott signatures after the well-understood Ruelle-Pollicott resonances that govern the decay of correlations in classical chaotic systems featuring dissipation. Following this framework, a deterministic fitting method is applied to the correlation functions of numerical simulations of closed unitary quantum systems. This examination will focus on how the number of frequencies needed to reproduce correlation functions relates to other signatures of quantum chaos.

TT 99.11 Fri 12:30 HÜL/S186

Refinements of the Eigenstate Thermalization Hypothesis — ●ELISA VALLINI¹, LAURA FOINI², and SILVIA PAPPALARDI¹ — ¹University of Cologne, Köln, Germany — ²Université Paris-Saclay, France

Understanding how isolated quantum many-body systems reach thermal equilibrium is a central question in nonequilibrium physics. The Eigenstate Thermalization Hypothesis (ETH) provides a powerful framework by linking thermalization to the statistical properties of matrix elements of physical observables in the energy eigenbasis.

In this talk, I will present our recent work, in which we revisit and clarify in detail the ideas that have led to the formulation of full ETH, a generalization of the ETH ansatz that captures multi-point correlation functions. Specifically, using tools from free probability, we explore the implications of local rotational invariance, a property that emerges from the statistical invariance of observables under random basis transformations induced by small perturbations of the Hamiltonian.

This approach allows us to analytically characterize subleading corrections to matrix-element correlations, thereby refining the ETH ansatz. Finally, I will show numerical results from non-integrable Floquet systems that support our analytical predictions.