Monday Contributed Sessions (MON)

Stefan Kehrein
Fakultät für Physik
Universität Göttingen
Friedrich-Hund-Platz 1
37077 Göttingen, Germany
stefan.kehrein@theorie.physik.uni-goettingen.de

Thomas Weitz
Fakultät für Physik
Universität Göttingen
Friedrich-Hund-Platz 1
37077 Göttingen, Germany
thomas.weitz@uni-goettingen.de

Overview of Sessions

(Lecture halls ZHG001, ZHG002, ZHG003, ZHG004, ZHG006, ZHG007, ZHG008, ZHG009, ZHG101, ZHG103, ZHG104, and ZHG105; Poster ZHG Foyer 1. OG)

Sessions

MON 1.1–1.7	Mon	14:15–16:00	ZHG001	**QIP Implementations: Photons I**
MON 2.1–2.8	Mon	14:15–16:15	ZHG002	**Quantum Control**
MON 3.1–3.8	Mon	14:15–16:15	ZHG003	**Many-Body Quantum Dynamics I**
MON 4.1–4.8	Mon	14:15–16:15	ZHG004	**DPG Promotionskolleg Next Generation Computing**
MON 5.1–5.7	Mon	14:15–16:00	ZHG006	**Optical Quantum Devices**
MON 6.1–6.8	Mon	14:15–16:15	ZHG007	**QIP Implementations: Trapped Ions**
MON 7.1–7.8	Mon	14:15–16:15	ZHG008	**Foundational / Mathematical Aspects – Quantum Measurement**
MON 8.1–8.6	Mon	14:15–15:45	ZHG009	**Quantum Sensing and Decoherence: Contributed Session to Symposium I**
MON 9.1–9.8	Mon	14:15–16:15	ZHG101	**Quantum Entanglement**
MON 10.1–10.8	Mon	14:15–16:15	ZHG103	**Standard Model and Beyond**
MON 11.1–11.7	Mon	14:15–16:00	ZHG104	**Quantum Transport I**
MON 12.1–12.6	Mon	14:15–15:45	ZHG105	**Quantum Magnets**
MON 13.1–13.6	Mon	16:30–18:00	ZHG001	**QIP Implementations: Photons II**
MON 14.1–14.8	Mon	16:30–18:30	ZHG002	**QIP Implementations: Solid-State Devices I**
MON 15.1–15.7	Mon	16:30–18:15	ZHG003	**Many-Body Quantum Dynamics II**
MON 16.1–16.7	Mon	16:30–18:15	ZHG004	**Quantum Spectroscopy**
MON 17.1–17.8	Mon	16:30–18:30	ZHG006	**Quantum Communication and Networks: Theory**
MON 18.1–18.7	Mon	16:30–18:15	ZHG007	**Quantum Algorithms**
MON 19.1–19.7	Mon	16:30–18:15	ZHG008	**Foundational / Mathematical Aspects – Quantum Optics and Quantum Information**
MON 20.1–20.8	Mon	16:30–18:30	ZHG009	**Quantum Sensing and Decoherence: Contributed Session to Symposium II**
MON 21.1–21.8	Mon	16:30–18:30	ZHG103	**Quantum Materials**
MON 22.1–22.5	Mon	16:30–17:45	ZHG104	**Quantum Transport II**
MON 23.1–23.63	Mon	18:30–20:30	ZHG Foyer 1. OG	**Poster Session: Fundamental Aspects and Model Systems**

MON 1: QIP Implementations: Photons I

Time: Monday 14:15–16:00 Location: ZHG001

MON 1.1 Mon 14:15 ZHG001

Boosted fusions for photonic quantum computation — •Nico Hauser[1], Matthias Bayerbach[1], Simone D'Aurelio[1], Raphael Weber[2], Matteo Santandrea[2], Shreya P. Kumar[2], Ish Dhand[2], and Stefanie Barz[1] — [1]Universität Stuttgart, Institut für funktionelle Materie und Quantentechnologien — [2]QC Design GmbH, Ulm

Entangling two-photon measurements, called fusions, are a fundamental requirement for photonic fusion-based quantum computation. One way of implementing such a fusion is a linear-optical Bell-state measurement. However, conventional linear-optical Bell-state measurements are limited to an overall success probability of 50%. This constraint significantly reduces the scalability of fusion-based quantum computation, where reliable fusions are needed. Here, we present a boosted fusion that surpasses this 50% success probability limit by using an entangled ancillary photon pair along with a fibre-based 4x4 multimode interferometer. By simulating fusion networks with boosted fusions, we show a significant increase in the performance of fusion-based quantum computation. We find that using boosted fusions significantly increases the robustness of fusion-based schemes to photon loss, which is one of the most prominent errors in photonic quantum technologies.

MON 1.2 Mon 14:30 ZHG001

Integrated resonant squeezer for GBS — •Jonas Sichler, Christine Silberhorn, Philip Mues, Werner Ridder, and Simone Atzeni — IQO, Universität Paderborn, Deutschland

Single-spectral-mode single-mode squeezed states are a key resource for Gaussian boson sampling (GBS) and other large-scale photonic networks. We investigate an integrated, resonator-enhanced, type-0 parametric down-conversion source in titanium-indiffused lithium niobate waveguides. By tuning the pump pulse length and tailoring the cavity geometry and mirror reflectivities correlations are suppressed and single-modeness can be achieved. The phase-matching center is set by the periodic poling and custom dielectric coatings define the cavity finesse. Achieving full single-modeness still requires external filtering in order to reject the neighboring cavity modes separated by the GHz-scale free spectral range, a demanding yet tractable task, which can be achieved, for example, with the use of filter cavities. Simulations incorporating realistic fabrication tolerances confirm that this multidimensional optimization delivers the desired joint-spectral amplitude. The resulting chip-scale Ti:LiNbO3 source provides a practical, low-loss building block for deployment in large quantum photonic networks, for example as the workhorse of GBS.

MON 1.3 Mon 14:45 ZHG001

Enhanced phase sensitivity in displacement-assisted SU(1,1) interferometer with photon recycling — Taj Kumar, Aviral Kumar Pandey, Anand Kumar, and •Devendra Kumar Mishra — Department of Physics, Institute of Science, Banaras Hindu University, Varanasi-221005, Uttar Pradesh, India

In this work, we propose a novel method to improve the phase sensitivity of the displacement-assisted SU(1,1) (DSU(1,1)) interferometer (with displacement strength γ) via photon recycling. We consider vacuum and squeezed vacuum (with squeezing parameter r) states as inputs, with a phase shift ϕ in one of the arms. This setup is modified by re-injecting the one output mode into the input mode after a phase shift θ, and the photon loss, characterized by $\sqrt{1-\mathrm{T}}$, where T is the transmission coefficient of a fictitious beam splitter. We determined the phase sensitivity of the photon recycled DSU(1,1) (PR-DSU(1,1)) interferometer under the single-intensity and homodyne detection schemes along with the quantum Cramér-Rao bound (QCRB). Then, we compared its performance with the conventional DSU(1,1) interferometer and found that the PR-DSU(1,1) interferometer can achieve improved phase sensitivity and a lower QCRB compared to the latter. Moreover, for both detection schemes, we observed the improvement in the phase sensitivity and QCRB of the PR-DSU(1,1) interferometer relative to the SNL, which further increases with an increase in T, g, $|\gamma|$, and r. Therefore, our work offers a novel approach to increase phase sensitivity via photon recycling. This work is based on our recent publication [APL Quantum 2, 016127 (2025)].

MON 1.4 Mon 15:00 ZHG001

Low-noise cascaded frequency conversion of 637.2 nm light to the telecommunication C-band in a single-waveguide device — Fabrice von Chamier, Joscha Hanel, Chris Müller, Wanrong Li, •Roger Kögler, and Oliver Benson — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstraße 15, 12489, Berlin, Germany

Quantum devices and optical states often operate at disparate frequencies, making frequency conversion essential for connecting nodes in quantum networks. Here, we demonstrate a two-stage frequency conversion using an integrated device, successfully converting 637.2 nm photons emitted by nitrogen-vacancy centers in diamond into telecom wavelengths. Our system achieves low internal (external) noise spectral densities of 2.4 ± 0.8 (16 ± 5) cps/GHz, owing to the cascaded architecture, which mitigates excess noise typically introduced by spontaneous parametric down-conversion from the strong pump field.

The device is based on a periodically poled lithium niobate waveguide featuring two distinct poling sections. Remarkably, it also exhibits a phase-matched interaction between thermally generated photons and the pump field, which we investigate in detail. Additionally, we demonstrate tunable frequency conversion across the C-band by thermally controlling the phase-matching conditions of each stage. This enables wavelength targeting in the range of 1559.0 nm to 1564.9 nm, with external (internal) conversion efficiencies reaching $3.0 \pm 0.1\%$ ($20.5 \pm 0.8\%$).

MON 1.5 Mon 15:15 ZHG001

Phase stabilization of high-bandwidth squeezed and entangled states over 1km distributed optical fiber — •Sophie Verclas[1], Benedict Tohermes[1], and Roman Schnabel[2] — [1]Institut für Quantenphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg — [2]Institut für Quantenphysik & Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

Quantum Key Distribution (QKD) is a technology for secure communication between two parties, using the principles of quantum mechanics. Our continuous-variable QKD experiment implements a fiber-based scheme, connecting two laboratories in two separated buildings (building A and B). We set up an EPR entanglement source in building A, consisting of two squeeze lasers and overlapped their outputs at a 50/50 beamsplitter to generate two-mode squeezed states. They are shared between A and B via a 1km optical fiber. In both buildings, the states are measured with self built balanced homodyne detectors. Due to the entanglement, the results are random but also correlated and can be used to generate a secret key. Attacks on the channel and on devices in building B reduce the entanglement strength and can thus be quantified. A major challenge in this setup is the phase stabilization and synchronization between the two buildings. Here, I will introduce the experiment, discuss the problem of phase noise and our approach to a control scheme for its compensation. As a first result, I will show measurements for the phase lock of distributed squeezed states, which is an important first step towards stabilized entanglement.

MON 1.6 Mon 15:30 ZHG001

Optical Protocol for Generating non-Gaussian state in C-band. — •Elnaz Bazzazi, Roger Alfredo Kögler, Leon Reichgardt, Marco Schmidt, and Oliver Benson — Department of Physics, Humboldt University Berlin, Berlin, Germany

Non-Gaussian states play a crucial role in fault-tolerant quantum computing, where the encoded information is protected from decoherence processes [1]. Certain classes of non-Gaussian states, however, coherent state superpositions known as cat states, pose challenges in generation due to the complexity of breeding protocols and limitations in their output states [2,3]. In this study, we explore the state engineering of squeezed coherent state superpositions (SCSS) through a catalysis protocol [4].

In this scheme, a beam splitter operation applied to two input states: a vacuum squeezed state and an m-photon Fock state, followed by photon number resolving detection in one of the output arms. Simulations results demonstrate the potential of this protocol to generate high-amplitude squeezed cat states with realistic quantum resources. We also outline an experimental implementation, and present the current progress. This research contributes to advances in quantum state engineering methods, crucial for the generation of resource states for fault-tolerant quantum computing.

[1] D. S. Schlegel et al., Phys. Rev. A 106, 022431 (2022).
[2] K. Takase et al., Phys. Rev. A 103, 013710 (2021).
[3] M. Endo et al., Opt. Express 31, 12865 (2023).
[4] R. J. Birrittella et al., J. Opt. Soc. Am. B 35, 1514 (2018).

MON 1.7 Mon 15:45 ZHG001

Topology-Optimized Integrated Photonics for Quantum Experiments — •Shiang-Yu Huang[1], Shreya Kumar[1], Jeldrik Huster[1], Yannick Augenstein[2], Carsten Rockstuhl[2,3], and Stefanie Barz[1,4] — [1]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [3]Institute of Nanotechnology, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [4]Center for Integrated Quantum Science and Technology (IQST), University of Stuttgart, 70569 Stuttgart, Germany

Interference of single photons plays a central role in photonic quantum technologies as it is an essential process for creating and manipulating desired quantum states in linear optical systems. By incorporating integrated photonics, multiphoton interference can take place within on-chip interferometers featuring a minimal footprint. Furthermore, such devices can be miniaturized even further by applying inverse design methods, showing a promising path for innovating conventional integrated systems for photonic quantum technologies. Here we demonstrate the inverse-designed interferometers developed using topology optimization with an ultracompact footprint. We showcase their capabilities for quantum experiments through multiphoton interference. We also inversely design on-chip couplers to facilitate high-efficiency interconnection with an exceptionally small footprint. These topology-optimized components have great potential for building up high integration density integrated circuits for photonic quantum technologies.

MON 2: Quantum Control

Time: Monday 14:15–16:15 Location: ZHG002

MON 2.1 Mon 14:15 ZHG002

Quantum control by fast driving — •Sandro Wimberger — Department of Mathematical, Physical and Computer Sciences, Parma University — INFN, Sezione Milano-Bicocca, Parma group

We present a scheme for the systematic design of quantum control protocols based on shortcuts to adiabaticity. To fight decoherence, the adiabatic dynamics is accelerated by introducing high-frequency modulations in the control Hamiltonian, which mimic a time-dependent counterdiabatic correction. We present several applications for the high-fidelity realization of quantum state transfers and quantum gates based on effective counterdiabatic driving, in platforms ranging from superconducting circuits to Rydberg atoms [1]. We briefly sketch as well related ideas to control many-body interactions [2] and evolution errors by compensating terms in the Hamiltonian [3].

[1] F. Petiziol, F. Mintert, S. Wimberger, EPL 145, 15001 (2024); [2] S. Dengis, S. Wimberger, P. Schlagheck, PRA 111, L031301 (2025); [3] M. Delvecchio, F. Petiziol, E. Arimondo, S. Wimberger, PRA 105, 042431 (2022)

MON 2.2 Mon 14:30 ZHG002

Model predictive quantum control: A modular strategy for improving efficiency of quantum control — Eya Guizani and •Julian Berberich — Institute for Systems Theory and Automatic Control, University of Stuttgart, Germany

Model predictive control (MPC) is one of the most successful modern control methods. It relies on repeatedly solving a finite-horizon optimal control problem and applying the beginning piece of the optimal input. In this contribution, we explore the application of MPC for closed quantum systems governed by finite-dimensional Hamiltonian dynamics. Multiple MPC schemes are proposed to address different problem formulations, allowing us to trade off computational complexity with performance while retaining systems-theoretic guarantees on stability and convergence. Numerical experiments benchmark the performance of these formulations against competing approaches. Our results demonstrate the flexibility of MPC and its ability to achieve high performance in quantum optimal control problems.

MON 2.3 Mon 14:45 ZHG002

Optimization of algorithm-specific resource states for trotterized quantum dynamics and universal quantum computation — •Thierry N. Kaldenbach[1,2], Isaac D. Smith[2], Hendrik Poulsen Nautrup[2], Matthias Heller[3,4], and Hans J. Briegel[2] — [1]Institute of Materials Research, German Aerospace Center (DLR), Cologne, Germany — [2]Institute for Theoretical Physics, University of Innsbruck, Austria — [3]Fraunhofer Institute for Computer Graphics Research IGD, Darmstadt, Germany — [4]Interactive Graphics Systems Group, Technical University of Darmstadt, Germany

The direct compilation of algorithm-specific graph states in measurement-based quantum computation (MBQC) potentially leads to resource reductions in terms of circuit depth, entangling gates, and sometimes even the number of qubits. In this work, we extend previous studies on algorithm-tailored graph states to periodic sequences of Pauli rotations, which commonly appear in, e.g., trotterized quantum dynamics. We also use our approach to derive universal resource states from generating sets of Pauli unitaries, whose structure relates to the anticommutation pattern of the set. In addition, we implement a significantly enhanced annealing-based algorithm to find optimal resource states within local-Clifford MBQC. We demonstrate and compare both of our technique based on examples from quantum chemistry, binary optimization, and universal quantum computation. In particular, we showcase how graph states tailored for specific observables can lead to qubit reductions beyond the Z2 symmetries exploited in qubit tapering.

MON 2.4 Mon 15:00 ZHG002

Lower bounds for the Trotter error — •Alexander Hahn[1], Paul Hartung[2], Daniel Burgarth[2,1], Paolo Facchi[3,4], and Kazuya Yuasa[5] — [1]Center for Engineered Quantum Systems, Macquarie University, 2109 NSW, Australia — [2]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany — [3]Dipartimento di Fisica, Università di Bari, I-70126 Bari, Italy — [4]Istituto Nazionale di Fisica Nucleare, Sezione di Bari, I-70126 Bari, Italy — [5]Department of Physics, Waseda University, Tokyo 169-8555, Japan

In analog and digital simulations of practically relevant quantum systems, the target dynamics can only be implemented approximately. The Trotter product formula is the most common approximation scheme as it is a generic method which allows tuning accuracy. The Trotter simulation precision will always be inexact for noncommuting operators, but it is currently unknown what the minimum possible error is. This is an important quantity because upper bounds for the Trotter error are known to often be vast overestimates. Here we present explicit lower bounds on the error, in norm and on states, allowing to derive minimum resource requirements. Numerical comparison with the true error shows that our bounds offer accurate and tight estimates.

Based on Phys. Rev. A 111, 022417
https://doi.org/10.1103/PhysRevA.111.022417

MON 2.5 Mon 15:15 ZHG002

Riemannian quantum circuit optimization based on matrix product operators — •Isabel Nha Minh Le[1,2], Shuo Sun[1,2], and Christian B. Mendl[1,2,3] — [1]Technical University of Munich, School of Computation, Information and Technology, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — [3]Technical University of Munich, Institute for Advanced Study, 85748 Garching, Germany

We significantly enhance the simulation accuracy of initial Trotter circuits for Hamiltonian simulation of quantum systems by integrating first-order Riemannian optimization with tensor network methods. Unlike previous approaches, our method imposes no symmetry assumptions, such as translational invariance, on the quantum systems. This technique is scalable to large systems through the use of a matrix product operator representation of the reference time evolution propagator. Our optimization routine is applied to various spin chains and fermionic systems described by the transverse-field Ising Hamiltonian, the Heisenberg Hamiltonian, and the spinful Fermi-Hubbard Hamiltonian. In these cases, our approach achieves a relative error improvement of up to four orders of magnitude for systems of 50 qubits. Furthermore, we demonstrate the versatility of our method by applying it to molecular systems, specifically lithium hydride, achieving an error improvement of up to eight orders of magnitude. This proof of concept highlights the potential of our approach for broader applications in quantum simulations.

MON 2.6 Mon 15:30 ZHG002

Counterdiabatic driving for random gap Landau-Zener (LZ) transitions — •Georgios Theologou[1], Mikkel F. Andersen[2,3], and Sandro Wimberger[4,5] — [1]ITP, Universität Heidelberg — [2]Department of Physics, University of Otago — [3]Dodd-Walls Centre for Photonic and Quantum Technologies — [4]Department of Mathematical, Physical and Computer Sciences, Parma University — [5]INFN, Sezione Milano-Bicocca, Parma group

The LZ model describes a two-level quantum system governed by a time-dependent Hamiltonian which undergoes an avoided crossing. In the adiabatic limit, the transition probability $\mathcal{P}_{\rm LZ}$ vanishes. To enforce an adiabatic evolution at arbitrary speed, an auxiliary control field $H_{\rm CD} = f_{\rm CD}\boldsymbol{\sigma}$ can be reverse-engineered, such that the full Hamiltonian $H + H_{\rm CD}$ drives the states transitionlessly. In the LZ case, $f_{\rm CD}$ takes the form of a Lorentzian pulse centered at the crossing, and the matrix $\boldsymbol{\sigma}$ is determined by the orthogonality of $H_{\rm CD}$ with $H_{\rm LZ}$ and $\dot{H}_{\rm LZ}$. Our aim is to construct a single $H_{\rm GCD}$ that controls an ensemble of LZ-type Hamiltonians with a distribution of energy gaps. For a single realization, the evolution is not any more adiabatic nor the final transition probability is zero. $H_{\rm GCD}$ can be optimized to minimize the expectation value of a given cost function. We consider the effect of different sweeps and prefactors $f_{\rm CD}$. We found a systematic trade-off between instantaneous adiabaticity and the final transition probability. As an analytically solvable limit, we examine the LZ model in the presence of a $\delta(t)$ potential and the connection to the minimization of the corresponding non-adiabatic probablity $\mathcal{P}_{\rm LZD}$.

MON 2.7 Mon 15:45 ZHG002

Spectral Control of a Noisy Quantum Emitter with Optical Pulses — •Kilian Unterguggenberger[1], Alok Gokhale[1], Aleksei Tsarapkin[1,2], Wentao Zhang[2], Katja Höflich[1,2], Herbert Fotso[3], Tommaso Pregnolato[1,2], Laura Orphal-Kobin[1], and Tim Schröder[1,2] — [1]Humboldt-Universität zu Berlin, Germany — [2]Ferdinand-Braun-Institut (FBH), Berlin, Germany — [3]University at Buffalo SUNY, Buffalo, USA

Indistinguishability of single photons gives rise to quantum interference, making it an essential ingredient for quantum information processing. Optimizing single-photon sources for indistinguishability represents an ongoing technological challenge. Solid-state emitters for instance typically exhibit inhomogenous frequency broadening due to charge noise. Current mitigation strategies such as feedback loops or post-selection introduce a large experimental overhead or drastically reduce the usable photon rate. In this work, we demonstrate a conceptually simple and efficient all-optical spectral control protocol on a nitrogen vacancy center in diamond. We observe that periodic excitation by optical π-pulses during the excited state lifetime reduces the emitter linewidth almost to the lifetime limit. Half of the spectral weight can be shifted to a target frequency selected by the pulse carrier frequency. The protocol [Fotso et al., PRL 116, 033603 (2016)] was proposed for the universal two-level system, rendering our approach applicable to a wide range of atomic and solid-state single-photon sources. Our work establishes a promising new avenue towards scalable sources of indistinguishable single photons.

MON 2.8 Mon 16:00 ZHG002

Coherent Control of a Carbon-13 nuclear spin proximal to a Tin-Vacancy Center in Diamond — •Jeremias Resch[1], Ioannis Karapatzakis[1], Philipp Fuchs[2], Marcel Schrodin[1], Michael Kieschnick[3], Julia Heupel[4], Mohamed Elshorbagy[1], Luis Kussi[1], Christoph Sürgers[1], Cyril Popov[4], Jan Meijer[3], Christoph Becher[2], Wolfgang Wernsdorfer[1], and David Hunger[1] — [1]Karlsruher Institut für Technologie — [2]Universität des Saarlands — [3]Universität Leipzig — [4]Universität Kassel

Robust quantum networks require an interface between photons and long-lived spin degrees of freedom. Due to its strong spin-orbit splitting, the Tin-Vacancy center electron spin possesses long spin lifetimes and has been shown to be able to be coherently controlled with high fidelity. In order to store information longer than the communication time between two nodes, even more long-lived nuclear spin degrees need to be coherently addressed. For high fidelity control of both electron and nuclear spin, the use of microwave fields is required. Recent work has shown the manipulation using aluminum wire bonds and on-chip gold waveguides. Both methods suffer from Ohmic losses in the microwave line, restricting coherence through heat induction. To overcome this challenge, we fabricate a superconducting coplanar waveguide made from Niobium on a diamond membrane through all-optical lithography. Using this, we demonstrate initialization of a single carbon-13 spin by optical pumping, perform high fidelity coherent manipulation, randomized benchmarking, and achieve a coherence time up to 1.3s.

MON 3: Many-Body Quantum Dynamics I

Time: Monday 14:15–16:15 Location: ZHG003

MON 3.1 Mon 14:15 ZHG003

Quantum circuit expectation values and real-time operator evolution via sparse Pauli dynamics — •Tomislav Begusic and Garnet Kin-Lic Chan — Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, California 91125, USA

We present sparse Pauli dynamics, a method for simulating quantum circuit expectation values and real-time operator evolution. We first demonstrate its performance on the example of kicked Ising model dynamics on 127 qubits, which was proposed as evidence for quantum utility of modern quantum devices. Here, we show that sparse Pauli dynamics can simulate observables orders of magnitude faster than the quantum experiment and can also be systematically converged beyond the experimental accuracy. Furthermore, we study real-time operator evolution. On the examples of energy diffusion in 1D spin chains and sudden quench dynamics in the 2D transverse-field Ising model, it is shown that this approach can compete with state-of-the-art tensor network methods. We further demonstrate the flexibility of the approach by studying quench dynamics in the 3D transverse-field Ising model which is highly challenging for tensor network methods.

MON 3.2 Mon 14:30 ZHG003

A comprehensive exploration of interaction networks—a connection between entanglement and network structure — •Yoshiaki Horiike[1,2] and Yuki Kawaguchi[1,3] — [1]Department of Applied Physics, Nagoya University, Nagoya, Japan — [2]Department of Neuroscience, University of Copenhagen, Copenhagen, Denmark — [3]Research Center for Crystalline Materials Engineering, Nagoya University, Nagoya, Japan

Recent experimental advances in various platforms for quantum simulators have enabled the realization of irregular interaction networks, which are intractable to implement with conventional crystal lattices. Another hallmark of these advances is the ability to observe the time-dependent behaviour of quantum many-body systems. However, the relationship between irregular interaction networks and quantum many-body dynamics remains poorly understood. Here, we investigate the connection between the structure of the interaction network and the eigenstate entanglement of the quantum Ising model by exploring all possible interaction networks up to seven spins. We find that the eigenstate entanglement depends on the structure of the Hilbert space diagram, particularly the structure of the equienergy subgraph. We further reveal a correlation linking the structure of the Hilbert space diagram to the number of unconstrained spin pairs. Our results demonstrate that the minimum eigenstate entanglement of the quantum Ising model is governed by the specific structure of the interaction network. (arXiv:2505.11466)

MON 3.3 Mon 14:45 ZHG003

Semiclassical Reconstruction of Many-Body Interference in the Beam Splitter — •Raphael Wiedenmann, Edoardo Carnio, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

The beam splitter is a key optical element for observing quantum interference, most famously in the experiment of Hong, Ou and Mandel. In this talk, we investigate to what extent many-body interference effects can be captured by a semiclassical treatment. To this end, we study the approximation of the Fock-space propagator based on classical orbits in phase space.

MON 3.4 Mon 15:00 ZHG003

Single- and many-body interference in a generalized Mach-Zehnder interferometer — •Farouk Albalacy, Gabriel Dufour, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

We study the interplay of single- and many-body interference effects in a generalized Mach-Zehnder interferometer with N particles and N ports. Single-particle interference is controlled by the phase differences between the interferometer's arms. The effect of bosonic or fermionic many-body interference is singled out by tuning the distinguishability of the particles through their internal states. We analyse the output counting statistics for $N = 2$ or 3 partially distinguishable particles as a function of the interferometer phases and of the particles' internal states.

MON 3.5 Mon 15:15 ZHG003

More global randomness from less random local gates — •Ryotaro Suzuki[1], Hosho Katsura[2], Yosuke Mitsuhashi[2], Tomohiro Soejima[3], Jens Eisert[1], and Nobuyuki Yoshioka[2] — [1]Freie Universität Berlin, Berlin, Germany — [2]The University of Tokyo, Tokyo , Japan — [3]Harvard University, Cambridge, USA

Random circuits giving rise to unitary designs are key tools in quantum information science and many-body physics. In this work, we investigate a class of random quantum circuits with a specific gate structure. Within this framework, we prove that one-dimensional structured random circuits with non-Haar random local gates can exhibit substantially more global randomness compared to Haar random circuits with the same underlying circuit architecture. In particular, we derive all the exact eigenvalues and eigenvectors of the second-moment operators for these structured random circuits under a solvable condition, by establishing a link to the Kitaev chain, and show that their spectral gaps can exceed those of Haar random circuits. Our findings have applications in improving circuit depth bounds for randomized benchmarking and the generation of approximate unitary 2designs from shallow random circuits.

MON 3.6 Mon 15:30 ZHG003

Fourier analysis of partial distinguishability in many-body systems — •Gabriel Dufour and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

The dynamics of bosonic and fermionic many-body systems is sensitive to partial distinguishability arising from internal states of the particles. Indeed, although they do not participate in the dynamics, these internal states may allow to individuate the particles and thereby affect their many-body interference. We show that the Fourier transform over the group of permutations of N objects is a powerful tool to understand the effect of partial distinguishability on many-body dynamics. This generalisation of the discrete Fourier transform allows to analyse how the many-body state transforms under permutations of the particles in terms of irreducible symmetry types. Beyond the bosonic and fermionic symmetries which occur in systems of perfectly indistinguishable particles, partially distinguishable particles are characterised by the appearance of additional, mixed symmetry types.

MON 3.7 Mon 15:45 ZHG003

Exploiting emergent symmetries in disorder-averaged quantum spin systems — •Mirco Erpelding[1], Adrian Braemer[2], and Martin Gärttner[1] — [1]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-University Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Symmetries are a key tool in understanding quantum systems and, among many other things, allow efficient numerical simulation of dynamics. Disordered systems usually feature reduced symmetries and additionally require averaging over many realizations, making their numerical study computationally demanding. However, when studying quantities linear in the time evolved state, i.e. expectation values of observables, one can apply the averaging procedure to the time evolution operator resulting in an effective dynamical map, which restores symmetry on the level of super-operators. In this work, we develop schemes for efficiently constructing symmetric sectors of the disorder-averaged dynamical map using short-time and weak-disorder expansions. To benchmark the method, we apply it to an Ising model with random all-to-all interactions in the presence of a transverse field. After disorder averaging, this system becomes effectively permutation invariant, and thus the size of the symmetric subspace scales polynomially in the number of spins allowing for the simulation of very large systems.

MON 3.8 Mon 16:00 ZHG003

Josephson-like dynamics of the low-energy crystal Goldstone mode in trapped supersolid spin-orbit-coupled Bose gases — •Kevin T. Geier, Vijay Pal Singh, Juan Polo, and Luigi Amico — Quantum Research Center, Technology Innovation Institute, PO Box 9639, Abu Dhabi, United Arab Emirates

Supersolidity is a phase of quantum matter that combines superfluidity with a solid-like crystal structure. These exotic properties are characterized by the spontaneous breaking of both phase and translational symmetry. According to Goldstone's theorem, there is a gapless mode associated with each broken symmetry. For the broken translational invariance, the Goldstone mode corresponds to a rigid translation of the supersolid pattern, which costs zero energy in an infinite system. However, in a finite system, e.g., in the presence of an external trapping potential, this motion acquires a finite energy cost and can exhibit nontrivial dynamics. Here, we show that the low-energy crystal Goldstone mode in trapped supersolid spin-orbit-coupled Bose-Einstein condensates can exhibit Josephson-like dynamics, analogous to a nonrigid pendulum. Depending on the amount of energy injected into the system by a uniform spin perturbation, the supersolid density stripes either oscillate back and forth, or undergo a unidirectional motion. We illustrate this dynamics through numerical simulations and explain the different regimes analytically under a two-mode approximation, where the equations of motion have the same structure as those governing a bosonic Josephson junction. Finally, we discuss perspectives for an observation of these effects in cold-atom experiments.

MON 4: DPG Promotionskolleg Next Generation Computing

Time: Monday 14:15–16:15 Location: ZHG004

MON 4.1 Mon 14:15 ZHG004

From Qubits to Neuromorphic Computing: Technologies Shaping the Future of Computing (Part 1) — •Jonah Elias Nitschke[1], Noah Stiehm[2], Sebastian Grossenbach[3], and Alexander Cornelius Heinrich[4] — [1]TU Dortmund university, Dortmund, Germany — [2]TU Ilmenau, Ilmenau, Germany — [3]Uni Konstanz, Konstanz, Germany — [4]QuantumBW, Stuttgart, Germany

What will the future of computing look like? Which technologies will define it, and what might succeed classical digital computation?

The technological landscape is diverse and rapidly evolving, with emerging fields such as analog and neuromorphic computing, as well as quantum computing. The German Physical Society (DPG) has launched its first Graduate Program (DPG-Promotionskolleg) to provide a structured perspective on these developments.

This initiative is not only focused on a new topic but also introduces an innovative format. The DPG Graduate School is a pilot initiative designed to encourage interdisciplinary and cross-institutional collaboration among PhD students over a period of 18 months. Participants will work alongside experts from academia, industry, and consulting to address complex questions related to the future of computing. The program emphasizes collaboration across various disciplines and encourages participants to look beyond their research topics and answer questions such as: How does my research contribute to the broader development of next generation computer technology, and why is it relevant to society?

MON 4.2 Mon 14:30 ZHG004

From Qubits to Neuromorphic Computing: Technologies Shaping the Future of Computing (Part 2) — David Ohse[1], •David Steffen[2], Julia Diana Küspert[3], Sebastian Bürger[4], and Verena Feulner[5] — [1]Uni of Bonn, Bonn, Germany — [2]DLR Institue of Engineering Thermodynamics, Ulm, Germany — [3]The European Synchrotron, Grenoble, France — [4]University of Leipzig, Leipzig, Germany — [5]University of Erlangen-Nuremberg, Erlangen, Germany

In our first session, we will introduce the DPG Graduate Program concept and share practical insights from its first cohort. Participants will present key findings from their research on emerging computing technologies, with a particular emphasis on quantum computing. We provide an overview of the status of various hardware implementations, software architectures, and algorithm development. We further discuss how the DPG Graduate Program Next Generation Computing encouraged scientific collaboration and outreach.

In the following sessions, selected participants will provide an introduction to their research topic and explain their motivation for joining the first cohort of the DPG Graduate School. In the last part, our scientific advisory board will join us for a panel discussion to address the significant challenges the field is expected to face over the next decade and how acceptance and trust in new computing technologies can be fostered in society.

MON 4.3 Mon 14:45 ZHG004

Towards a Parallel Electrical Read-Out for Spin-Wave-Based Spectrometers — •Johannes Greil[1], Felix Naunheimer[1], Valentin Ahrens[1], Manuel Wilke[1], Tobias Mohr[1], Levente Maucha[2], Ádám Papp[2], György Csaba[2], and Markus Becherer[1] — [1]Technical Universtiy of Munich, Munich, Germany — [2]Pázmány Peter Catholic University, Budapest, Hungary

This work presents the fine-tuning and electrical characterization of a demonstrator that combines a magnonic spectrometer in the Rowland circle arrangement with an RF circuit board for electrical read-out. We fabricate the Rowland circles by sputter deposition of Yttrium-Iron-Garnet (YIG) on a Gadolinium-Gallium-Garnet (GGG) substrate, followed by wet-chemical etching of the amorphous YIG film. In a subsequent lithography step, we fabricate a curved stripline transducer as input and several u-shaped transducers as local pick-ups for the output. We have achieved a mono-frequent detection resolution of around 45MHz in a usable band of 180MHz using time-resolved MOKE (trMOKE) measurements. With this system, we could successfully show that two-tone excitation and, consequently, wavefront separation is possible. The next step toward a more self-standing demonstrator device is the electrical detection of the locally picked-up magnonic signals. For this, we suggest a simple yet powerful method of power detection using RF diodes instead of RF amplifiers or mixers. To perform such measurements, we designed a circuit board providing one RF power detector per pick-up transducer, which can be read using any analog-to-digital converter (ADC).

MON 4.4 Mon 15:00 ZHG004

Quantum Computing with Trapped Ions — •Florian Ungerechts — Institut für Quantenoptik, Leibniz Universität Hannover, Germany

Trapped ions are a leading platform for quantum computing, providing high gate fidelities, long coherence times, and all-to-all connectivity between the qubits. But how does quantum computing with trapped ions work?

We begin by motivating what makes trapped ions great qubits, followed by an introduction to the basics of ion traps and how they allow for precise control of individual ions. Finally, we give a brief insight into the current status of ion-trap quantum processors in research and industry.

MON 4.5 Mon 15:15 ZHG004

Robustly optimal dynamics for active matter reservoir computing — •Mario U. Gaimann and Miriam Klopotek — Stuttgart Center for Simulation Science (SimTech), Cluster of Excellence EXC 2075, University of Stuttgart, Germany

Information processing abilities of active matter are studied in the reservoir computing (RC) paradigm to infer the future state of a chaotic signal. We uncover an exceptional regime of agent dynamics that has been overlooked previously. It appears robustly optimal for performance under many conditions, thus providing valuable insights into computation with physical systems more generally. The key to forming effective mechanisms for information processing appears in the system's intrinsic relaxation abilities. These are probed without actually enforcing a specific inference goal. The dynamical regime that achieves optimal computation is located just below a critical damping threshold, involving a relaxation with multiple stages, and is readable at the single-particle level. At the many-body level, it yields substrates robustly optimal for RC across varying physical parameters and inference tasks. A system in this regime exhibits a strong diversity of dynamic mechanisms under highly fluctuating driving forces. Correlations of agent dynamics can express a tight relationship between the responding system and the fluctuating forces driving it. As this model is interpretable in physical terms, it facilitates re-framing inquiries regarding learning and unconventional computing with a fresh rationale for many-body physics out of equilibrium. Reference: Gaimann, M. U., & Klopotek, M. (2025), arXiv:2505.05420.

MON 4.6 Mon 15:30 ZHG004

Silicon-germanium: A platform for both, spin qubit and superconducting planar qubit circuits — •Pauline Drexler and Jakob Walsh — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany

Silicon-germanium in principle offers a unique possibility to implement two very different types of solid-state qubits within the same materials platform: semiconductor spin qubits and superconducting flux qubits. In this approach, spin qubits are realized in Coulomb blockade-based quantum dots. Flux qubits are envisioned to be created via assemblies of gate-tunable hybrid Josephson junctions, based on a superconducting film, in proximity interaction with the semiconductor. The common basis of both types of quantum circuits is an epitaxially grown silicon-germanium quantum-confined semiconductor thin film structure. Each type of qubit then essentially relies on different planar, surface electrode circuitry layouts. In my presentation, I will discuss the epitaxy of hybrid semiconductor structures and practical aspects of the realization of both types of qubits quantum circuits. I will highlight the advantages of the planar circuit approach regarding scaling of future quantum processors and the high compatibility of the silicon-germanium platform with the current semiconductor chip industry.

MON 4.7 Mon 15:45 ZHG004

Panel discussion about Next Generation Computing and its impact on industry and society (Part 1) — •Andreas Böhm[1], Adrian Auer[2], Jeanette Lorenz[3], Hans Huebl[4], Niclas Götting[5], and Markus Hoffmann[6] — [1]Bayern Innovativ, Nuremberg, Germany — [2]IQM GmbH, Munich, Germany — [3]Fraunhofer IKS, Munich, Germany — [4]Walther-Meißner-Institut, Munich, Germany — [5]University of Bremen, Bremen, Germany — [6]FAU Erlangen-Nuremberg, Erlangen, Germany

In this panel discussion, we will focus on how to strengthen the exchange between science and industry in the dynamic field of next generation computing. Joined by our scientific advisory board consisting of Jeanette Lorenz (Fraunhofer Gesellschaft), Andreas Böhm (Bayern Innovativ), Adrian Auer (IQM), and Hans Hübl (Bavarian Academy of Sciences and Humanities), we will discuss which strategies and platforms can encourage knowledge transfer and accelerate innovation.

MON 4.8 Mon 16:00 ZHG004

Panel discussion about Next Generation Computing and its impact on industry and society (Part 2) — •Martin Mauser[1], Christoph Huettl[2], Max Mangold[3], Niclas Popp[4], and Nils-Erik Schütte[5] — [1]University of Vienna, Vieann, Austria — [2]Charité Berlin, Berlin, Germany — [3]TUM, Munich, Germany — [4]Eberhard Karl University of Tübingen, Tübingen, Germany — [5]University of Bremen, Bremen, Germany

Another key focus will be on the major challenges the field is expected to face over the next decade, ranging from technological challenges to ethical considerations. Furthermore, the discussion will address how society can be actively involved in the development and application of new computing technologies to foster acceptance and trust. Our goal is to bring together diverse perspectives and develop concrete recommendations for future-oriented collaboration.

MON 5: Optical Quantum Devices

Time: Monday 14:15–16:00 Location: ZHG006

MON 5.1 Mon 14:15 ZHG006

Magneto-optical trap of aluminium monofluoride — •Jose Eduardo Padilla-Castillo[1], Jionghao Cai[1], Russell Thomas[1], Sebastian Kray[1], Boris Sartakov[1], Stefan Truppe[2], Gerard Meijer[1], and Sidney Wright[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Centre for Cold Matter, Imperial College, SW7 2AZ London, UK

Despite impressive progress in direct laser cooling of molecules, magneto-optical trapping has thus far been restricted to species with spin-doublet electronic ground states. These molecules are chemically reactive and only support a simple laser cooling scheme when exciting from the first rotationally excited level of the ground state.

In this talk, we will present the first magneto-optical trap (MOT) of the diatomic molecule aluminium monofluoride (AlF). This $^1\Sigma^+$ ground state molecule is amongst the most deeply bound molecules known, and even survives collision with vacuum walls of our experiment. Despite the challenging laser wavelengths required for the MOT (λ = 227.5 - 232 nm), we take advantage of the intense $A^1\Pi \leftarrow X^1\Sigma^+$ transition in AlF, which allows trapping three different rotationally excited levels of the ground via their respective Q(J) lines.

Our results set a new record for the shortest wavelength MOT, narrowly surpassing the 18 year-old milestone set by atomic Cd (λ = 228.9 nm). Similar to Cd, AlF possesses a spin-forbidden transition between its two lowest spin-singlet and triplet states. Magneto-optical trapping is a key step towards precise spectroscopy and control of the molecule via this narrow, ultraviolet transition.

MON 5.2 Mon 14:30 ZHG006

Material aspects for high-precision optical metrology — •Nico Wagner[1,2], Liam Shelling Neto[1,2], and Stefanie Kroker[1,2,3] — [1]Institut für Halbleitertechnik, Technische Universität Braunschweig, Hans-Sommer-Str. 66, Braunschweig, 38106 Germany — [2]Laboratory for Emerging Nanometrology, Langer Kamp 6a-b, Braunschweig, 38106 Germany — [3]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

High-precision optical metrology relies on materials with outstanding thermal and mechanical stability to push the limits of frequency accuracy. We explore material solutions that enhance the performance of ultra-stable optical cavities and laser systems. NEXCERA, a ceramic with a ultra-low thermal expansion coefficient at room temperature, shows reduced thermal noise compared to commonly used materials, making it ideal for cavity spacers. In mirror development, crystalline AlGaAs/GaAs coatings demonstrate lower mechanical loss than traditional amorphous coatings, though light-induced effects can introduce additional noise. We present insights into how illumination affects the mechanical loss and elasticity of GaAs. Furthermore, metamirrors—structured single-layer reflectors—offer a route to high reflectivity with significantly reduced thermal noise. For spectral-hole burning applications, the rare-earth-doped crystal Eu^{3+}:Y_2SiO_5 exhibits low cryogenic mechanical losses, making it a promising candidate for alternative laser stabilization techniques. These material innovations contribute to the advancement of robust and compact systems for future applications in optical frequency standards and precision metrology.

MON 5.3 Mon 14:45 ZHG006

Shapiro steps in driven atomic Josephson junctions — •Vijay Singh[1], E. Bernhart[2], M. Röhrle[2], H. Ott[2], G. Del Pace[3], D. Hernandez-Rajkov[3], N. Grani[3], M. Frometa Fernandez[3], G. Nesti[3], J. A. Seman[4], M. Inguscio[3], G. Roati[3], L. Mathey[5], and L. Amico[1] — [1]QRC, TII, Abu Dhabi, UAE — [2]RPTU Kaiserslautern, Germany — [3]LENS, University of Florence, Italy — [4]UNAM Mexico — [5]ZOQ and IQP, Universität Hamburg, Germany

We report the observation of Shapiro steps in atomic Josephson junctions formed by coupling two ultracold atom clouds. As predicted in the theoretical proposal, periodic modulation of the position of the tunneling barrier induces Shapiro steps in the dc current-chemical potential characteristic. Experiments on a Josephson junction of ^{87}Rb atoms display Shapiro steps in the current-potential characteristic, exhibiting universal features and providing key insight into the microscopic dissipative dynamics associated with phonon emission and soliton nucleation. Experiments with strongly-interacting Fermi superfluids of ultracold atoms also show the creation of Shapiro steps in the current-potential characteristics, with their height and width reflecting the external drive frequency and the junction nonlinear response. Direct measurements of the current-phase relationship reveal the underlying dissipation mechanism via the emission of vortex-antivortex pairs. These results establish a significant connection between superconducting and atomic Josephson dynamics, with unprecedented control and flexibility over physical parameters. Finally, our results lay the foundation for the development of new atomtronic devices and sensors.

MON 5.4 Mon 15:00 ZHG006

A Free-Electron-Driven Quantum Light Source — •F. Jasmin Kappert[1,2], Armin Feist[1,2], Guanhao Huang[3], Germaine Arend[1,2], Yujia Yang[3], Jan-Wilke Henke[1,2], Arslan Sajid Raja[3], Rui Ning Wang[3], Hugo Lourenco-Martins[1,2], Rudolf Haindl[1,2], Zheru Qiu[3], Junqiu Liu[3], Ofer Kfir[1,2], Tobias J. Kippenberg[3], and Claus Ropers[1,2] — [1]MPI for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Germany — [3]Institute of Physics, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland

Tailored nonclassical light is essential for photonic quantum technologies, yet generating complex optical states remains challenging. Inelastic free-electron scattering offers a promising new method for creating parametric and wavelength-tunable quantum light, particularly through coherent cathodoluminescence.

Here, we present a novel platform that efficiently couples free-electron beams to silicon nitride integrated photonics [1], enabling the generation of electron-photon pair states [2]. By post-selecting electrons with quantized energy loss, we can herald nonclassical single and multi-photon states [2,3]. This establishes a versatile source of tailored quantum light, potentially leading to a new class of hybrid quantum technology that combines electrons and photons.

[1] J.-W. Henke, FJK et al., Nature 600, 653 (2021)
[2] A. Feist, FJK et al., Science 377, 777 (2022)
[3] G. Arend et al., arXiv:2409.11300 (2024)

MON 5.5 Mon 15:15 ZHG006

Optimal quantum control and optical beam shaping for atomic gravi-gradiometer. — •Joel Gomes Baptista, Louis Pagot, Léo Rol, Niranjan Myneni, Leonid Sidorenkov, Sébastien Merlet, and Franck Pereira Dos Santos — LTE-Observatoire de Paris, Paris, France

Cold-atom interferometry-based inertial sensors represent a highly developed quantum technology, capable of achieving performances comparable to those of conventional sensors. Our sensor measures simultaneously the vertical component of the gravitational acceleration $\vec{g}$ and its gradient using a Mach-Zehnder-like interfermoter on two laser cooled ^{87}Rb atomic cloud separated by 1 m. Currently, the clouds temperature ($\approx 2\mu K$) limits the performance of the gradiometer. The Doppler detunings and the ballistic expansion at long interrogation times ($T \approx 200$ ms) reduce the efficiency of the atom-optics based on high-order Bragg transitions.

Here, we use an optimal control theory algorithm based on GRAPE method to generate dedicated evolution patterns of the coupling phase during the interrogation pulses and demonstrate the enhanced fidelity of Bragg atom-optics in our gravi-gradiometer.

In addition, we mitigate the coupling inhomogeneities originating from the usual Gaussian beam using a custom-built top-hat collimator, which generates a uniform intensity profile and maintains a stable wavefront over 3.5m propagation. We explore the integration of OCT methods with top-hat laser beam profiles to overcome key limitations of large momentum transfer atom optics for μK-range atom sources.

MON 5.6 Mon 15:30 ZHG006

Modeling and Characterization of Active Silicon Microring Resonators — •Kambiz Jamshidi, Abdou Shetewy, and Menglong He — Integrated Photonics Devices Group, Chair of RF and Photonics, Technische Universität Dresden, 01069, Dresden, Germany

Silicon ring resonators can be used for several applications in communication, signal processing, and computing. By embedding the silicon waveguide in a pn junction, it is possible to tune the free carrier lifetime of the waveguide, which provides an additional degree of freedom to tune the steady-state response of these resonators and therefore the regime in which they operate. A theoretical framework is required to model the dynamics of light evolution in these resonators, taking into account the number of free carriers in the resonator and its temperature. In this article, the nonlinear coupled equations required for this modeling will be reviewed. In addition, characterization results of the resonators, which are fabricated in a standard process using silicon-on-insulator technology, will be discussed. Finally, several applications of the resonators at different biases will also be presented.

MON 5.7 Mon 15:45 ZHG006

Leveraging Large Language Models as Qualitative Figures of Merit — •Liam Shelling Neto[1], Nico Wagner[1], and Stefanie Kroker[1,2] — [1]Technische Universität Braunschweig, Institute of Semiconductor Technology, Hans-Sommer-Str. 66, Braunschweig, 38106, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, Braunschweig, 38116, Germany

Inverse design of photonic components, particularly in quantum technology, typically relies on quantitative figures of merit (FoMs) such as efficiency, transmission, or beam waist, metrics derived from precisely defined simulation data. However, many design goals are inherently qualitative or difficult to express numerically. We propose using large language models (LLMs) as evaluators of qualitative figures of merit (qFoMs) to complement traditional FoMs. These qFoMs can assess visual or descriptive attributes of optical responses, such as field distributions, via natural language prompts and image inputs. For example, when optimizing a grating coupler to produce a Gaussian beam, early designs often yield patterns far from Gaussian, rendering quantitative fits ineffective. An LLM-based qFoM, similar to a human, can still assign a "Gaussianity" score to guide the optimizer in the right direction, even in these early, low-performance stages. By integrating qFoMs with traditional metrics, LLMs act as pseudo-intelligent agents that bridge the gap between human intuition and algorithmic evaluation, enabling more robust and flexible optimization, especially when the target functionality is poorly defined or initially unmet.

MON 6: QIP Implementations: Trapped Ions

Time: Monday 14:15–16:15 Location: ZHG007

MON 6.1 Mon 14:15 ZHG007

Quantum Information Processing with Trapped Rydberg Ions — •Katrin Bolsmann[1,2], Thiago L. M. Guedes[1,2], Joseph W. P. Wilkinson[3], Igor Lesanovsky[3,4], and Markus Müller[1,2] — [1]Institut für Quanteninformation, RWTH Aachen University — [2]PGI-2, Forschungszentrum Jülich — [3]Institut für Theoretische Physik, Universität Tübingen — [4]School of Physics and Astronomy, University of Nottingham

Combining the strong, long-range interactions of cold Rydberg atoms with the controllability of trapped ions, trapped Rydberg ions provide a promising platform for scalable quantum information processing. As demonstrated in a breakthrough experiment (Zhang et al., Nature 580, 345, 2020), microwave dressing of Rydberg states induces permanent rotating dipole moments leading to strong interactions between highly excited ions. Due to the separation of timescales, the fast electronic dynamics of Rydberg ions decouple from the slower motional modes of the linear Coulomb crystal, which typically mediate entangling gates in ground-state ion systems. Therefore, Rydberg ions enable significantly faster gate operations.

In this talk, we will discuss how the unique features of trapped Rydberg ions can be used to realize fast and high-fidelity entangling gates, along with the associated challenges and strategies to address them. We will present different types of gate protocols for two- and multi-qubit entangling gates with trapped Rydberg ions, analyze sources of infidelity, and compare the performance with other platforms based on neutral atoms and ground-state ions.

MON 6.2 Mon 14:30 ZHG007

Register-Based Trapped-Ion Quantum Processors with Near-Field Microwave Control — •Florian Ungerechts[1], Rodrigo Munoz[1], Janina Bätge[1], M.Masum Billah[1], Axel Hoffmann[1,2], Giorgio Zarantonello[1,3], and Christian Ospelkaus[1,4] — [1]Inst. f. Quantenoptik, Leibniz Universität Hannover — [2]Inst. f. Hochfrequenztechnik und Funksysteme, Leibniz Universität Hannover — [3]QUDORA Technologies GmbH — [4]Physikalisch-Technische Bundesanstalt

Trapped ions are a leading platform for quantum information processing, offering long coherence times, high gate fidelities, and unmatched quantum volume. Scalable architectures, such as the Quantum Charged Coupled Device (QCCD) architecture, enable all-to-all connectivity between atomic ion qubits in dedicated registers and can be implemented on microfabricated surface-electrode traps. However, as chip size increases, external free-space lasers become infeasible. To address this, quantum logic gates with chip-integrated microwave conductors have been demonstrated, also eliminating spontaneous emission as an intrinsic error source in laser-driven gates. Although shown individually, combining the QCCD architecture with the near-field microwave control technique into scalable devices is a current research topic. We present an overview of our recently developed surface-electrode traps for near-term quantum information processing with up to 50 atomic ion qubits. We compare the chip architectures and highlight the design of radiofrequency junctions, bucket-brigade storage registers, and chip-integrated microwave conductors.

MON 6.3 Mon 14:45 ZHG007

Framework for optimization of Paul trap design and control voltages for X-junction shuttling — •Andreas Conta, Ulrich Poschinger, and Ferdinand Schmidt-Kaler — Institut für Physik, Johannes Gutenberg-Universität Mainz

Trapped-ion quantum computing is a promising architecture for large-scale quantum computing. We aim to scale up the shuttling-based [1] approach. This requires complex multi-segmented traps that include junctions [2]. We present our work of a framework for optimization of trap designs and control voltages waveforms, with the goal of shuttling a linear crystals an X-junction. Commercially available tools are used to create parameterised models of traps and potentials of the electrodes [3]. Our custom Segmented Ion Trap CONtrol System (SITCONS) then performs a multipole expansion, thereby enabling the calculation of control voltages using quadratic programming. We analyse the influence of different trap designs and electrode shapes on the shuttling through an X-junction.

[1] Ruster et al., Phys. Rev. A 90, 033410 (2014)
[2] Delaney et al., Phys. Rev. X 14, 041028 (2024)
[3] Nullspace Inc., Nullspace ES [software], https://www.nullspaceinc.com/

MON 6.4 Mon 15:00 ZHG007

Generating arbitrary coupling matrices for multi-qubit quantum gates — •Patrick H. Huber, Dorna Niroomand, Markus Nünnerich, Patrick Barthel, and Christof Wunderlich — Department of Physics, School of Science and Technology, University of Siegen, 57068 Siegen, Germany

An always-on, all-to-all Ising-type interaction between qubits in a quantum register can be provided by the Magnetic Gradient Induced Coupling (MAGIC) approach to quantum computing with trapped ions [1,2]. In that case, the interaction strength between radio frequency(rf)-controlled qubits is determined by the trapping potential and the applied magnetic field gradient.

Here we present a novel method that allows for the tuning of the qubits' interaction without changing the trapping potential nor the magnetic field while simultaneously preserving the qubits' coherence. This method uses pulsed dynamical decoupling and is demonstrated experimentally in a quantum register of four qubits encoded into hyperfine states of the electronic ground state of laser-cooled $^{171}Yb^{+}$ ions . We synthesize an arbitrary coupling matrix within this quantum register and, furthermore, generate non-interacting subregisters. Thus, this method opens up a new path for efficiently synthesizing quantum algorithms when using an all-to-all Ising-type interaction between qubits.

[1] A. Khromova *et al.*, Phys. Rev. Lett. **108**, 220502 (2012). [2] P. Baßler *et al.*, Quantum **7**, 984 (2023).

MON 6.5 Mon 15:15 ZHG007

Fast radio frequency-driven entangling gates with trapped ions using rapid phase switching — •Markus Nünnerich, Patrick Huber, Dorna Niroomand, and Christof Wunderlich

— Department of Physics, School of Science and Technology, University of Siegen, 57068 Siegen, Gemany

Entangling gates are a fundamental component of any quantum processor, ideally operating at high speeds in a robust and scalable manner. Here, we experimentally investigate a novel radio frequency (RF)-driven two-qubit gate with trapped and laser cooled $^{171}\mathrm{Yb}^+$ ions exposed to a static magnetic gradient field of 19 T/m that induces an effective qubit-qubit interaction (Magnetic Gradient Induced Coupling, MAGIC). The hyperfine states $|0\rangle \equiv |^2\mathrm{S}_{1/2}, \mathrm{F}=0, \mathrm{m_F}=0\rangle$ and $|1\rangle \equiv |^2\mathrm{S}_{1/2}, \mathrm{F}=1, \mathrm{m_F}=-1\rangle$ are used as qubits. We generate Bell states by applying continuously two RF driving fields, each one of them on resonance to one of the qubit transitions. By modulating the phase or amplitude of the driving fields, qubits are protected from addressing and RF amplitude fluctuations. In the experiments presented here, the phase of the driving fields varies periodically in discrete values, yielding effectively a sequence of back-to back dynamical decoupling pulses. By adjusting the Rabi frequency induced by the driving fields, the effective coupling of the qubits to the ions' motional state is changed, and the entangling gate speed can be varied between ≈ 4 ms and $\approx 300\mu$s. In currently used micro-structured traps with larger magnetic field gradients, gate speeds on par with laser-driven gates in trapped ions are expected.

MON 6.6 Mon 15:30 ZHG007

Scaling-up a trapped-ion quantum computer using MAGIC — •Saptarshi Biswas[1], Ivan Boldin[1], Benjamin Bürger[1], Friederike J. Giebel[3,4], Radhika Goyal[2], Patrick Huber[1], Eike Iseke[3,4], Lukas Kilzer[2], Nila Krishnakumar[3,4], Rodolfo Muñoz Rodriguez[1], Tobias Pootz[2], Kais Rejaibi[1], David Stuhrmann[2], Nora Daria Stahr[2,4], Jacob Stupp[2,4], Konstantin Thronberens[3,4], Celeste Torkzaban[2], Pedram Yaghoubi[1], Christian Ospelkaus[2,3,4], and Chritsof Wunderlich[1] — [1]Department of Physics, School of Science and Technology, University of Siegen, 57068 Siegen, Germany — [2]Gottfried Wilhelm Leibniz Universität, Hannover, Germany — [3]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [4]Laboratory of Nano and Quantum-Engineering, Hannover, Germany

We present the status of a cryogenic (4K) experimental set-up for quantum computing with radio frequency (rf)-controlled trapped ions. It incorporates a novel micro-structured planar Paul trap with integrated micromagnets and we report on the characterization of the first trap generation to be used in this set-up. The ions interact via magnetic gradient induced coupling (MAGIC).Also, progress in developing laser cooling techniques for mixed Yb^+-Ba^+ crystals is reported.

MON 6.7 Mon 15:45 ZHG007

Efficient simulation workflow for micro-structured planar Paul traps — •Kais Rejaibi, Dorna Niroomand, Patrick Huber, and Christof Wunderlich — Department of Physics, School of Science and Technology University of Siegen, 57068 Siegen, Gemany

Trapped-ion experiments require precise control of ion motion, minimal micromotion, and stable quantum state manipulation. To support this, we developed a simulation workflow based on the Boundary Element Method (BEM), which accurately models electric fields from complex electrode layouts, including junction-type planar Paul traps and designs using Magnetic Gradient Induced Coupling (MAGIC). The method handles open boundary conditions efficiently and is suitable for iterative design.

We use a solid harmonics decomposition to analyze the simulated fields. This helps us to identify and to reduce higher-order multipole components that can cause residual micromotion. In addition, we can add specific higher-order components in a controlled way to create interaction patterns for many-body quantum systems, for instance by shaping the effective J-coupling matrix between ions.

This approach-combining simulation, field analysis, and voltage control-helps us design planar Paul traps that support reliable ion transport through regions with varying magnetic fields. It improves design efficiency and supports the development of more capable systems for quantum information experiments.

MON 6.8 Mon 16:00 ZHG007

Micro-structured ion traps with integrated magnets for quantum science — •Benjamin Bürger, Patrick Huber, and Christof Wunderlich — Department of Physics, School of Science and Technology, University of Siegen, 57068 Siegen, Germany

We present the design and implementation of quasi-two-dimensional (2D) micromagnets tailored to generate an inhomogeneous static magnetic field. This field, when integegrated into a micro-structured ion trap, enables frequency-selective addressing of ions through radio frequency radiation (RF) and conditional quantum dynamics with trapped ions. We will integrate the magnet design into a planar Paul trap that is split into two types of regions: An interaction zone and a cooling/readout zone. The micromagnets are meticulously designed to produce high field gradients while maintaining a low absolute field strength, effectively minimizing decoherence induced by magnetic field noise within the qubit interaction zones. In the cooling/readout zones, the magnets are designed to generate a small homogeneous magnetic field to facilitate efficient Doppler cooling on larger strings. Furthermore, the magnetic field orientation is optimized to support both σ and π polarized RF-driven transitions in $^{171}\mathrm{Yb}^+$ ions facilitating efficient cooling on the magnetic-field-insensitive π transition and utilizing the σ transition for gate operations.

MON 7: Foundational / Mathematical Aspects – Quantum Measurement

Time: Monday 14:15–16:15 Location: ZHG008

MON 7.1 Mon 14:15 ZHG008

Weak values as stereographic projections — Lorena Ballesteros Ferraz[1,3], Dominique L. Lambert[2], and •Yves Caudano[3] — [1]Present address: Lab. de Physique Théorique et Modélisation, CNRS Unité 8089, CY Cergy Paris Université, France — [2]SPS department, esphin and naXys, University of Namur, Belgium — [3]Physics department, naXys and NISM, University of Namur, Belgium

Quantum weak measurements generate a lot of fundamental and practical interest, as weakly perturbing probes or means of amplifying small effects. In a pre- and post-selected weak measurement, the experimental deflection of the measuring device depends on the real part or on the imaginary part of the weak value, a complex number. However, weak values also possess a polar representation. We have connected the argument of weak values in N-level systems to a geometric phase [1] related to a geodesic triangle in the quantum state manifold. Building on results developed for open quantum systems [2], we now demonstrate that arbitrary weak values can be interpreted as a stereographic projection of the post-selected state. This offers a comprehensive geometric interpretation of the weak value's modulus and argument, enabling its visualisation jointly with the associated quantum states. Then, the geometric phase appears as both a complex-plane angle and a solid angle on the Bloch sphere, effectively mapping the weak value onto an effective two-level system.

[1] L. B. Ferraz, D. L. Lambert, and Y. Caudano, Quantum Sci. Technol. 7 (2022) 045028. [2] L. B. Ferraz, J. Martin, and Y. Caudano, Quantum Sci. Technol. 9 (2024) 035029.

MON 7.2 Mon 14:30 ZHG008

Present status and future challenges of non-interferometric tests of collapse models — •Matteo Carlesso — University of Trieste, Strada Costiera 11, 34151 Trieste — Istituto Nazionale di Fisica Nucleare, Trieste Section, Via Valerio 2, 34127 Trieste, Italy

The superposition principle is the cornerstone of quantum mechanics, leading to a variety of genuinely quantum effects. Whether the principle applies also to macroscopic systems or, instead, there is a progressive breakdown when moving to larger scales is a fundamental and still open question. Spontaneous wavefunction collapse models predict the latter option, thus questioning the universality of quantum mechanics. Technological advances allow to increasingly challenge collapse models and the quantum superposition principle, with a variety of different experiments. Among them, non-interferometric experiments proved to be the most effective in testing these models. We provide an overview of such experiments, including cold atoms, optomechanical systems, X-ray detection, bulk heating and comparisons with cosmological observations. We also discuss avenues for future dedicated experiments, which aim at further testing collapse models and the validity of quantum mechanics.

MON 7.3 Mon 14:45 ZHG008

The role of redundant correlated records in the emergence of Objective Classical Reality — •VIshal Johnson[1,2], Ashmeet Singh[3], and Torsten Ensslin[1,2] — [1]Max Planck Institute for Astrophysics, Garching, Germany — [2]Ludwig Maximilians University, Munich, Germany — [3]Whitman College, Walla Walla, USA

Quantum measurement inevitably involves a physical system, the observer, in which the result of the measurement procedure is stored. Therefore, in the context of unitary (reversible) quantum mechanics, one has to include the observer as a physical system operating within the limits of quantum mechanics. We argue that a physical quantity (correlation) is a resource used up in each quantum measurement. We put constraints on the nature of environmental/observer states which lead to redundant, classical record formation — correlation can be provided by a GHZ-like state before or after the interaction with the measured system. A network of such measurements establishes a stable objective classical reality — the redundant agreement of several observers on the state of the measured quantum system. We verify our hypotheses by simulating the quantum measurement procedure — observer network states with a high amount of correlation gives rise to high fidelity measurement results.

MON 7.4 Mon 15:00 ZHG008

Ultradecoherence model of the measurement process — •Hai-Chau Nguyen — University of Siegen

It is proposed that measurement devices can be modelled to have an open decoherence dynamics that is faster than any other relevant timescale, which is referred to as the ultradecoherence limit. In this limit, the measurement device always assumes a definite state upto the accuracy set by the fast decoherence timescale. Further, it is shown that the clicking rate of measurement devices can be derived from its underlying parameters, not only for the von Neumann ideal measurement devices but also for photon detectors in equal footing. This study offers a glimpse into the intriguing physics of measurement processes in quantum mechanics, with many aspects open for further investigation.

MON 7.5 Mon 15:15 ZHG008

Quantifying quantum coherence and the deviation from the total probability formula — •Antoine Soulas — IQOQI Vienna, Austria

Quantum coherence is the main resource exploited by quantum computers. Unsurprisingly, over the past few years, there has been a strong interest in the task of finding appropriate measures of coherence. We propose a novel approach which, contrary to the previous ones, relies on foundational/philosophical considerations. It allows to solve two drawbacks of the resource theoretic approach: the lack of physical meaning, and the restriction to one particular basis in which to quantify coherence. In our approach, coherence is understood as the ability for a quantum system's statistics to deviate from the total probability formula.

After motivatng the importance of the total probability formula in quantum foundations, we then propose a new set of axioms that a measure of coherence should satisfy, and show that it defines a class of measures different from the previous proposals. Finally, we prove a general result about the dependence of the l2-coherence norm on the basis of interest, namely that it is well approximated by the square root of the purity in most bases. Such a behaviour (the nearly constant level of coherence in most bases) is actually expected for any measure of coherence, because of the mathematical phenomenon known as "concentration of measure".

MON 7.6 Mon 15:30 ZHG008

Which-way knowledge increase via feed-forward of the interfering particle's phase — •Elisabeth Meusert, Marc-Oliver Pleinert, and Joachim von Zanthier — Friedrich-Alexander Universität, Erlangen, Germany

Complementarity constitutes a central aspect of quantum theory. It manifests itself for example in a two-way interferometer, where the simultaneous observation of an interference pattern and the aquisition of which-way information are limited by an inequality, known as the duality relation.

We investigate which-way information in a double-slit interferometer. We find that, depending on the which-way detector observable chosen, the which-way information can be correlated to the interfering particle's phase at the interferometer screen, leading to a phase-dependent which-way knowledge. In specific cases, this knowledge can locally exceed the limit set by the duality relation. Based on this observation, we propose a delayed choice protocol that aims at maximizing the which-way information locally for each phase after the particle has been read out. This allows us to surpass the duality relation limit on phase-average. We present analytical results as a proof of principle of our protocol as well as numerical outcomes quantifying the amount of achievable which-way knowledge.

MON 7.7 Mon 15:45 ZHG008

The Contextual Heisenberg Microscope — •Jan-Åke Larsson — Linköpings Universitet, Linköping, Sweden

The Heisenberg microscope provides a powerful mental image of the measurement process of quantum mechanics (QM), attempting to explain the uncertainty relation through an uncontrollable back-action from the measurement device. However, Heisenberg's proposed back-action uses features that are not present in the QM description of the world, and according to Bohr not present in the world. Therefore, Bohr argues, the mental image proposed by Heisenberg should be avoided. Later developments by Bell and Kochen-Specker shows that a model that contains the features used for the Heisenberg microscope is in principle possible but must be nonlocal and contextual. In this paper we will re-examine the measurement process within a restriction of QM known as Stabilizer QM, that still exhibits for example Greenberger-Horne-Zeilinger nonlocality and Peres-Mermin contextuality, using a recent extension of stabilizer QM, the Contextual Ontological Model (COM), where the system state gives a complete description of future measurement outcomes reproducing the quantum predictions, including the mentioned phenomena. The resulting contextual Heisenberg microscope back-action can be completely described within COM; the associated randomness originates in the initial state of the pointer system, exactly as in the original description of the Heisenberg microscope. The presence of contextuality, usually seen as prohibiting ontological models, suggests that the contextual Heisenberg microscope picture can be enabled in general QM.

MON 7.8 Mon 16:00 ZHG008

Measuring the speed of quantum particles without a round-trip under non-synchronized quantum clocks — •Tomer Shushi — Ben-Gurion University of the Negev, Beer Sheva, Israel

In this talk, we show that it is possible, in principle, to measure the velocity of particles that travel at the speed of light without assuming a round-trip once we adopt a quantum mechanical description under two boundary conditions to the state of the quantum system followed by the two-state-vector formalism while assuming non-synchronized quantum clocks with unknown time dilation [1]. The weak value of velocity can be measured for a test particle that has a clock that is not synchronized with the clock of the quantum particle. Following the proposed setup, when the weak value of the velocity is known even without knowing the time states of the system, such a weak velocity is the two-way speed of light. We further explore some fundamental implications of the setup. The proposed approach opens a new avenue toward measuring the velocities of quantum particles while overcoming relativistic issues regarding the synchronization of clocks. [1] Shushi, T. (2025). Measuring the speed of quantum particles without a round-trip under non-synchronized quantum clocks. Proceedings of the Royal Society A. 481: 20240708.

MON 8: Quantum Sensing and Decoherence: Contributed Session to Symposium I

Time: Monday 14:15–15:45 Location: ZHG009

MON 8.1 Mon 14:15 ZHG009

Diamond-based quantum processors - State-of-the-art and future challenges — Lukas Antoniuk[1], Gopi Balasubramanian[1], Priya Balasubramanian[1,2], Jan Binder[1], Jason Choudhury[1], Florian Frank[1], Matthias Gerster[1], •Julian Rickert[1], Janani Sevvel[1], and Mukesh Tripathi[1] — [1]XeedQ GmbH, Augustusplatz 1-4, D-04109 Leipzig, Germany — [2]Institute for Quantum Optics, Ulm University, Albert-Einstein-Allee 11, D-89081 Ulm, Germany

Engineered colour centres within diamond have demonstrated the potential for quantum sensing, communication, and computing. Coherent control of a few qubits has been demonstrated in group-IV- and NV-centres. Currently, NV systems are the only commercially available diamond quantum processors. State-of-the-art designs couple NV centres to nearby nuclear spins and directly to other NVs. Our work employs electron-beam lithography and focused ion beam implantation to fabricate high-purity diamond chips with tailored defects. We characterize these chips by benchmarking qubit coherence, single- and two-qubit NV gate operations, NV-nuclear spin control protocols, and NV-NV entanglement. Our efforts deliver comprehensive quantum control beyond existing lab demonstrations. However, scaling beyond a few qubits is complicated by material quality, fabrication precision, and nanoscale addressability. We are working on overcoming engineering, integration, and control challenges to enable scalable networks of interlinked NV centres.

MON 8.2 Mon 14:30 ZHG009

Towards Hyperpolarization at the Solid Surface - A Progress Report — •Konstantin Herb and Christian Degen — Department of Physics, ETH Zurich, Switzerland

Traditionally, nuclear magnetic resonance (NMR) spectroscopy suffers from intrinsically low sensitivity due to the relatively weak coupling of nuclear spins to an external magnetic field. To significantly enhance the sensitivity of NMR spectroscopy, electron spins may be used as a polarizing source. Transferring nuclear spin polarization from the Nitrogen-Vacancy (NV) center to its surrounding is a long-standing goal in field. In this talk, I will present our recent progress towards achieving hyperpolarization at the solid surface. We explore the possibilities and limits of transferring polarization from NV centers to the surface of diamond. We will discuss the challenges we face in this process, including the need for efficient transfer mechanisms and the optimization of experimental conditions.

MON 8.3 Mon 14:45 ZHG009

Height Calibration of Nitrogen Vacancy Diamond Tips Using Current-Carrying Wires — Robin Abram, •Ricarda Reuter, Alexander Fernández Scarioni, Sibylle Sievers, and Hans Werner Schumacher — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Scanning Nitrogen Vacancy Microscopy (SNVM) is a measurement technique capable of resolving the spatial distribution of magnetic stray fields with nanometer and microtesla resolution, respectively. It combines optical field detection with a scanning probe-like approach, where the key component is a diamond scanning tip containing a single NV center. While magnetic field measurements are quantum-calibrated with respect to the position of the NV center, precise knowledge of the distance to the sample is required to also consider the height dependence. Unfortunately, the latter can currently only be estimated with an uncertainty of up to several nanometers, most commonly from a calibration based on the stray field detection of ferromagnetic microstructures. We propose an improved height calibration based on SNVM studies of the current-induced Oersted field in Pt wires by Lee et al.. The out of plane field component is extracted from the raw data taken along the NV spin axis, following the approach first established by Schendel et al. and later applied to SNVM by Dovzhenko et al., and fitted to a numerical model. Compared to the calibration with ferromagnets, this approach is highly adaptable in terms of both magnetic and spatial resolution, thus contributing to fully exploiting the potential of the NV center as a quantum-based magnetic field sensor.

MON 8.4 Mon 15:00 ZHG009

Exploring non-Markovian dynamics in microwave spin control of group-IV color centers coupled to a phononic bath — •Mohamed Belhassen[1], Gregor Pieplow[1], and Tim Schröder[1,2] — [1]Humboldt-Universität zu Berlin, Berlin, Germany — [2]Ferdinand-Braun-Institut, Berlin, Germany

Microwave control is a well-established technique for driving the electronic spin of diamond color centers. In our earlier work [1], we demonstrated that optimizing the orientation of the static magnetic field lifting the spin degeneracy and the polarization of the microwave field driving the spin, is essential for achieving efficient control conditions in a low strain environment. Expanding on this, we now incorporate the phononic bath, which introduces decay and decoherence to the qubit's quantum state. We examine the system dynamics using both Markovian and non-Markovian master equations, revisiting the interplay between magnetic and microwave field orientations and applied strain, with a focus on their impact on the qubit decay and decoherence times. We interpret our simulation results and compare them with the most recent experimental results. Finally, we assess the validity of the Born-Markov approximation and investigate how bath memory effects impact quantum state evolution.

[1] G. Pieplow, M. Belhassen, T. Schröder, Phys. Rev. B 109, 115409

MON 8.5 Mon 15:15 ZHG009

Nonlocal metasurface coupled to a single-photon emitter for on-chip applications — •Amitrajit Nag and Jaydeep Kumar Basu — Department of Physics, Indian Institute of Science, Bangalore, India-560012

Solid-state single-photon emitters (SPE) are indispensable in the emerging applications for qubits and photonic communications due to their higher quantum yield, spectral tunability, and scalability. All-dielectric guided mode resonant metasurfaces (GMR-MSR) are interesting photonic systems with low losses, waveguiding, and asymmetric Fano resonance features. The near-field coupling between an SPE and a GMR-MSR brings up interesting features like the resonance linewidth narrowing, directional emission, long-range photon transport, etc. In this work, we emphasize the field nonlocality property of a GMR-MSR, which controls and tunes the overall partial coherence of the coupled SPE-MSR system.

$$\mathbf{E}(\mathbf{r}_D, \omega) = \int \mathbf{G}(\mathbf{r}_D, \mathbf{r}'_d, \omega) \cdot \frac{\mathbf{P}(\mathbf{r}', \omega)}{\epsilon_0} d^3 r' \quad (1)$$

The in-plane component of this defined Green's function of the SPE-MSR system quantifies this nonlocal field behavior. Our experimental results on SPEs integrated to GMR-MSR, capable of showing field nonlocality along with an appreciable antibunching property, makes the coupled system emerge as a new platform to efficiently generate directional, high spectral purity photons with precision control parameters, and the waveguiding gives the system an additional leap as a viable platform for on-chip integrated photonic applications.

MON 8.6 Mon 15:30 ZHG009

Non-destructive characterization of ceramics using mid-infrared optical coherence tomography with undetected photons — •Felipe Gewers[1], Fabian Wendt[2], Gunnar Blume[3], Emma Pearce[1], Martin Laurowski[4], Ivan Zorin[5], Bettina Heise[5], Katrin Paschke[3], Helen Chrzanowski[1], and Sven Ramelow[1,6] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Fraunhofer-Institut für Lasertechnik ILT, Aachen, Germany — [3]Ferdinand-Braun-Institut (FBH), Berlin, Germany — [4]NELA, Lahr, Germany — [5]Research Center for Non-Destructive Testing GmbH, 4040 Linz, Austria — [6]IRIS Adlershof, Berlin, Germany

Optical coherence tomography (OCT) is a non-destructive imaging technique widely used in industry and biomedicine. However, imaging ceramic micro-components is challenging due to their strong light scattering. Mid-infrared (mid-IR) wavelengths (2-4μm) can reduce scattering, but conventional OCT systems in this range are expensive, complex, and noisy.

We present a compact, low-cost OCT system based on undetected photons. Using a nonlinear interferometer and a 660nm laser, entangled photon pairs are generated: the sample is probed with mid-IR field (3.3-4.3μm), and detection occurs in the near-infrared (780-820nm) using a standard silicon spectrometer.

Our system accurately measures ceramic thickness and refractive index, and resolves subsurface structures, demonstrating its potential for affordable imaging of highly scattering materials.

MON 9: Quantum Entanglement

Time: Monday 14:15–16:15 Location: ZHG101

MON 9.1 Mon 14:15 ZHG101

Measurable entanglement lower bounds for cold atom quantum simulators using kinetic operators — •Maike Reckermann[1], Niklas Euler[1,2], and Martin Gärttner[1] — [1]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-University Jena, Germany — [2]Physikalisches Institut, Universität Heidelberg, Deutschland

The entanglement dimension plays a key role for understanding quantum many-body phenomena such as topological order, recently realized with cold atoms in lattice geometries. Although, it is challenging to measure the entanglement spectrum directly, the entanglement dimension, which is the number of non-zero values in the spectrum, can be lower bounded with measurements in two bases using fidelity witnesses. We develop a method to bound the entanglement dimension, using the information contained in the measurement of kinetic operators in double wells, which was recently pioneered with ultracold bosonic atoms in a 2D optical lattice. We also develop a method to estimate reliable error intervals for the fidelity witnesses, which are obtained using semi-definite programming. We demonstrate our scheme by showing that it can be used to detect entanglement between two attractively interacting distinguishable atoms in 1D and 2D lattice geometries.

MON 9.2 Mon 14:30 ZHG101

Analytical structures in high-dimensional entanglement — •Robin Krebs and Mariami Gachechiladze — Technische Universität Darmstadt, Darmstadt, Hesse, Germany

Efficient and generic methods for analyzing high-dimensional entanglement are crucial for scalable and resilient quantum computation and quantum communication protocols. Understanding the necessary mathematical structures requires analyzing high Schmidt number (SN) PPT states. We prove a generalization of the projection property, which relates the Schmidt number of a quantum state with its lower-dimensional projections. Then, we introduce the concept of a local extension, increasing local dimensions and entanglement content. This new method is then used to construct an extreme point of the PPT set in dimensions 4x5 with SN 3, the lowest dimensional known instance of SN 3 PPT entanglement. To accurately detect the SN for such extreme points, a sufficient and necessary generalization of the range criterion is introduced. We also present various examples of the implications of these results for the structure of high-dimensional entanglement.

MON 9.3 Mon 14:45 ZHG101

Metrological entanglement criteria — •Szilárd Szalay[1] and Géza Tóth[1,2] — [1]Wigner Research Centre for Physics, Budapest, Hungary — [2]University of the Basque Country UPV/EHU, Bilbao, Spain

We show that the quantum Fisher information in quantum metrology in a multiparticle system provides a lower bound on the average size of entangled subsystems. Before it has been known only that the quantum Fisher information puts a lower bound on the entanglement depth. We illustrate the strength of this new criterion and compare it to the previous approach.

[1] Sz. Szalay and G. Tóth, Quantum 9, 1718 (2025)
[2] Sz. Szalay, Quantum 3, 204 (2019)

MON 9.4 Mon 15:00 ZHG101

Exact steering bound for two-qubit Werner states — •Martin J. Renner — ICFO - The Institute of Photonic Sciences, 08860 Castelldefels, Barcelona, Spain

Many quantum technologies rely on nonlocality, correlations between distant particles that defy classical explanation. To harness this, it's essential to know which quantum states can or cannot display nonlocal behavior. A seminal 1989 result by Reinhard Werner showed that some entangled states can be fully explained by local models, but only under the restricted class of projective measurements. We extend this result for two-qubit Werner states to the most general class of measurements, known as positive operator-valued measures (POVMs). Our model identifies exactly which of these states can demonstrate quantum steering, the effect Einstein famously called "spooky action at a distance." Surprisingly, we find that POVMs offer no advantage over projective measurements for revealing steering in these states, resolving a long-standing open question in quantum foundations. Beyond this, our results have implications for measurement incompatibility: we determine the critical visibility under white noise at which all qubit measurements become jointly measurable.

Reference: MJ Renner, Compatibility of Generalized Noisy Qubit Measurements, Phys. Rev. Lett. 132, 250202

MON 9.5 Mon 15:15 ZHG101

Chiral Symmetries of Multiparticle Entanglement — •Sophia Denker[1], Satoya Imai[2], and Otfried Gühne[1] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — [2]QSTAR, INOCNR, and LENS, Largo Enrico Fermi 2, 50125 Firenze, Italy

Symmetries play a central role in physics. Particularly in entanglement theory many works investigate the separability of states with certain symmetries. However, while in bipartite systems quantum states can show symmetric or antisymmetric behavior, when exploring multipartite systems also quantum states with chiral symmetries can appear.

In this work we investigate chiral subspaces with respect to their entanglement properties. Starting with the case of three qubits we show that these subspaces are highly entangled with respect to their geometric measure of entanglement and are further related to measurements that are useful to estimate entanglement. We then consider these spaces in higher dimensions and define operators related to the structure constants of Lie algebras whose eigenspace coincides with the sum of those chiral subspaces. These operators act as strong entanglement witnesses, which can detect genuine multipartite entangled states with positive partial transpose. Moreover, while we find that these operators are sums of permutations and therefore invariant under unitary transformations, we further translate those operators to sums of permutations and their partial transposed leading to subspaces invariant under orthogonal transformations, which are even more entangled.

MON 9.6 Mon 15:30 ZHG101

Improved bounds on Quantum Max-Cut via entanglement theory constraints — •Minh Duc Tran, Lucas Vieira, and Mariami Gachechiladze — Department of Computer Science, Technical University of Darmstadt, Darmstadt, 64289 Germany

The Quantum Max-Cut (QMC) problem is a paradigmatic example in the study of many-body physics and quantum Hamiltonian complexity. While variational methods present lower bounds on the energy of the most exciting state of the given Hamiltonian, semidefinite programming (SDP) hierarchies have been used to obtain upper bounds by solving a relaxed problem. The feasible points for the solutions, which in the relaxed problem may not represent valid quantum states, are then rounded back to a valid state to obtain the approximation ratio. There are two potential venues for improvements: first, speeding up convergence of the SDP by adding extra constraints, and second, improving the rounding schemes. In this work, we present an improved SDP relaxation of QMC for arbitrary graphs by applying polynomial constraints from entanglement theory, achieving tighter bounds on the true values compared to existing approximations. We further extend this framework to the rounding schemes by using the solutions of the SDPs to obtain better initial parameters for variational algorithms.

MON 9.7 Mon 15:45 ZHG101

Symmetric extensions for the geometric measure of entanglement — •Lisa T. Weinbrenner[1], Xiao-Dong Yu[2], and Otfried Gühne[1] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Germany — [2]Department of Physics, Shandong University, Jinan 250100, China

Entanglement plays an important role in quantum information theory and is often considered to be a resource for quantum metrology, quantum cryptography or other applications. As such, there is an ongoing search for characterization and quantification techniques, measuring the amount and usefulness of entanglement in quantum states. One possible approach is given by the geometric measure of entanglement, which quantifies the entanglement of a state by its distance to the separable states. Although this measure is easily defined, it is known to be in general hard to obtain for multipartite states. The aim of this contribution is to investigate how the geometric measure can be determined by using multiple copies of the state and applying different symmetrization arguments, deriving a hierarchy for the geometric measure.

MON 9.8 Mon 16:00 ZHG101

Strong quantum nonlocality in multipartite system — •Mengying Hu[1,2], Ting Gao[1], and Fengli Yan[3] — [1]School of Mathematical Sciences, Hebei Normal University, Shijiazhuang 050024, China — [2]University of Siegen, Siegen, Germany — [3]College of Physics, Hebei Normal University, Shijiazhuang 050024, China

Strong quantum nonlocality is a stronger form of nonlocality than that manifested by locally indistinguishable quantum states. It has efficient applications in quantum information hiding and quantum secret sharing. We construct strongly nonlocal orthogonal genuinely entangled sets and strongly nonlocal orthogonal genuinely entangled bases in an N -qutrit system, which provide an answer to the open problem in Ref. [Phys. Rev. Lett. 122, 040403 (2019)]. The strongly nonlocal orthogonal genuinely entangled set we constructed in N-qutrit systems contains much fewer quantum states than previous one. When $N > 3$, our result answers the open question in Ref. [Phys. Rev. A 104, 012424 (2021)]. A sufficient and necessary condition for the strongest nonlocality in general N-partite systems is presented. We successfully construct the strongest nonlocal genuinely entangled sets in $(C^d)^{\otimes N}$ for $d \geq 4$, which have a smaller size than the existing sets as N increases.

MON 10: Standard Model and Beyond

Time: Monday 14:15–16:15 Location: ZHG103

MON 10.1 Mon 14:15 ZHG103

QCD chemistry and heavy-light diquarks — •Mikhail Shifman — William Fine Theoretical Physics Institute, University of Minnesota, MN 55455, USA

In connection with recent discoveries of heavy-quark containing exotic states publications discussing Qq diquarks (Q,q stand for a heavy and light quarks, respectively) proliferated in the literature. After a brief summary of the diquark concept I present various general reasons why the heavy-light diquark (with sufficiently heavy Q) does not exist. Then I argue (this is the focus of my talk) that the most direct way to confirm non-existence of the Qq diquarks is the study of pre-asymptotic corrections in the inclusive decays of Qqq baryons, e.g. Λb. Since the c quarks are much lighter than b, namely, the ratio (m_b)^2/(m_c^2) is of the order of 11, traces of the cq attraction in the color anti-triplet spin-0 state may or may not be present in the cqq baryons.

MON 10.2 Mon 14:30 ZHG103

Quarkonia spectroscopy in the quark-gluon plasma — •Georg Wolschin — Institute for Theoretical Physics, Heidelberg, Germany

In relativistic heavy-ion collisions at RHIC and LHC energies, the spectroscopy of heavy-quarkonia states such as J/ψ and $\Upsilon(nS)$ that are mostly produced in the initial stages of the collision is modified through the presence of the hot plasma of gluons and light quarks. Here, we investigate the in-medium effects on the Υ and χ_b states in our theoretical Heidelberg model.

It considers, in particular, screening of the real quark-antiquark potential, collisional damping through the imaginary part of this potential, gluon-induced dissociation of the six states involved below threshold, and reduction of the feed-down contribution to the $\Upsilon(1S)$ spin-triplet ground state because of the screening of the higher-lying states [1]. Centrality- and transverse-momentum dependent results are compared with CMS and STAR data for the $\Upsilon(nS)$ states, including recent CMS results [2] for $\Upsilon(3S)$. The model has also been applied to Υ physics in p-Pb collisions, where the hot-medium influence can not be neglected, although cold-matter effects are dominant – as is shown in a detailed comparison with LHCb and ALICE data.

[1] G. Wolschin, Int. J. Mod. Phys. A 35, 2030016 (2020).

[2] A. Tumasyan et al. (CMS Collaboration), Phys. Rev. Lett. 133, 022302 (2024).

MON 10.3 Mon 14:45 ZHG103

Extensions of Minimal SU(5) GUT — •Clive Reese — Georg-August Univesity, Göttingen, Germany

Grand Unified Theories (GUTs) extend the Standard Model (SM) embedding the SM gauge groups into one larger group that spontaneously breaks down to the SM at high energy scales. Thereby they predict the unification of gauge couplings and explain the charge quantization of the fermions. However, the minimal non-supersymmetric scenario based on the SU(5) group predicts too fast proton decay. In our work we extend the scalar sector of the model and study the resulting parameter space to find out if it is possible to obtain unification of the couplings at higher scale and to reconcile large masses for the proton decay mediators, while keeping the SM Higgs naturally light.

MON 10.4 Mon 15:00 ZHG103

On the Equivalence Principle in the relativistic and quantum domain — •Claus Lämmerzahl and Hansjörg Dittus — University of Bremen, Am Fallturm 1, 28359 Bremen

The Equivalence Principle (EP) states that all pointlike particles fall in the same way in a gravitational field or that inertial mass is equivalent to gravitational mass. While this is very clear in a non-relativistic classical framework there are open issues in a relativistic and quantum context. First, it is not clear how to introduce in a covariant way a violation of the EP without referring to a bi-metric theory which is ruled out with very high precision from light propagation experiments. Second, quantum states are non-local and, thus, fail to be pointlike which leads to an at least apparent violation of the EP. Here we propose a new covariant approach to violations of the EP in stationary relativistic space-times. This approach naturally includes gravitomagnetic degrees of freedom and, thus, leads to a notion of an EP including all kinds of relativistic degrees of freedom. All these various aspects in principle can be tested with, e.g., atom interferometry. However, one has to further refine the notion of an EP in the quantum domain so that apparent violations of the EP owing to the spatial extension of quantum systems can be uniquely identified. Finally, we are left with an EP which holds both in the relativistic and in the quantum domain.

MON 10.5 Mon 15:15 ZHG103

The Projected Sensitivity of the DELight Experiment — •Eleanor Fascione, Belina von Krosigk, and Francesco Toschi — Kirchhoff-Institute for Physics, Heidelberg University, Heidelberg, Germany

There is vast unexplored parameter space for dark matter masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. In particular, low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to e.g. the xenon-based experiments currently providing the strongest overall constraints on many dark matter models.

The Direct search Experiment for Light dark matter (DELight) will deploy a target of superfluid ^{4}He instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for low mass dark matter searches. In this talk an overview of this upcoming experiment will be presented, including preliminary background models and sensitivity projections.

MON 10.6 Mon 15:30 ZHG103

Shaping DELight: signal propagation in superfluid helium-4 — •Francesco Toschi, Eleanor Fascione, and Belina von Krosigk — Kirchhoff-Institute for Physics, Heidelberg University, 69120 Heidelberg, Germany

Large dual-phase noble liquid TPCs strongly constrain the parameter space for dark matter candidates above the GeV/c^2 but can barely explore lighter candidates. Probing this low-mass regime requires ultra-low energy thresholds, which solid-state cryogenic detectors can reach by measuring phonons. However, their small target masses limit exposure and cannot scale in a monolithic way. The Direct search Experiment for Light dark matter (DELight) will use a superfluid helium-4 target instrumented with large area microcalorimeters (LAMCALs), combining the low threshold of phonon-based detection with the scalability of noble liquids. This allows DELight to explore masses down to below 100 MeV/c^2 with just 1 kg d of exposure.

DELight is in its design phase, and detailed simulations play a central role in informing the design and construction of the final detector. This talk will present the current GEANT4 simulation framework, with particular focus on the propagation of the different signal quanta deriving from an energy deposition in superfluid helium-4: photons, excimers, and quasiparticles, i.e. phonons and rotons. In particular, the role of quasiparticle collection efficiency in motivating the choice of a high aspect ratio (or 'pancake') geometry for the detector cell will be discussed.

MON 10.7 Mon 15:45 ZHG103

Towards dark matter detection with superfluid Helium: First results from the DELight Demonstrator — •Axel Brunold, Anna Bertolini, Christian Enss, and Belina von Krosig — Kirchhoff Institute for Physics, Heidelberg University

The search for light dark matter requires innovative detection techniques capable of probing weakly interacting particles with exceptional sensitivity. One promising approach involves studying elastic scattering interactions between dark matter particles and helium atoms in the superfluid phase at millikelvin temperatures.

As part of the Direct search Experiment for Light dark matter (DELight), a pilot experiment is conducted to investigate the behavior of magnetic microcalorimeters (MMCs) submerged in liquid helium referred to as DELight Demonstrator.

In this setup, a small copper cell (300 ml) is cooled to below 50 mK within a *He/*He dilution refrigerator and filled with *He. The liquid helium level, during both filling and operation of the MMC, is monitored using an LC circuit-based level meter. At these temperatures, *He is deep in its superfluid phase, enabling a long mean free path for phonons and rotons. An MMC fabricated on a 5 mm * 5 mm silicon substrate and a resistive heater are submerged in the liquid helium. This experiment aims to explore the response of a small-scale athermal MMC (SAMCAL, small-area magnetic microcalorimeter) to phonons excited by the heater in the superfluid.

This contribution presents the DELight Demonstrator setup and recent developments in the project.

MON 10.8 Mon 16:00 ZHG103

Mitigating the low-energy excess in cryogenic detectors for low-mass dark matter searches: Advances from the CRESST experiment — •Anna Bertolini — Kirchhoff-Institute for Physics, Heidelberg University, 69120 Heidelberg, Germany

The low-energy excess (LEE) observed in cryogenic detectors, characterized by a steeply increasing event rate below 200 eV, poses a significant challenge to dark matter searches, particularly at low masses. The CRESST experiment has pioneered efforts to understand and mitigate this phenomenon through extensive studies of detector response, novel module designs, and innovative analysis frameworks. Recent observations highlight the time-dependent decay of the LEE rate, offering a practical mitigation strategy through long-term stable cryogenic operation. Coupled with advancements in detector technology, such as DoubleTES sensors and Mini-Beaker modules, these efforts enable a tenfold reduction in the LEE rate, significantly enhancing sensitivity to dark matter interactions. This presentation will detail the latest insights and results of the CRESST Experiment, emphasizing the critical role of detector design in pushing the boundaries of cryogenic detector performance.

MON 11: Quantum Transport I

Time: Monday 14:15–16:00 Location: ZHG104

MON 11.1 Mon 14:15 ZHG104

Scattering approach to quantum radiative heat transfer — •Matthias Hübler[1], Denis M. Basko[2], and Wolfgang Belzig[1] — [1]Universität Konstanz, Konstanz, Deutschland — [2]University Grenoble Alpes CNRS LPMMC, Grenoble, France

We formulate the problem of near-field radiative heat transfer as an effective quantum scattering theory for excitations of the matter. Built from the same ingredients as the semiclassical fluctuational electrodynamics, the standard tool to handle this problem, our construction makes manifest its relation to the Landauer-Büttiker scattering framework, which appears only implicitly in the fluctuational electrodynamics. We show how to construct the scattering matrix for the matter excitations and give a general expression for the energy current in terms of this scattering matrix. We show that the energy current has an important non-dissipative contribution that can dominate the finite-frequency noise while being absent in the average current. Our construction provides a unified description of near-field radiative heat transfer in diverse physical systems.

MON 11.2 Mon 14:30 ZHG104

Anisotropic Electrical Transport in Quasi-1D $ZrSe_3$-Stripes — •Davin Höllmann[1], Lars Thole[1], Sonja Locmelis[2], and Rolf J. Haug[1,3] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Anorganische Chemie, Leibniz Universität Hannover, 30167 Hannover, Germany — [3]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, 30167 Hannover, Germany

The anisotropy in form of quasi one-dimensional (1D) chains in transition metal trichalcogenides (TMTCs), like ZrS_3 and $ZrSe_3$, makes them stand out compared to other more conventional two-dimensional (2D) materials [1]. We investigated the electrical properties of thin stripes of TMTCs, in particular $ZrSe_3$, regarding their width and thickness. Highlighting the influence of anisotropic effective electron masses [2] in the 2D-plane. The bulk material used was fabricated by a chemical vapor transport method and then exfoliated to achieve thin stripes.

We compared narrow samples with wider samples where both have comparably similar length and thickness and found that the conductivity happens dominantly in the outer selenium atoms i.e. across the chains [3]. We confirmed this using angle dependent electrical transport measurements.

[1] J. O. Island et al., 2D Materials 4, 0220033 (2017)
[2] Y. Jin et al., Phys. Chem. Chem. Phys. 17, 18665-18669 (2015)
[3] D. Höllmann et al., ACS Appl. Electron. Mater. 7, 9, 4049-4054 (2025)

MON 11.3 Mon 14:45 ZHG104

Boundary-driven magnetization transport in the spin-1/2 XXZ chain and the role of the system-bath coupling strength — •Mariel Kempa[1], Markus Kraft[1], Sourav Nandy[2], Jacek Herbrych[3], Jiaozi Wang[1], Jochen Gemmer[1], and Robin Steinigeweg[1] — [1]University of Osnabrueck, D-49076 Osnabrueck, Germany — [2]Max Planck Institute for Physics of Complex Systems, D-01187 Dresden, Germany — [3]Wroclaw University of Science and Technology, 50-370 Wroclaw, Poland

We revisit the Lindblad equation in the context of boundary-driven magnetization transport in integrable spin-1/2 XXZ chain. In particular, we explore the influence of the system-bath coupling strength γ on the quantitative value of the diffusion constant D. Employing numerical simulations on the basis of stochastic unraveling and time-evolving block decimation, we obtain the curve $D(\gamma)$ for finite system sizes, yet outside the range of exact diagonalization. We unveil that $D(\gamma)$, as extracted from the steady state, depends significantly on γ and disagrees with the Kubo formula. We suggest a physical explanation of this disagreement.

MON 11.4 Mon 15:00 ZHG104

Scaling of diffusion constants in perturbed easy-axis Heisenberg spin chains — •Markus Kraft[1], Mariel Kempa[1], Jiaozi Wang[1], Sourav Nandy[2], and Robin Steinigeweg[1] — [1]University of Osnabrück, Department of Mathematics/Computer Science/Physics, D-49076 Osnabrück, Germany — [2]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany

Understanding the physics of the integrable spin-1/2 XXZ chain has witnessed substantial progress, due to the development and application of sophisticated analytical and numerical techniques. Since integrability is rather the exception than the rule, a crucial question is the change of infinite-temperature magnetization transport under integrability-breaking perturbations. This question includes the stability of superdiffusion at the isotropic point and the change of diffusion constants in the easy-axis regime. In our work, we study this change of diffusion constants by a variety of methods and cover both, linear response theory in the closed system and the Lindblad equation in the open system, where we throughout focus on periodic boundary conditions. In the closed system, we find evidence for a continuous change of diffusion constants over the full range of perturbation strengths. In the open system weakly coupled to baths, we find diffusion constants in quantitative agreement with the ones in the closed system in a range of nonweak perturbations, but disagreement in the limit of weak perturbations. Using a simple model in this limit, we point out the possibility of a diverging diffusion constant in such an open system.

MON 11.5 Mon 15:15 ZHG104

Andreev reflection and interferometry of integer quantum Hall edge states — •Tom Menei 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 modeling 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 QH edge state theory and incorporate realistic models of the superconductor to derive the effective coupling mechanisms at the interface. We analyze 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.

MON 11.6 Mon 15:30 ZHG104

Unconventional Josephson Supercurrent Diode Effect Induced by Chiral Spin-Orbit Coupling — •Andreas Costa[1], Osamu Kanehira[2], Hiroaki Matsueda[2], and Jaroslav Fabian[1] — [1]University of Regensburg, Germany — [2]Tohoku University, Japan

First-principles calculations have recently predicted that chiral materials lacking mirror symmetries—such as twisted van der Waals homobilayers—can feature unconventional radial Rashba coupling with spins aligned fully parallel (instead of tangential) to momentum.

In this talk, we will address Josephson transport through vertical superconductor/ferromagnet/superconductor junctions hosting crossed (radial and tangential) Rashba fields at the interfaces and demonstrate that their interplay with ferromagnetic exchange can lead to supercurrent rectification even when the magnetization is collinear with the current. This so-called unconventional supercurrent diode effect (SDE) originates from spin precessions inside the ferromagnet, which imprint polarity-dependent transmission probabilities on the Cooper pairs being well-distinct from the conventional SDE, and provides a sensitive probe of chiral spin textures.

This work, published in Phys. Rev. B 111, L140506 (2025), has been supported by DFG Grants 454646522 and 314695032 (SFB 1277).

MON 11.7 Mon 15:45 ZHG104

Josephson vortex pinning in two-dimensional SNS-arrays — •Christian Schäfer[1,2], Justus Teller[1,2], Benjamin Bennemann[3], Matvey Lyatti[1,2], Florian Lentz[4], Detlev Grützmacher[1,2], Roman-Pascal Riwar[5], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany — [3]Peter Grünberg Institut (PGI-10), Forschungszentrum Jülich, 52425 Jülich, Germany — [4]Helmholtz Nano Facility, Forschungszentrum Jülich, 52425 Jülich, Germany — [5]Peter Grünberg Institut (PGI-2), Forschungszentrum Jülich, 52425 Jülich, Germany

We fabricated Josephson arrays by etching stacked platinum-niobium (Pt-Nb) thin films. By analyzing both small (3×3) and large (30×30 and 50×50) arrays, we examined how array size and edge effects affect the frustration patterns created by the flow of Josephson vortices. Upon cooling the arrays below 300 mK, the energy barrier for vortex motion increases, immobilizing the vortices and causing the array's behavior to resemble that of a single reference junction. In this vortex-pinned regime, we studied the switching dynamics of the arrays. To determine the distribution of single-junction critical currents within the array, we compared our experimental findings with simulations based on the resistively and capacitively shunted junction (RCSJ) model.

MON 12: Quantum Magnets

Time: Monday 14:15–15:45 Location: ZHG105

MON 12.1 Mon 14:15 ZHG105

Quantum skyrmions and antiskyrmions in monoaxial chiral magnets — Stefan Liscak, Andreas Haller, Andreas Michels, •Thomas L. Schmidt, and Vladyslav M. Kuchkin — Department of Physics and Materials Science, University of Luxembourg, L-1511 Luxembourg, Luxembourg

Classical monoaxial chiral magnets represent a unique magnetic system that allows for the stabilization of both skyrmions and antiskyrmions of equal energy. Unlike a similar situation in frustrated magnets, the energy landscape here is much simpler, consisting of four states: the saturated ferromagnetic state, spin-spiral, skyrmion, and antiskyrmion. This simplicity makes such systems interesting for potential applications that rely on manipulating these states. We study the quantum analog of the already established classical theory by investigating the low-energy excitation spectra of a spin-1/2 quantum Heisenberg model with monoaxial Dzyaloshinskii-Moriya interaction. Using the density matrix renormalization group method, we establish that such a model supports the existence of skyrmion and antiskyrmion states of equal energy. This degeneracy allows for the existence of a mesoscopic Schrödinger cat state exhibiting properties of both skyrmion and antiskyrmion. To characterize this superposition, we calculate two-point correlation functions that can be measured in neutron scattering experiments. Finally, we introduce a perturbation in the form of a magnetic field gradient to induce a non-trivial time evolution of the superposition state. We study this time evolution using both a numerical variational method and the collective coordinates approach.

MON 12.2 Mon 14:30 ZHG105

Revealing Magnetic Chirality in Non-Collinear Kagome Antiferromagnets through Spin-Seebeck Measurements — •Feodor Svetlanov Konomaev, Mithuss Tharmalingam, and Kjetil Magne Dørheim Hals — Department of Engineering Sciences, University of Agder, 4879 Grimstad, Norway

Non-collinear antiferromagnets (NCAFMs) are attractive for antiferromagnetic spintronics, as they combine the advantages of collinear antiferromagnets with novel emergent phenomena arising from their complex spin textures. One such phenomenon is the intrinsic chirality of the ground-state spin configuration, which strongly influences the spin-wave excitation spectrum. In this work, we investigate an NCAFM with a kagome lattice structure interfaced with a normal metal and demonstrate that the ground-state chirality can be probed via measurements of the spin Seebeck effect (SSE). Starting from a microscopic spin Hamiltonian, we derive the corresponding bosonic Bogoliubov-de Gennes (BdG) Hamiltonians for the distinct chiral configurations. Using linear response theory, we obtain a general expression for the spin current thermally pumped into the normal metal due to the SSE. Our results show that a substantial in-plane spin current arises only when the NCAFM is in the negative chiral state, offering a clear experimental signature for real-time detection of chirality switching in kagome NCAFMs.

MON 12.3 Mon 14:45 ZHG105

The effect of Rashba on the magnetic field dependence of Ising superconductors — •Joren Harms, Michael Hein, and Wolfgang Belzig — Fachbereich Physik, Universität Konstanz, Konstanz, Germany

Ising superconductors are transition metal dichalgogenides which can withstand large in-plane external magnetic fields. To a large extent, the protection of the superconducting state from the external magnetic *eld comes from the presence of Ising spin-orbit coupling (ISOC). Since ISOC breaks inversion symmetry and not time-reversal symmetry (TR) it could protect against external magnetic fields. In this work, we study the influence of Rashba SOC on the magnetic field dependence of Ising superconductors.

MON 12.4 Mon 15:00 ZHG105

Thermoelectric response in Altermagnets — •Javad Vahedi[1], Martin Gärttner[1], and Ali Moghaddam[2] — [1]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-University Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Computational Physics Laboratory, Physics Unit, Faculty of Engineering and Natural Sciences, Tampere University, FI-33014 Tampere, Finland

We study the thermoelectric properties of altermagnets using semi-classical Boltzmann transport theory with constant relaxation time. Altermagnets, with zero net magnetization but spin-split bands from staggered magnetic order, enable exploration of unconventional transport. Using a 2D tight-binding model with spin-independent hopping, altermagnetic exchange, and spin-orbit coupling, we analyze both Drude and Berry curvature contributions. Without a magnetic field, longitudinal conductivities σ_{xx} and α_{xx} vary strongly with spin-orbit coupling λ and exchange J, peaking at intermediate λ. Symmetry-induced Berry curvature cancellation suppresses transverse responses σ_{xy} and α_{xy}. A weak out-of-plane magnetic field breaks these symmetries, inducing notable transverse transport tied to band topology. Finite doping leads to complex Berry curvature patterns and sharp peaks in the anomalous Nernst signal α_{xy}, reflecting resonant entropy transport. The transport behavior as a function of μ, λ, and J highlights the interplay between spin-orbit coupling, magnetic order, and topology. Our findings position altermagnets as tunable platforms for topological and spintronic applications.

MON 12.5 Mon 15:15 ZHG105

V_2Se_2O and Janus V_2SeTeO: Monolayer altermagnets for the thermoelectric recovery of low-temperature waste heat — •Shubham Rakesh Singh, Paresh C. Rout, Mohammed Ghadiyali, and Udo Schwingenschlögl — Physical Science and Engineering Division (PSE), King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabi

We determine the thermoelectric properties of the V_2Se_2O and Janus V_2SeTeO monolayer altermagnets with narrow direct band gaps of 0.74 and 0.26 eV, respectively. Monte Carlo simulations reveal Néel temperatures of 800 K for V_2Se_2O and 525 K for Janus V_2SeTeO. The electrical conductivity is higher for p-type charge carriers than for n-type charge carriers due to lower effective masses. The presence of heavy Te atoms in Janus V_2SeTeO results in lower phonon group velocities, higher phonon scattering rates, and higher lattice anharmonicity than in the case of V_2Se_2O, leading to an almost 19-fold reduction of the lattice thermal conductivity at 300 K. The thermoelectric figure of merit of V_2Se_2O reaches 0.4 (0.1) and that of Janus V_2SeTeO reaches 2.7 (1.0) just below the Néel temperature at the optimal p-type (n-type) charge carrier density, demonstrating that altermagnets have excellent potential in the thermoelectric recovery of low-temperature waste heat.

MON 12.6 Mon 15:30 ZHG105

Katsura-Nagaosa-Balatskiy magnetoelectricity in molecular magnets: Bipartite entanglement transfer with the aid of electric field. — •Zhirayr Adamyan[1,2], Vadim Ohanyan[1,2], Ani Chobanyan[1], Hamid Arian Zad[3], Jozef Strecka[3], Azadeh Ghannadan[4], and Saeed Haddadi[4,5] — [1]Laboratory of Theoretical Physics, Yerevan State University, 1 Alex Manoogian, 0025 Yerevan, Armenia — [2]Synchrotron Research Institute, 31 Acharyan Str., 0040 Yerevan, Armenia — [3]Department of Theoretical Physics and Astrophysics, Faculty of Science, P. J. Safarik University, Park Angelinum 9, 041 54 Kosice, Slovak Republic — [4]Saeeds Quantum Information Group, P.O. Box 19395-0560, Tehran, Iran — [5]Faculty of Physics, Semnan University, P.O. Box 35195-363, Semnan, Iran

The quantum entanglement of spin states in molecular magnets has important applications in quantum information technologies. Currently, qubit models based on magnetic molecules are being developed to advance quantum computation and communication technologies. In this study, we examine a molecular magnet consisting of a spin-1/2 triangular configuration, with a Katsura-Nagaosa-Balatsky(KNB) mechanism to couple spin degrees of freedom with an external electric field. Thanks to the KNB mechanism, the system allows for extensive control over quantum entanglement through the magnitude and direction of the electric field. By utilizing a rotating configuration of the KNB-coupled electric field where the field magnitude remains fixed while its direction rotates-the controllable transfer of bipartite entanglement between different pairs of spins in the model is demonstrated.

MON 13: QIP Implementations: Photons II

Time: Monday 16:30–18:00 Location: ZHG001

MON 13.1 Mon 16:30 ZHG001

Distinguishability, mixedness and symmetry in multiphoton quantum interference — •Shreya Kumar[1], Alex E Jones[2], Matthias Bayerbach[1], Simone D'Aurelio[1], Nico Hauser[1], and Stefanie Barz[1] — [1]Institute for Functional Matter and Quantum Technologies, and IQST, University of Stuttgart, 70569 Stuttgart, Germany — [2]2QET Labs, University of Bristol, Bristol BS8 1FD, UK

Quantum interference is fundamental to many quantum technologies and is governed by properties such as distinguishability, mixedness, and the symmetry of quantum states. Here, we present how these properties influence multiphoton scattering statistics. In particular, we demonstrate that three photons can exhibit distinct scattering statistics depending on whether they are in pure or mixed states, even when they display identical pairwise Hong-Ou-Mandel (HOM) interference. This highlights that pairwise HOM interference is insufficient to fully characterise multi-photon quantum interference. We further investigate the role of quantum state symmetry in quantum interference. Together, these results provide new fundamental insights into the nature of quantum interference and highlight the role of distinguishability, mixedness, and symmetry in multiphoton interference. Apart from providing fundamental insight into the nature of quantum interference, our results have significant implications for quantum technologies that rely on photonic interference, including quantum computing and quantum simulation.

MON 13.2 Mon 16:45 ZHG001

Switching, Amplifying, and Chirping Diode Lasers with Current Pulses for High Bandwidth Quantum Technologies — •Gianni Buser, Roberto Mottola, Suyash Gaikwad, and Philipp Treutlein — Universität Basel, Departement Physik, Klingelbergstrasse 82, 4056 Basel, Schweiz

High-bandwidth asynchronous (fast and triggered) operation is key to establishing the technological relevance of current proof-of-principle quantum devices. Therein, achieving sufficient speed and contrast in amplitude and phase modulation of light is a widespread performance limitation. For instance, quantum memories storing photons in collective matter excitations by optical control often suffer from unintentional readout due to leaking control light during the storage time [1,2]. Moreover, the control intensities are regularly such, that two-photon process like read/write operations technically require chirped pulses to remain on resonance over the course of their dynamics because of induced atomic level shifts. This talk describes direct current modulation methods that grant independent phase and amplitude control over diode lasers. A system capable of producing watt power level, nanosecond duration optical pulses with 60 dB intensity contrast between their on and off states and simultaneous chirps at rates up to 150 MHz/ns on demand [3] is presented, and application to high bandwidth quantum technology is discussed. [1] PRX Quantum 3, 020349 (2022), [2] PRL 131, 260801 (2023), [3] RSI 95, 123001 (2024).

MON 13.3 Mon 17:00 ZHG001

Applications of boosted Bell-state measurements — Matthias J. Bayerbach[1,2], •Simone E. D'Aurelio[1,2], and Stefanie Barz[1,2] — [1]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Stuttgart, Germany. — [2]Center for Integrated Quantum Science and Technology (IQST), University of Stuttgart, Stuttgart, Germany

Bell-state measurements are a key component to realize in many quantum communication and computing applications. They are at the heart of quantum repeaters or measurement-device-independent quantum key distribution protocols and essential in the generation of larger entangled state in measurement-based quantum computing. Linear optical implementations are favourable due to their simplicity, but limited

in their success rates. Boosting the success rate of these measurements with ancillary photons allow one to overcome this flaw, while keeping the advantages of linear optics.

In this talk, we present experimental implementations of such a scheme. We demonstrate boosted quantum teleportation and boosted entanglement swapping, both critical components of a quantum repeater. Using single photon sources at 1550 nm, our system is compatible with existing telecommunication infrastructure. Our work demonstrated the practicality and usefulness of ancillary state boosting for any application relying on Bell-state measurements.

MON 13.4 Mon 17:15 ZHG001

Generation a 3-mode NOON state with heralding — •Sukhjit Singh, Emanuele Polino, Farzad Ghafari, Simon White, Geoff Pryde, Sergei Slussarenko, and Nora Tischler — Queensland Quantum and Advanced Technologies Institute and Centre for Quantum Computation and Communication Technology, Griffith University, Yuggera Country, Brisbane, QLD 4111, Australia

The preparation of photonic entangled states is generally probabilistic, and their successful generation is mainly verified by destructively measuring them (post-selection), making them impractical for many large-scale applications. This problem can be avoided by heralding, which means creating the entangled state with additional photon(s) in ancilla modes, and upon only measuring these modes, the desired state's successful generation can be verified.

Multi-mode NOON states, a coherent superposition of N photons in one mode and none in the other d modes, are optimal probes for multiphase sensing and key resources for phase imaging in optical microscopy. However, it must be generated in a heralded manner. Only then can it be used efficiently to perform phase sensing, without reducing the Fisher information due to failed state generation attempts.

Using single photons, linear optics and SNSPDs, we have experimentally created for the first time a 3-mode NOON state whose successful generation can be verified by detecting one and only one auxiliary photon in an additional mode: (|2,0,0> + |0,2,0> + |0,0,2>)|1>.

MON 13.5 Mon 17:30 ZHG001

Homodyne detection of pulsed squeezed states of light for Gaussian Boson Sampling — •Florian Lütkewitte[1], Sanaz Haddadian[2], Mikhail Roiz[1], Kai Hong Luo[1], Jan-Lucas Eickmann[1], J. Christoph Scheytt[2], Benjamin Brecht[1], Michael Stefszky[1], and Christine Silberhorn[1] — [1]Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098, Paderborn, Germany — [2]System and Circuit Technology Group, Heinz Nixdorf Institute, Paderborn University, 33102 Paderborn, Germany

With the advent of complex, hybrid photonic networks such as Gaussian Boson Sampling (GBS), it becomes increasingly important to produce high-quality single-spectral-mode single-mode squeezed states of light (SMSS), requiring precise engineering of spectral properties. Here, SMSS are generated by interfering the modes of a decorrelated, spectrally indistinguishable two-mode squeezed state.

Naturally, one also needs to verify the quality of these states, which can be done using single-shot homodyne detection, requiring tailored electronics and optics. This detection scheme also enables time-multiplexed architectures and measurement of complex heralded quantum states by post-selection. Here, we will show the suitability of single-shot homodyne detection for characterizing single-spectral-mode single-mode squeezed states for GBS

MON 13.6 Mon 17:45 ZHG001

Demonstration of free-electron-photon entanglement — •Jan-Wilke Henke[1,2], Hao Jeng[1,2], Murat Sivis[1,2], and Claus Ropers[1,2] — [1]Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]University of Göttingen, 4th Physical Institute, Göttingen, Germany

Most emerging quantum technologies including quantum computation and sensing rely on quantum entanglement. Verifying the entanglement between different quantum system is thus of high relevance. While the interaction of free electrons with optical fields is expected to induce free electron-photon entanglement [1,2], its proof has been an outstanding challenge.

Here, we demonstrate quantum entanglement between free electrons and photons [3]. Harnessing a quantum eraser-type setup [4], we employ dual electron beams in a transmission electron microscope that generate photons of distinct polarisation at a nanostructure. The joint electron-photon state is reconstructed from measurements in different bases and shown to violate the Peres-Horodecki entanglement criterion by more than 7 standard deviations. This proof of electron-photon entanglement will be a cornerstone of free electron quantum optics, enabling quantum-enhanced sensing in electron microscopy.

[1] O. Kfir, Phys. Rev. Lett. 123, 103602 (2019);
[2] A. Konecńa, F. Iyikanat, and F. J. García de Abajo, Sci. Adv. 8, eabo7853 (2022);
[3] J.-W. Henke et al., arXiv:2504.13047 (2025);
[4] J.-W. Henke, H. Jeng & C. Ropers, Phys. Rev. A 111, 012610 (2025)

MON 14: QIP Implementations: Solid-State Devices I

Time: Monday 16:30–18:30 Location: ZHG002

MON 14.1 Mon 16:30 ZHG002

Fast quantum gates for exchange-only qubits using simultaneous exchange pulses — •Irina Heinz[1], Felix Borjans[2], Matthew J. Curry[2], Roza Kotlyar[2], Florian Luthi[2], Mateusz T. Madzik[2], Fahd A. Mohiyaddin[2], Nathaniel Bishop[2], and Guido Burkard[1] — [1]Department of Physics, University of Konstanz, Konstanz, Germany — [2]Intel Technology Research, Intel Corporation, Hillsboro, OR, USA

The benefit of exchange-only qubits compared to other spin qubit types is the universal control using only voltage controlled exchange interactions between neighboring spins. As a compromise, qubit operations have to be constructed from non-orthogonal rotation axes of the Bloch sphere and result in rather long pulsing sequences. We theoretically develop a faster implementation of single-qubit gates using simultaneous exchange pulses and manifests their potential for the construction of two-qubit gates. We introduce faster pulse sequences and show that subsequences on three spins in two-qubit gates could be implemented in fewer steps. We experimentally demonstrate and characterize a simultaneous exchange implementation of X rotations in a SiGe quantum dot device and compare to the state of the art with sequential exchange pulses. Our findings can particularly speed up gate sequences for realistic idle times between sequential pulses and we show that this advantage increases with more interconnectivity of the quantum dots. We further demonstrate how a phase operation can introduce a relative phase between the computational and some of the leakage states, which can be advantageous for the construction of two-qubit gates.

MON 14.2 Mon 16:45 ZHG002

Sub-harmonic control of a fluxonium qubit via a Purcell-protected flux line — •Christian Schneider[1,2], Johannes Schirk[1,2], Florian Wallner[1,2], Longxiang Huang[1,2], Ivan Tsitsilin[1,2], Niklas Bruckmoser[1,2], Leon Koch[1,2], Klaus Liegener[1,2], and Stefan Filipp[1,2,3] — [1]Walther-Meißner-Insitut, Bayerische Akademie der Wissenschaften, 85748 Garching — [2]Technische Universität München, TUM School of Natural Sciences, 85748 Garching — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 München

Isolating qubits from environmental noise while maintaining fast, high-fidelity control is a central challenge in quantum information processing. In this talk, I present our findings on isolating a superconducting fluxonium qubit from its noisy control environment while maintaining fast, high-fidelity control. We achieve this by adding a low-pass filter below the qubit frequency, which suppresses resonant coupling between the qubit and the control channel. Although this prevents resonant qubit control, we overcome the limitation by driving the qubit at integer fractions of its transition frequency, allowing us to achieve Rabi oscillations through the Purcell-protected channel. We demonstrate coherent control using up to 11-photon processes through driving the qubit at 1/11 of its resonant frequency and have developed an effective Hamiltonian model using a Magnus expansion, which accurately predicts the observed behavior. These results open a scalable approach for fluxonium control via a single Purcell-protected channel, preserving intrinsic qubit coherence while allowing for fast, high-fidelity control.

MON 14.3 Mon 17:00 ZHG002

Transmon-based thermometrics through integrated control of cryo-system parameters and automated quantum chip diagnostics — •Thorsten Last, Adam Lawrence, Koushik Kumaran, Gerben Erens, Kelvin Loh, and Adriaan Rol — Orange Quantum Systems, Elektronicaweg 2, 2628 XG Delft, NL

Thermometric analysis of superconducting qubits gives valuable insights into their environment such as the quantum processor, the I/O unit they are connected to, and the steadily increasing number of components required for scaling the cryogenic part of the quantum system. Analyzing their various decoherence channels and minimizing their thermal load becomes increasingly important. Hence, here we report on the development of an quantum chip test setup in which cryogenic and quantum control units are fully integrated to enable efficient and automated quantum chip testing and qualification. Purpose-built cryogenic and quantum control hardware systems are integrated under a unified control software platform which provides an application-specific operating system for quantum chip control. This integrated quantum test setup offers a practical advantage in the optimization of quantum chip characterization. The unified software interface allows for intelligent feedback between quantum control parameters and cryogenic control and monitoring. We will show that this enables novel features for the prevention, diagnostics and mitigation of a range of practical issues that can occur in cryogenic chip benchmarking, as well as providing a unified interface for quantum experiments involving cryogenic parameters for utility-scale quantum processors.

MON 14.4 Mon 17:15 ZHG002

Optimized flip chip bonding for 3D integrated superconducting quantum circuits — •Lea Richard[1,2], Julius Feigl[1,2], Niklas Bruckmoser[1,2], Leon Koch[1,2], Lasse Södergen[1,2], and Stefan Filipp[1,2] — [1]Technical University of Munich — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften

In order to use quantum computing to tackle classically intractable problems, quantum processors must grow to larger scales. Yet, in current planar architectures, routing multiple lines to an increasing number of qubits while minimizing crosstalk remains a significant challenge. 3D-integration techniques, such as flip-chip bonding enable more efficient connectivity. However, implementing a novel circuit geometry introduces challenges, including maintaining high coherence and preserving precise parameter targeting. Flip-chip bonding relies on indium bump bonds to mechanically and galvanically connect two separate chips. The additional fabrication steps can lead to new loss channels and degrade overall system performance. Moreover, in superconducting quantum circuits, capacitances and inductances are determined by the design of the electrodes. In a flip-chip assembly, these parameters depend on the gap separating the bonded chips and variations during the bonding process can limit accurate parameter targeting. To address these challenges, we present the fabrication of high-thickness indium bumps and the development of an optimized flip-chip bonding process for high-coherence quantum circuits. Additionally, we introduce a method for improving interchip spacing control and parameter targeting using polymer spacers.

MON 14.5 Mon 17:30 ZHG002

Passive leakage removal unit based on a disordered transmon array — •Gonzalo Martín-Vázquez[1,2], Taneli Tolppanen[2], and Matti Silveri[2] — [1]Departamento de Física Aplicada II, Universidad de Sevilla, E-41012 Seville, Spain — [2]Nano and Molecular Systems Research Unit, University of Oulu, FI-90014 Oulu, Finland

Leakage out from the qubit subspace compromises standard quantum error correction protocols and poses a challenge for practical quantum computing. We propose a passive leakage removal unit based on an array of coupled disordered transmons and last-site reset by feedback-measurement or dissipation. We find that the unit effectively removes leakage with minimal effect to the qubit subspace by taking advantage of energy level disorder for qubit subspace and resonant leakage energy levels. There are two optimal measurement rates for removing leakage, which we show analytically to correspond to characteristic time scales of leakage propagation and disintegration in the system. The performance of the leakage removal unit depends on the strength of disorder, coupling between the transmons, and the length of the array. We simulate the system under experimentally feasible parameters and present an optimal configuration. Our approach is readily compatible with existing superconducting quantum processors considering realistic conditions.

MON 14.6 Mon 17:45 ZHG002

Josephson Qubits with a DC Voltage Drive — •Florian Höhe[1], Ciprian Padurariu[1], Björn Kubala[1,2], and Joachim Ankerhold[1] — [1]ICQ and IQST, Ulm University, Ulm, Germany — [2]Institute of Quantum Technologies, German Aerospace Center (DLR), Ulm, Germany

Superconducting qubits utilize a Josephson junction as a nonlinear element to create a non-linear oscillator with unequally spaced energy levels. Coherent AC pulses, resonant with the transition frequency between the two lowest energy eigenstates, $|0\rangle$ and $|1\rangle$, enable quantum gate operations while leaving higher energy states largely unaffected.
In Josephson-photonics devices, a DC-biased Josephson junction generates excitations within a microwave LC resonator. Although the resonator's energy levels are equally spaced, the intrinsic nonlinearity of the drive can be exploited to suppress the $|1\rangle \to |2\rangle$ transition. This effectively turns the system into a two-level qubit that can be controlled by tuning the Josephson energy through a SQUID, eliminating the need for AC pulses.
In this work, we propose a method for implementing both single- and multi-qubit gates for qubits based on DC-biased Josephson junctions. The typically large Josephson energy in these devices may allow for fast and efficient gate operations.

MON 14.7 Mon 18:00 ZHG002

Robust, fast and high-fidelity composite single-qubit gates for superconducting transmon qubits — •Hristo Tonchev[1], Boyan Torosov[2], and Nikolay Vitanov[1] — [1]Center for Quantum Technologies, Department of Physics, Sofia University, James Bourchier 5 blvd., 1164 Sofia, Bulgaria — [2]Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tsarigradsko chaussee, 1784 Sofia, Bulgaria

We introduce a novel quantum control method for superconducting transmon qubits that significantly outperforms conventional techniques in precision and robustness against coherent errors. Our approach leverages composite pulses (CP) to effectively mitigate system-specific errors, such as qubit frequency and anharmonicity variations. By utilizing CP, we demonstrate both complete and partial population transfers between qubit states, as well as the implementation of two essential single-qubit quantum gates. Simulations reveal substantial reductions in common error rates and gate durations. The effectiveness of our method is validated through four independent verification techniques, underscoring its potential for advancing quantum computing with superconducting qubits.

MON 14.8 Mon 18:15 ZHG002

Characterization of Impedance-Matched Broadband Josephson Parametric Amplifier — •Maria-Teresa Handschuh[1,2], Kedar E. Honasoge[1,2], Florian Fesquet[1,2], Simon Gandorfer[1,2], Achim Marx[1,2], Rudolf Gross[1,2,3], and Kirill G. Fedorov[1,2,3] — [1]Walther-Meissner-Institute, 85748 Garching, Germany — [2]School of Natural Sciences, Technische Universität München, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology, 80799 Munich, Germany

Josephson parametric amplifiers (JPAs) are essential tools in experiments involving superconducting quantum circuits due to their near quantum-limited performance. However, traditional JPAs suffer from narrow bandwidths and limited compression powers, which restricts their applicability in systems requiring broader frequency range and higher signal powers. In this talk, we present the design and characterization measurements of a broadband JPA that integrates an on-chip impedance-matching circuit based on two coupled resonators. Gain measurements reveal a spectral bandwidth enhancement of nearly two orders of magnitude, as compared to conventional JPAs. In addition, we present the noise performance across a wider frequency range, highlighting the amplifier's suitability for advanced quantum applications.

MON 15: Many-Body Quantum Dynamics II

Time: Monday 16:30–18:15 Location: ZHG003

MON 15.1 Mon 16:30 ZHG003

Towards a Many-Body Generalization of the Wigner-Smith Time Delay — •Georg Maier[1], Carolyn Echter[2], Juan Diego Urbina[1], Caio Lewenkopf[3], and Klaus Richter[1] — [1]Institut für Theoretische Physik Universität Regensburg, Regensburg, Germany — [2]Fakultät für Mathematik, Universität Regensburg, 93040 Regensburg, Deutschland — [3]Instituto de Física, Universidade Federal do Rio de Janeiro, 21941-972 Rio de Janeiro, RJ, Brazil

Many body systems with a large number of degrees of freedom are usually described by statistical physics on the theoretical side while experiments usually relay on scattering (e.g. particle physics). Is it possible to relate scattering and statistical physics, or to measure scattering-related observables which directly relate to quantities of statistical physics? At least for single particle systems a close relation exists between the well known Wigner-Smith delay time in scattering theory and the density of states of the scattering system.

I will present a novel ansatz relating a many-body version of dwell-/Wigner-Smith delay time and many body density of states based on the famous Birman-Krein-Friedel-Loyd formula connecting scattering theory and statistical observables in the many-body context. Due to the flexibility of this ansatz it can be used to investigate a wide variety of MB systems. I will discuss interesting scaling behaviors for different systems, like the harmonic trap[1] or the free particle together with the different behavior of bosons, fermions and indistinguishable particles.

[1] C. Echter et. al 2409.08696

MON 15.2 Mon 16:45 ZHG003

Equilibrium, Relaxation and Fluctuations in homogeneous Bose-Einstein Condensates: Linearized Classical Field Analysis — •Nils A. Krause[1,2] and Ashton S. Bradley[1,2] — [1]Department of Physics, University of Otago, Dunedin, New Zealand — [2]Dodd-Walls Centre for Photonic and Quantum Technologies

We present a thorough analysis of the linearized stochastic projected Gross-Pitaevskii equation (SPGPE) describing finite temperature in Bose-Einstein condensates (BECs). Our study reveals an optimal choice for the cut-off that divides the Bose gas into a low energy coherent region forming a classical wave and a high energy thermal cloud acting as a reservoir. Moreover, it highlights the relevance of energy damping, the number conserving scattering between thermal and coherent atoms. We analyze the equilibrium properties and near equilibrium relaxation of a homogeneous BEC in one, two and three dimensions at high phase space density. Simulations of the full nonlinear SPGPE are in close agreement, and extend our arguments beyond the linear regime. Our work suggests the need for a re-examination of decay processes in BECs studied under the neglect of energy damping.

MON 15.3 Mon 17:00 ZHG003

Creating NOON Wavepackets via Resonance and Chaos-Assisted Tunneling of Ultracold Atoms in a Ring — •Diego Morachis and Peter Schlagheck — CESAM Research Unit, University of Liège, 4000 Liège, Belgium

A way to generate microscopic quantum superpositions for repulsively interacting ultracold atoms confined in a ring-shaped trap is proposed. Periodically driving the system renders a mixed phase space where chaotic dynamics coexist with stable resonant islands. These islands act as effective double-well potentials, enabling the confinement of atoms in distinct wavepackets with the possibility of achieving states in a perferctly balanced superposition known as a NOON state. We explore the creation of such states by studying the evolution of experimentally feasible coherent states as initial wavepackets. Parameter sets enabling the self-trapping regime are identified, which suppresses individual tunneling and promotes collective tunneling as the dominant mechanism. By performing exact numerical simulations of the many-body dynamics, we characterize NOON state formation timescales for distinct particle numbers. Preliminary results suggest specific driving windows where this resonance and chaos-assisted approach may generate nonclassical states in atomic traps.

MON 15.4 Mon 17:15 ZHG003

NOON entanglement via quantum control in Bose-Hubbard systems — •Simon Dengis[1], Sandro Wimberger[2,3], and Peter Schlagheck[1] — [1]CESAM Research Unit, University of Liege, 4000 Liege, Belgium — [2]Istituto Nazionale di Fisica Nucleare (INFN), Sezione Milano Bicocca, Gruppo collegato di Parma, Italy — [3]Dipartimento di Matematica, Fisica e Informatica, Università di Parma, Parco Area delle Scienze 7/A, 43124 Parma, Italy

A quantum control protocol is proposed for the creation of NOON states with N ultracold bosonic atoms on two modes, corresponding to the coherent superposition $|N,0\rangle + |0,N\rangle$. This state can be prepared by using a third mode where all bosons are initially placed and which is symmetrically coupled to the two other modes. Tuning the energy of this third mode across the energy level of the other modes allows the adiabatic creation of the NOON state. While this process normally takes too much time to be of practical usefulness, due to the smallness of the involved spectral gap, it can be drastically boosted through counterdiabatic driving which allows for efficient gap engineering. We then extend this entanglement protocol to the realization of multimode NOON states by employing a generic star-shaped Bose-Hubbard model with an arbitrary number of modes. We demonstrate that this process can be implemented in terms of static parameter adaptations that are experimentally feasible with ultracold quantum gases using Geodesic Counterdiabatic Driving, which saturates the quantum speed limit.

MON 15.5 Mon 17:30 ZHG003

Stability of Floquet sidebands and quantum coherence in 1D strongly interacting spinless fermions — •Karun Gadge and Salvatore R Manmana — Institute for Theoretical Physics, Georg-August-University Goettingen, Germany

For strongly correlated quantum systems, fundamental questions about the formation and stability of Floquet-Bloch sidebands (FBs) upon periodic driving remain unresolved. Here, we investigate the impact of electron-electron interactions and perturbations in the coherence of the driving on the lifetime of FBs by directly computing time-dependent single-particle spectral functions using exact diagonalization (ED) and matrix product states (MPS). We study interacting metallic and correlated insulating phases in a chain of correlated spinless fermions. At high-frequency driving we obtain clearly separated, long-lived FBs of the full many-body excitation continuum. However, if there is significant overlap of the features, which is more probable in the low-frequency regime, the interactions lead to strong heating, which results in a significant loss of quantum coherence and of the FBs. Similar suppression of FBs is obtained in the presence of noise. The emerging picture is further elucidated by the behavior of real-space single-particle propagators, of the energy gain, and of the momentum distribution function, which is related to a quantum Fisher information that is directly accessible by spectroscopic measurements.

Ref: arXiv:2502.12643

MON 15.6 Mon 17:45 ZHG003

Transport in quantum wires: Fractional charges and non-linear Luttinger liquids — •Sebastian Eggert[1], Flávia B. Ramos[1], Imke Schneider[1], and Rodrigo G. Pereira[2] — [1]University of Kaiserslautern-Landau — [2]Universidade Federal do Rio Grande do Norte, Natal

This talk will address the question about how a right-moving unit charge propagates along an interacting spinless wire. Using adaptive time-dependent DMRG, we observe that the charge spontaneously separates into three distinct parts: a fractional charge with free particle dynamics and left- and right-moving parts. As we will show the results are in full agreement with the non-linear Luttinger theory and provide deep insights into the universal correlated nature of these emergent particles. Corresponding out-of-equilibrium transport measurements offer a direct method to extract the interaction parameters governing correlations in the system even at higher energies.

MON 15.7 Mon 18:00 ZHG003

Many-body interference of anyons on a one-dimensional lattice — •Peter Robert Förderer[1], Gabriel Dufour[1], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

In addition to bosons and fermions, one- or two-dimensional systems can host anyons with non-trivial exchange phase φ. Here, we theoretically explore the dynamics of anyons on a one-dimensional lattice. This anyon-Hubbard model can be mapped onto a generalized Bose-Hubbard model with an occupation-dependent tunneling phase. In particular, we study the Hong-Ou-Mandel interference of two anyons scattering on a potential barrier. We show that the anyonic phase not only enables to interpolate between bosonic bunching and fermionic antibunching but also introduces new effects such as the formation of bound states and preferential scattering in one direction.

MON 16: Quantum Spectroscopy

Time: Monday 16:30–18:15 Location: ZHG004

MON 16.1 Mon 16:30 ZHG004

Two-photon excitation spectroscopy of high pressure xenon-noble gas mixtures — •Eric Boltersdorf, Thilo vom Hövel, Frank Vewinger, and Martin Weitz — Institut für Angewandte Physik, Bonn, Deutschland

When confined to a dye-filled optical microcavity, photons can exhibit Bose-Einstein condensation upon thermalization after repeated absorption and (re-)emission processes on the dye molecules. This has been experimentally demonstrated first in 2010.
In this work, an experimental approach is investigated to realize a Bose-Einstein condensate of vacuum-ultraviolet photons (100nm - 200nm) by absorption and (re-)emission cycles between xenon's $5p^6$ and $5p^5 6s$ (J = 1) state in dense xenon-noble gaseous ensembles. Here, we show the results of two-photon excitation spectroscopy to higher lying electronic states. We report on excitation spectra with excitation wavelengths ranging from 220nm to 260nm. The collected emission around 147nm is attributed to the decay of the $5p^5 6s$ (J = 1) state which is proposedly populated via collisional deactivation from the higher lying excited states. We show data for xenon-krypton as well as for xenon-helium mixtures.

MON 16.2 Mon 16:45 ZHG004

Sensitivity and Bandwidth Trade-Off in Rydberg Atom Sensors: A Superheterodyne-Homodyne Approach — •Dixith Manchaiah[1,2], Nikunjkumar Prajapati[1], and Christopher L Holloway[1] — [1]National Institute of Standards and Technology, Boulder, US — [2]University of Colorado, Boulder, US

Rydberg atom-based electric field sensors are emerging as powerful alternative to conventional antennas, offering high sensitivity and a broad frequency response. In this work, we explore the bandwidth and sensitivity of such sensors using Rydberg electromagnetically induced transparency (EIT) in rubidium vapor cell. The bandwidth of Rydberg sensors is typically limited by atomic transit time and the Rabi frequency of the coupling laser. While reducing beam size can increase bandwidth, it often leads to reduced signal strength and lower sensitivity.

To address this trade-off, we employ a radio frequency(RF) superheterodyne technique combined with optical homodyne detection. This approach allows us to optimize the relationship between bandwidth and sensitivity of the sensor. We further explore the effects of probe and coupling Rabi frequencies, and modulation schemes with different symbol rates and beatnote frequencies to understand the sensor performance. These findings demonstrate a practical path toward developing high bandwidth, high sensitivity Rydberg sensors suitable for applications in communication, radar, and metrology.

MON 16.3 Mon 17:00 ZHG004

Retrieving lost atomic information of an optical quantum system — •Laura Orphal-Kobin[1], Gregor Pieplow[1], Alok Gokhale[1], Kilian Unterguggenberger[1], and Tim Schröder[1,2] — [1]Department of Physics, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Ferdinand-Braun-Institut, Berlin, Germany

The precise characterization of quantum systems is critical for exploring fundamental questions and for assessing their potential in quantum technologies. Many characterization methods and prospective quantum applications rely on the detection of single photons and are therefore often time-consuming and resource-intensive. In this work, we leverage statistical Monte Carlo simulations to retrieve information from undersampled experimental data [1].

We perform a photoluminescence excitation spectroscopy measurement to estimate the optical linewidth of a quantum emitter, here a single nitrogen-vacancy center in diamond. We emulate regimes of high and low photonic signals by adding a neutral density filter in the detection path of the setup. In a regime of weak signals, standard data analysis methods result in unphysically narrow linewidths. Using a Monte Carlo method, synthetic data is generated with different input parameters, here linewidth and detected photon number. The comparison of the simulations with experimental data sets allows to determine the system parameters with high accuracy even when the experimental data are undersampled. Therefore, the Monte Carlo method unlocks new experimental regimes in quantum optics.

[1] L. Orphal-Kobin et al., arXiv:2501.07951 (2025).

MON 16.4 Mon 17:15 ZHG004

Quantum interference effects in cathodoluminescence — •Hebrew Benhur Crispin and Nahid Talebi — Christian-Albrechts-Universität, Kiel, Germany

Free electrons have emerged as a versatile tool for investigating the quantum properties of light at a nanoscale level. Recent advances in electron microscopy have made it possible to observe quantum optical phenomena, such as photon antibunching and superbunching, through the excitation of quantum emitters by an electron beam. This has sparked significant interest in understanding photon statistics and electron-emitter interactions in cathodoluminescence. Previous studies have largely relied on classical models, focusing on electron excitations of two-level quantum systems only.

Here, we introduce a theoretical model for cathodoluminescence from a multi-level quantum emitter. We derive a quantum optical master equation for the system by treating the free-electron beam excitation as an incoherent, broadband pump driving the emitter. We demonstrate that the existence of numerous transition pathways can result in quantum interference effects that significantly modify both the emitter dynamics and the time-resolved cathodoluminescence spectra. We demonstrate that the excitation rate, initial coherence and energy spacing between excited states are crucial parameters determining the influence of interference. Our work sheds light on free-electron-induced quantum interference in cathodoluminescence emission, providing a general framework with which to investigate quantum optical effects in the electron-beam excitation of multi-level quantum emitters.

MON 16.5 Mon 17:30 ZHG004

Attosecond pulse generation in laser-assisted radiative recombination — •Katarzyna Krajewska[1], Deeksha Kanti[1], Jerzy Z. Kaminski[1], and Liang-You Peng[2] — [1]University of Warsaw, Warsaw, Poland — [2]Peking University, Beijing, China

Electron-ion radiative recombination in the presence of a bicircular laser pulse is analyzed beyond the dipole approximation [1]. A bicircular pulse consists of two counter-rotating circularly polarized laser pulses with commensurate carrier frequencies. It is demonstrated that the broad bandwidth radiation can be generated in the process and that its spectrum can be significantly enhanced by tailoring the laser field [2]. A special emphasis is put on analyzing temporal properties of generated radiation, which is released as either an isolated attosecond pulse or an attosecond pulse train.

References
[1] D. Kanti et al., Phys. Rev. A 110, 043112 (2024).
[2] D. Kanti et al., Photonics 12, 320 (2025).

MON 16.6 Mon 17:45 ZHG004

Nondipole effects in multiphoton ionization — •Katarzyna Krajewska and Jerzy Z. Kaminski — University of Warsaw, Warsaw, Poland

We study nondipole effects in multiphoton ionization of a two-dimensional hydrogen-like atom by a flat-top laser pulse. To this end, we solve numerically the Schrodinger equation treating a propagating laser pulse exactly in the entire interaction region [1]. We demonstrate a directional dependence of the energy-angular photoelectron distributions for propagating laser pulses of moderate and high intensities. It is analytically interpreted based on the leading order relativistic expansion of the electron Volkov state, showing a significant contribution of the electron recoil to that behavior. In contrast, the retardation correction originating from the space- and time-dependence of the laser field leads to a tiny redshift of the photoelectron energy spectra. Other features of ionization distributions are also analyzed, including the sidelobes and the double-hump structures of multiphoton peaks, or their disappearance for intense propagating laser pulses [2].

References
[1] M. C. Suster et al., Phys. Rev. A 107, 053112 (2023).
[2] K. Krajewska, J. Z. Kaminski, Phys. Rev. A (submitted) (2025).

MON 16.7 Mon 18:00 ZHG004

Control of laser-assisted radiative recombination beyond the dipole approximation — Deeksha Kanti[1], •Mateusz Majczak[1], Jerzy Kamiński[1], Liang-You Peng[2], and Katarzyna Krajewska[1] — [1]Institute of Theoretical Physics, Faculty of Physics, University of Warsaw, Warsaw, 02-093, Poland — [2]State Key Laboratory for Mesoscopic Physics and Frontiers Science Center for Nano-optoelectronics, School of Physics, Peking University, Beijing, 100871, China

We present a comprehensive theoretical description of laser-assisted radiative recombination (LARR) in the presence of short laser pulses, that accounts for nondipole corrections of the leading order in $1/c$. They are derived systematically by the relativistic reduction, enabling us to follow the origin of various nondipole contributions. As it follows from our numerical analysis, the most important of them originates from the electron recoil off the laser pulse. We recognize that it results in extension of the LARR high-energy plateau and is a cause of an asymmetry of energy distributions of generated radiation with respect to the polar angle of the recombining electron. As we show, the remaining nondipole corrections of the leading order in $1/c$ turn out to be less significant.

In addition, we analyze ways to control the LARR radiation using external laser pulses. Despite the aforementioned nondipole effects which arise entirely from the presence of the laser field, we investigate the possibility of manipulating the intensity of the cutoff portion of LARR by chirping the accompanying laser pulse.

MON 17: Quantum Communication and Networks: Theory

Time: Monday 16:30–18:30 Location: ZHG006

MON 17.1 Mon 16:30 ZHG006

Resolution of Holevo's Conjecture on Classical-Quantum Channel Coding via Uncertainty Relations — •Joseph M. Renes — Institute for Theoretical Physics, ETH Zurich, Switzerland

The notion of complementarity is fundamental to quantum theory, as evidenced by the uncertainty principle. In quantum information theory complementarity and uncertainty relations have become important tools in designing and analyzing information processing protocols, e.g. in quantum key distribution. Here I report on another use, in determining the error exponent of classical-quantum (CQ) channels.

The error exponent of a given channel W and rate R is the constant $E(W, R)$ which governs the exponential decay of decoding error when using ever larger optimal codes of fixed rate R to communicate over ever more (memoryless) instances of a given channel W. Here I show a lower bound on the error exponent of communication over arbitrary CQ channels which matches Dalai's sphere-packing upper bound for rates above a critical value, exactly analogous to the known results for the case of classical channels. This resolves a conjecture made by Holevo in 2000 from his investigation of the problem.

Unlike the classical case, however, the argument does not proceed via a refined analysis of a suitable decoder, but instead by leveraging a bound by Hayashi on the error exponent of the cryptographic task of privacy amplification. This bound is then related to the coding problem via tight entropic uncertainty relations, providing another illustration of their use in quantum information theory.

MON 17.2 Mon 16:45 ZHG006

No-Go Theorem for Generic Simulation of Qubit Channels with Finite Classical Resources — •Sahil Gopalkrishna Naik[1], Nicolas Gisin[2,3,4], and Manik Banik[1] — [1]S. N. Bose National Center for Basic Sciences, Kolkata, India — [2]University of Geneva, 1211 Geneva 4, Switzerland. — [3]Constructor University, Bremen, Germany. — [4]Constructor Institute of Technology, Geneva, Switzerland.

The mathematical framework of quantum theory, though fundamentally distinct from classical physics, raises the question of whether quantum processes can be efficiently simulated using classical resources. For instance, a sender (Alice) possessing the classical description of a qubit state can simulate the action of a qubit channel through finite classical communication with a receiver (Bob), enabling Bob to reproduce measurement statistics for any observable on the state. Here, we contend that a more general simulation requires reproducing statistics of joint measurements, potentially involving entangled effects, on Alice's system and an additional system held by Bob. We establish a no-go result, demonstrating that such a general simulation for the perfect qubit channel is impossible with finite classical communication. Furthermore, we show that entangled effects render classical simulation significantly more challenging compared to unentangled effects. On the other hand, for noisy qubit channels with depolarizing noise, we demonstrate that general simulation is achievable with finite communication. Notably, the required communication increases as the noise decreases, revealing that large classical resources are necessary for its classical simulation.

MON 17.3 Mon 17:00 ZHG006

Extending Entropic Uncertainty Relations in QKD to multiple measurements — •Maik Romancewicz and Ramona Wolf — Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany

Uncertainty is a fundamental property of quantum mechanics, and entropic uncertainty relations (EURs) provide a means to quantify and use it for various applications. EURs play a central role in analysing the security of quantum key distribution (QKD) protocols, especially in the finite-size regime. For the case of two different measurement settings, many useful relations are well-established and have been used to analyse QKD protocols such as BB84, obtaining high key rates and strong security guarantees. However, their applicability to study more complex QKD protocols, employing multiple measurements, such as the six-state-protocol, or higher dimensional systems, remains limited. In this work we study how to extend these relations, aiming to provide new results that can be useful in analysing the security of more complex QKD protocols.

MON 17.4 Mon 17:15 ZHG006

Quantum Conference Key Agreeement with Pre-shared Basis Choice — •Yien Liang, Anton Trushechkin, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany

Quantum conference key agreement is a quantum protocol that distributes a secret key among more than two parties. The participants of the protocol share an entangled quantum state and they measure it in the same basis to obatin the secret key. However, as the number of parties increases, the probability of all participants independently randomly choosing the same basis decreases exponentially. In previous literature, key pre-sharing is mentioned as a possible solution to increase the output of the protocol: here, the participants share a secret basis choice. However, no details were given about how to perform basis pre-sharing. In our work, we show how we can securely perform practical basis-sharing without introducing loopholes in the security proof.

MON 17.5 Mon 17:30 ZHG006

Quantum conference key agreement in pair-entangled networks: Fundamental bounds — •Anton Trushechkin, Justus Neumann, Hermann Kampermann, and Dagmar Bruss — Heinrich Heine University Düsseldorf, Faculty of Mathematics and Natural Sciences, Institute for Theoretical Physics III, Universitätsstr. 1, Düsseldorf 40225

Networks of nodes connected by sources of bipartite entangled states are in focus. The nodes can perform collective measurements on the particles coming from different sources. After many repetitions of such rounds, the nodes postprocess the obtained data to agree on a secret conference key. This scenario is relevant to future quantum networks. We derive fundamental bounds on the conference key generation rate based on properties of the graph of the network. In particular, the bounds can reveal global bottleneck structures in the network, i.e., node partitions that set tightest restrictions the conference key rate.

MON 17.6 Mon 17:45 ZHG006

Merging-based Quantum Repeater — Maria Flors Mor-Ruiz[1], Jorge Miguel-Ramiro[1], •Julius Wallnöfer[1], Tim Coopmans[2,3], and Wolfgang Dür[1] — [1]Institute for Theoretical Physics, University of Innsbruck, Austria — [2]QuTech, Delft University of Technology, The Netherlands — [3]EEMCS, Delft University of Technology, The Netherlands

We introduce an alternative approach for the design of quantum repeaters based on generating entangled states of growing size. The scheme utilizes quantum merging operations, also known as fusion type-I operations, that allow the reintegration and reuse of entanglement. Unlike conventional swapping-based protocols, our method preserves entanglement after failed operations, thereby reducing waiting times, enabling higher rates, and introducing enhanced flexibility in the communication requests. Through proof-of-principle analysis, we demonstrate the advantages of this approach over standard repeater protocols, highlighting its potential for practical quantum communication scenarios.

MON 17.7 Mon 18:00 ZHG006

Unlocking Quantum Advantage in Distributed Communication Networks — •Ananya Chakraborty[1], Ram Krishna Patra[1], Kunika Agarwal[1], Samrat Sen[1], Pratik Ghosal[1], Sahil Gopalkrishna Naik[1], Manik Banik[1], Mir Alimuddin[3], Edwin Peter Lobo[2], and Amit Mukherjee[4] — [1]Department of Physics of Complex Systems, S. N. Bose National Center for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700106, India. — [2]Laboratoire d'Information Quantique, Universite libre de Bruxelles (ULB), Av. F. D. Roosevelt 50, 1050 Bruxelles, Belgium. — [3]ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain — [4]Indian Institute of Technology Jodhpur, Jodhpur 342030, India

In this work (Phys.Rev.A,vol.111,032617(2025)), we show a quantum advantage in multipartite communication complexity using n+1 partite GHZ states, enabling perfect evaluation of a global Boolean function with an n-1 bit reduction over classical protocols. Even for noisy GHZ states this advantage persists.For n = 3 and 4, genuine multipartite entanglement is necessary; for n greater than 4, inseparable states can suffice, broadening the range of useful quantum resources. In this work(New J. Phys. 27 023027), we show that qubit communication can outperform classical strategies in simulating MACs, without shared entanglement, bypassing the Frenkel-Weiner bound via joint quantum decoding. Our protocol links to nonlocality without entanglement,semi-device-independent certification of entangled measurements.

MON 17.8 Mon 18:15 ZHG006

Emergent statistical mechanics in holographic random tensor networks — •Shozab Qasim, Alexander Jahn, and Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universitat Berlin, 14195 Berlin, Germany

Random tensor networks, formed by contracting locally random tensors chosen from the unitary Haar measure, define a class of ensembles of quantum states whose properties depend on the tensor network geometry. Of particular interest are random tensor networks on hyperbolic geometries, leading to properties resembling those of critical boundary states of holographic bulk-boundary dualities. In this work, we elevate this static picture of ensemble averages to a dynamic one, leveraging earlier work on random matrix product state to show that random tensor network states exhibit equilibration of time-averaged operator expectation values under a highly generic class of Hamiltonians with non-degenerate spectra. We show that random tensor networks on hyperbolic geometries equilibrate faster than on flat ones, consistent with the expectation that the former describe highly chaotic holographic boundary theories, and that equilibration is further accelerated by the insertion of high- bond dimension black hole tensors in the network, consistent with previous holographic constructions. These results show that random tensor network techniques can describe aspects of holographic boundary dynamics without the explicit construction of a boundary Hamiltonian.

MON 18: Quantum Algorithms

Time: Monday 16:30–18:15 Location: ZHG007

MON 18.1 Mon 16:30 ZHG007

Simulation of IQP circuits with hypergraph states — •Matthias Heller[1], Paul Haubenwallner[1], and Mariami Gachechiladze[2] — [1]Fraunhofer Institut für Graphische Datenverarbeitung IGD, Darmstadt, Germany — [2]Techniche Universität Darmstadt, Darmstadt, Germany

Instantaneous quantum polynomial (IQP) circuits have recently gained a significant amount of attention due to their special structure, which allows for fault-tolerant implementation in the near future. It has been argued that classical sampling from these circuits is computationally hard, making this task a prime candidate for demonstrating quantum advantage. In this talk, we discuss the connection between IQP circuits and hypergraph states and show how graphical rules can be used to simulate these circuits. We test our approach for hypercube IQP circuits, a fault-tolerant instance of IQPs that has been introduced recently in the literature. Finally, we identify IQP structures which are easy to simulate.

MON 18.2 Mon 16:45 ZHG007

Variational quantum algorithms for continuum modelling of batteries — •Albert Pool[1,2], Michael Schelling[1,2], and Birger Horstmann[1,2,3] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Wilhelm-Runge-Str. 10, 89081 Ulm — [2]Helmholtz Institute Ulm, Helmholtzstr. 11, 89081 Ulm — [3]Department of Physics, Ulm University, Albert-Einstein-Allee 11, 89081 Ulm

We present variational quantum algorithms (VQAs) for continuum models in electro-chemical energy-storage-systems, focusing on transport equations in batteries. Our method uses a space-time encoding with time evolution based on the Feynman-Kitaev Hamiltonian, as introduced in [1]. We show how to implement the non-linear terms of the transport equations and discuss efficient quantum circuits to evaluate the terms of this Hamiltonian, and to realize suitable boundary conditions. Further, we present an adaptive optimisation strategy to find the ground state, which represents the solution to a differential-algebraic system of equations.

[1] Pool et al. Phys. Rev. Research 6, 033257 (2024).

MON 18.3 Mon 17:00 ZHG007

Influence of different feature maps on solving partial differential equations on quantum computers — •David Steffen[1,2], Michael Schelling[1,2], Felix Schwab[1,2], and Birger Horstmann[1,2,3] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Wilhelm-Runge-Str. 10, 89081 Ulm — [2]Helmholtz Institute Ulm, Helmholtzstr. 11, 89081 Ulm — [3]Department of Physics, Ulm University, Albert-Einstein-Allee 11, 89081 Ulm

Differentiable quantum circuits (DQCs) [1] are variational algorithms to solve partial differential equations on quantum computers. We investigate the potential of this method to solve systems of coupled partial differential equations as they occur in the simulation of electrochemical systems, e.g., fuel cells and batteries. A crucial part of DQCs is the feature space in which the input variables are encoded into quantum states. Possible choices are a Chebyshev feature map or a Fourier feature map, that generate a set of corresponding basis functions to fit the desired model. We show results on the influence of different feature maps on the expressibility and trainability for spatiotemporal models, on the use case of transport equations from battery simulation.

[1] Kyriienko, O. et al., Phys. Rev. A 2021, 103, 052416

MON 18.4 Mon 17:15 ZHG007

Bridging wire and gate cutting with ZX-calculus — •Marco Schumann[1,2], Tobias Stollenwerk[1], and Alessandro Ciani[1] — [1]Forschungszentrum Jülich GmbH, Peter Grünberg Institute, Quantum Computing Analytics (PGI-12), 52425 Jülich, Germany —

[2]Theor. Physics, Saarland University, 66123 Saarbrücken, Germany

Wire cuts and gate cuts allow one to reduce the required number of qubits for evaluating expectation values of the output states of quantum circuits. This comes at the price of a sampling overhead. While throughout the literature, wire and gate cutting are mostly seen as two independent methods for circuit cutting, our contribution in this work [1] is to establish a connection between them. We find that, since in ZX-calculus only connectivity matters, many known gate cuts can be obtained by cutting wires in these gates. Furthermore, we obtain a decomposition of the multi-qubit controlled-Z gate with decreased sampling overhead. Our work gives new ways of thinking about circuit cutting that can be particularly valuable for finding decompositions of large unitary gates. Besides, it sheds light on the question of why exploiting classical communication decreases the sampling overhead of a wire cut but does not do so for certain gate decompositions. In particular, using wire cuts with classical communication, we obtain gate decompositions that do not require classical communication.

[1] M. Schumann, T. Stollenwerk, A. Ciani, Bridging wire and gate cutting with ZX-calculus (2025). arXiv: 2503.11494.

[2] C. Ufrecht et al., Cutting multi-control quantum gates with zx calculus, Quantum 7, 1147 (2023).

MON 18.5 Mon 17:30 ZHG007

Optimizing ZX-diagrams with deep reinforcement learning — •Maximilian Nägele[1,2] and Florian Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [2]Physics Department, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

ZX-diagrams are a powerful graphical language for the description of quantum processes with applications in fundamental quantum mechanics, quantum circuit optimization, tensor network simulation, and many more. The utility of ZX-diagrams relies on a set of local transformation rules that can be applied to them without changing the underlying quantum process they describe. These rules can be exploited to optimize the structure of ZX-diagrams for a range of applications. However, finding an optimal sequence of transformation rules is generally an open problem. In this work, we bring together ZX-diagrams with reinforcement learning, a machine learning technique designed to discover an optimal sequence of actions in a decision-making problem and show that a trained reinforcement learning agent can significantly outperform other optimization techniques like a greedy strategy, simulated annealing, and state-of-the-art hand-crafted algorithms. The use of graph neural networks to encode the policy of the agent enables generalization to diagrams much bigger than seen during the training phase.

MON 18.6 Mon 17:45 ZHG007

Quantum Text Generation with Quantum Context-Sensitive Word Embeddings: A Comparative Architecture and Experimental Analysis — •Charles Varmantchaonala M.[1], Niclas Götting[1], Nils-Erik Schütte[1], J. L. E Fendji[2,3], and Christopher Gies[1] — [1]Institut für Physik, Fakultät V, Carl von Ossietzky Universität Oldenburg, 26129 Oldenburg — [2]Department of Computer Engineering University Institute of Technology University of Ngaoundéré, Ngaoundere, Cameroon — [3]Stellenbosch Institute for Advanced Study (STIAS) Wallenberg Research Centre at Stellenbosch University Stellenbosch, South Africa

Quantum machine learning has recently gained attention for its potential to enhance natural language processing tasks[1,2]. In this talk, we present a quantum-based text generation architecture that incorporates a quantum-native word embedding method using parameterized quantum circuits. This approach encodes classical contextual information into quantum states by designing specific quantum circuits, resulting in word embeddings that leverage quantum properties. These embeddings are then used in a prototype text generation model. To assess its effectiveness, we perform a comparative analysis against a classical model using small-scale and controlled datasets. The talk highlights both the current limitations and the potential of quantum word embeddings in language modeling. We conclude with a discussion on outlooks toward near-term quantum language tasks.

1. C. Varmantchaonala M. et al., IEEE Access 12, 99578 (2024)
2. J. Shi et al., IEEE TNNLS, 1 (2024)

MON 18.7 Mon 18:00 ZHG007

yquant - Typesetting quantum circuits in a human-readable language — •Benjamin Desef — DLR e.V., Ulm, Germany

After many months of intense work, you want to write down your results in a presentable way. Working in quantum information, it may well be that your paper will contain one, two, or many quantum circuits—either to quickly visualize something that is said in the main text anyway or because it is an integral part of your work. Of course, the result should look nice and embed well with the rest of your document, so you would rather not use some external tools to generate a picture. But you also don't want to spend hours trying to bring it to the tabular form that is required by qcircuit and quantikz. In fact, it would be nice if by looking at the LaTeX source code, you could directly understand the circuit and make modifications without going back to whatever tool generated this fify-column table.

To answer these—my own—demands, I developed yquant, which allows to write quantum circuits in a human-readable language directly in LaTeX, with no external tools involved. In this talk, I will give a quick overview, demostrate you can even use the package for your quick-and-not-dirty-at-all sketches, answer questions, and collect ideas for future features.

MON 19: Foundational / Mathematical Aspects – Quantum Optics and Quantum Information

Time: Monday 16:30–18:15 Location: ZHG008

MON 19.1 Mon 16:30 ZHG008

Operational theory for photonic circuits: the Hong-Ou-Mandel effect — •Ismael Septembre[1], Matthias Kleinmann[1], and Martin Plavala[2] — [1]University of Siegen, Germany — [2]University of Hannover, Germany

In this presentation, I will introduce a method that allows studying photonic circuits in a general operational probability theory in position-momentum space (phase space). We use our method to thoroughly study beam splitters. We show that the Hong-Ou-Mandel dip (often cited as a truly quantum effect) is a universal feature of all theories with no state preparation uncertainty, such as classical optics. We then discuss where does the 50% visibility of standard classical optics come from and construct alternative classical theories that reproduce the 100% visibility of quantum optics. Our work paves the way to the study of photonic quantum computing in a generalised setting and the origin of its alleged computing advantage.

MON 19.2 Mon 16:45 ZHG008

Preventing the Breakdown of the Tight Binding Approximation in Waveguide Quantum Optics — •Konrad Tschernig[1], Florian Huber[2], Janik Wolters[1,3], and Jasmin Meinecke[2,3] — [1]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Weltraumforschung, Berlin, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Technische Universität Berlin, Berlin, Germany

Many scientific advancements rely on the tight-binding approximation, which simplifies the description and prediction of complex system behaviors. In waveguide quantum optics, this approximation describes the dynamics of the single photon field by examining the coupling between the guided modes of individual single-mode waveguides. However, a crucial and often overlooked assumption in this framework is the mutual orthogonality of the guided modes. This assumption can fail when the waveguides are positioned very close to each other. We analyze the breakdown of the tight-binding approximation in scenarios involving small distances and then introduce the solution called Symmetric Löwdin Orthogonalization (SLO). By using SLO, we restore the orthogonality of the guided modes, leading to a closer alignment with the full continuous theory and improved agreement with experimental data compared to the standard tight-binding approach. Additionally, we explore the origin of nonreciprocal coupling in detuned waveguide systems within the SLO framework, which has previously been attributed to non-Hermitian effects.

MON 19.3 Mon 17:00 ZHG008

Causal influences in quantum many-body systems — •Leonardo Silva Vieira Santos and Otfried Gühne — Universität Siegen

In this contribution, I will present a quantum information-theoretic framework for consistently formulating cause-and-effect in quantum many-body systems. We define an operational measure of quantum causal influence, which quantifies how information and correlations propagate through the system. This reveals a causal interpretation of the 2nd law of thermodynamics, arising from the monogamy of entanglement and thus with no counterpart in classical physics. Finally, we show how causality constrains quantum dynamics and can be used to infer properties of many-body Hamiltonians, formulating a "converse Lieb-Robinson problem".

MON 19.4 Mon 17:15 ZHG008

Projective simulability of noisy SIC-POVMs — Raphael Brinster, Hermann Kampermann, Dagmar Bruss, and •Nikolai Wyderka — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany

Generalized measurements, i.e., POVMs, are known to yield an advantage over usual projective measurements in tasks like state discrimination, state tomography and entanglement detection. While any POVM can be realized as a projective measurement using auxiliary systems, some of them can be simulated through the process of classical randomization of projective measurements in the original system. Such POVMs are called projectively simulable, and every POVM becomes simulable if enough noise is added to it. While the exact amount of required noise (a quantity related to the so-called critical visibility) is in general unknown, it was conjectured that symmetric informationally complete POVMs (SIC-POVMs) are most robust against becoming simulable.

By employing a hierarchy of semidefinite programs together with constructing specific simulable decompositions for classes of noisy SIC-POVMs, we significantly enlarge the collection of POVMs for which exact critical visibilities are known. Finally, we show that there are POVMs which are more robust than certain SIC-POVMs.

MON 19.5 Mon 17:30 ZHG008

Understanding quantum theory — •Adán Cabello — University of Sevilla, Sevilla, Spain

"Nobody understands quantum mechanics" in the sense that nobody can "reduce it to the freshman level". Here, we ague that John Bell's observation that quantum theory is about "experiments" (rather than about "measurements"), together with a convenient rephrasing of four technical results, two of them about general theories of experiments [taken from G. Chiribella et al., Phys. Rev. Res. 2, 042001(R) (2020)] and two of them about sets of correlations in general physical theories [taken from B. Amaral et al., Phys. Rev. A 89, 030101(R) (2014) and A. Cabello, Phys. Rev. A 100, 032120 (2019)] provide a compelling narrative for understanding quantum theory and "where does it come from".

MON 19.6 Mon 17:45 ZHG008

Outcome communication cannot explain nonlocality — Carlos Vieira[1], •Carlos de Gois[2,3], Sébastien Designolle[4], Pedro Lauand[5], Lucas E. A. Porto[5,6], and Marco T. Quintino[6] — [1]IMECC, Unicamp, Brazil — [2]Naturwissenschaftlich-Technische Fakultät, Uni Siegen, Germany — [3]Inria, Université Paris-Saclay, France — [4]Zuse Institute Berlin, Germany — [5]IFGW, Unicamp, Brazil — [6]LIP6, Paris, France

Sixty years ago it was established that quantum theory cannot be completed by local hidden variables. This fact implies a fundamental separation between classical and quantum systems, and has since become a central aspect of quantum information. However, it does not rule out the possibility of non-local completions. In particular, it is known that local hidden variable models augmented with two bits of classical communication can explain the correlations of any two-qubit state. Would this still hold if communication is restricted to measurement outcomes? We show that any qubit-qudit state can be explained by outcome communication if and only if it is local. In other words, outcome communication does not help explain qubit-qudit correlations. In contrast to the standard local model, where only rank-1 measurements must be reproduced, the outcome communication model must explicitly account for full-rank measurements. This is not a limitation of our proof, but a general fact. To prove this, we construct an explicit outcome-local model for all rank-1 measurements on a nonlocal state, thus showing that the equivalence between the two models does not hold for these measurements alone.

MON 19.7 Mon 18:00 ZHG008

Lie Meets von Neumann for Symmetry Characterisation of Compact Lie Algebras — Emanuel Malvetti[1], Robert Zeier[2], and •Thomas Schulte-Herbrüggen[1] — [1]Technical University of Munich (TUM) — [2]Forschungszentrum Jülich GmbH, Peter Grünberg Institute, Quantum Control (PGI-8)

Von Neumann's celebrated double-centraliser theorem completely characterises an operator algebra by its symmetries/commutant. How can this idea be taken over to symmetry-characterise all simple compact Lie algebras (i.e. subalgs of $\mathfrak{u}(N)$) in finite dimension N?

Early contributions (inspired by Noether, Artin, van-der-Waerden) see group algebras to (regular representations of) finite groups as first incarnations of von Neumann algebras—still in finite dimensions.

For compact Lie groups and their Lie algebras, we elucidate the add-ons to central isotypic projections (via the commutant to the adjoint representation) that allow for such a full symmetry characterisation. We thus give a general algorithm that identifies a compact simple Lie algebra just from a given set of generators based on its joint symmetries thus substantially driving our earlier work [1-3] to a full classification.

Our algorithmic approach can be applied to problems in various fields such as measurement-based quantum computing, stabiliser design via Clifford algebras, phases of many-body systems—and last but not least quantum control.

[1] *J. Math. Phys.* **52**, 113510 (2011)
[2] *Phys. Rev. A* **92**, 042309 (2015)
[3] *J. Math. Phys.* **56**, 081702 (2015)

MON 20: Quantum Sensing and Decoherence: Contributed Session to Symposium II

Time: Monday 16:30–18:30 Location: ZHG009

MON 20.1 Mon 16:30 ZHG009

Ultrastable multicolor laser system with 10^-20-level frequency stability for quantum computing, sensing and timing applications — •Thomas Quenzel[1], Michele Giunta[1,2], Martin Wolferstetter[1], Maurice Lessing[1], Wolfgang Hänsel[1], Michael Mei[1], Marc Fischer[1], and Ronald Holzwarth[1,2] — [1]Menlo Systems GmbH, Bunsenstraße 5, D-82152 Martinsried, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München, Germany

Photonics-based quantum technologies often require ultrastable and ultralow phase noise lasers that are turn-key operated. Here we present such an ultrastable laser system with multiple wavelengths based on a continuous-wave (CW) laser referenced to an optical reference system (ORS), an optical frequency comb (OFC), and application-dependent CW lasers, supporting 20 digits of fractional stability measurements.

The ORS guarantees sub-Hz linewidth performance and fractional frequency stability of <7x10^-16 in 1 second. The OFC is based on a femtosecond fiber laser operating ~1560 nm, which is modelocked using the figure 9 technique. The stabilized CW laser serves as optical input to the OFC, and by a direct high-bandwidth phase lock the stability and narrow linewidth of this laser can be copied to every single comb line of the OFC. Finally, multiple CW lasers are locked to the corresponding comb lines extending from the UV to the Mid-IR, depending on the application. The outcome is a multicolor, ultrastable laser system, with fractional stability on the 10^-18 level in one second, and 10^-20 in 1,000 seconds.

MON 20.2 Mon 16:45 ZHG009

Top-Hat Laser Beams for Accurate Quantum Gravity Sensing — •Niranjan Myneni[1], Joël Gomes Baptista[1], Sébastien Merlet[1], Leonid Sidorenkov[1], Camille Janvier[2], and Franck Pereira Dos Santos[1] — [1]LTE, Observatoire de Paris, Université PSL, Sorbonne Université, Université Lille, LNE, CNRS, Paris, France.

— [2]Exail, Quantum Sensors, Gradignan, France.

Within the FIQUgS (Field Quantum Gravity Sensors) project, we investigate the use of top-hat laser beams to improve the performance of atom interferometers in precision inertial sensing. This work extends earlier efforts [1] demonstrating the benefits of flat-top beams towards evaluating systematic errors. We analyze both measured (Shack-Hartmann wavefront sensing) and simulated intensity and wavefront profiles, studying their propagation stability and aberration sensitivity over relevant distances. Atomic simulations quantify their impact on interferometric contrast, phase stability and accuracy. We explore beam-reducing/expanding optics to adapt top-hat beams to the required beam size for various sensor architectures. Simulations are conducted for both the FIQUgS instruments and other experimental platforms [2] available at LTE (formerly SYRTE). The results of these simulations will be benchmarked against the performance of the FIQUgS instruments evaluated during an extensive metrological campaign. This work contributes to advance compact, high-precision quantum gravimeters [3] and enhance their robustness for field deployment.

1. Appl. Phys. Lett., 113 (16), 161108(2018). 2. Phys. Rev. A 106, 013303 (2022). 3. Phys. Rev. A 105, 022801 (2022).

MON 20.3 Mon 17:00 ZHG009

Coherent feedback for quantum expander in gravitational wave observatories — •Niels Böttner, Joe Bentley, Roman Schnabel, and Mikhail Korobko — Institut für Quantenphysik und Zentrum für Optische Quantentechnologien, Universität Hamburg

The observation of gravitational waves from binary neutron star mergers offers insights into properties of extreme nuclear matter. However, their high-frequency signals in the kHz range are often masked by quantum noise of the laser light used. We propose the “quantum expander with coherent feedback”, a new detector design that features an additional optical cavity in the detector output and an internal squeeze operation. This approach allows to boost the sensitivity at high frequencies, at the same time providing a compact and tunable design for signal extraction. It allows to tailor the sensitivity of the detector to the specific signal frequency range. We demonstrate that our design allows to improve the sensitivity of the high-frequency detector concept NEMO (neutron star extreme matter observatory), increasing the detection rates by around 14%. Our approach promises new level of flexibility in designing the detectors aiming at high-frequency signals.

MON 20.4 Mon 17:15 ZHG009

Geometry of variational qubit dynamics with its applications on quantum control and sensing — •Xiu-Hao Deng — Shenzhen International Quantum Academy — Hefel National Lab

Quantum systems are fragile to perturbations from their environment. The variation of parameters brings deviation to the qubit dynamics. These variations may originate from noises, parameter uncertainty and weak signals to detect. We discover that the variational part of the qubit dynamics has beautiful geometric properties on its manifold, which includes space curves and areas. By applying the geometric theory to suppress the errors generated by noise, we find that the space curves on the manifold of the variational quantum dynamics should be close and encircle vanishing areas. Using this theory, we have obtained very robust quantum gates and quantum circuits. On the other hand, to obtain enhanced sensing, the curves should be far from the origin. We have also demonstrated enhanced signal precision and sensitivity. I will also present some experimental results in this talk.

MON 20.5 Mon 17:30 ZHG009

Phonon Dynamics and Quasi-Particle Interactions in Proximitized 2D Systems — •Zamin Mamiyev, Narmina O.Balayeva, Dietrich R.T. Zahn, and Christoph Tegenkamp — Institut für Physik, Technische Universität Chemnitz

Understanding and controlling phonon behavior in two-dimensional (2D) materials is crucial for tailoring their electronic, optical, thermal, and mechanical properties. In this context, confinement epitaxy serves as a versatile approach to create chemically protected, atomically thin 2D materials while enabling the study of proximity interactions in stacked structures [1]. In this work, we investigate phonon dynamics in epitaxial graphene (EG) intercalated with H, Sn, and In, using a combination of variable-wavelength and temperature-dependent Raman spectroscopy, complemented by electron energy loss spectroscopy. Our results demonstrate that intercalation is not merely a doping mechanism but an effective route to tune vibrational properties in EG via proximity effects [2]. Detailed analysis reveals that the primary mechanism influencing phonon behavior is the modification of electron-phonon coupling (EPC), governed by charge transfer or the strength and nature of interfacial interactions. While band filling and strain induce rigid phonon shifts, altered EPC impacts phonon group velocity. Furthermore, we show that beyond atomic-scale effects, interface engineering also significantly influences the thermal conductivity of EG.

[1] Z. Mamiyev et al., 2D Materials. 11 (2024) 025013
[2] Z. Mamiyev et al, Carbon 234 (2025) 120002

MON 20.6 Mon 17:45 ZHG009

Optomechanical cooling using a nonlinearly-driven cavity — Surangana Sengupta[1], Björn Kubala[1,2], Joachim Ankerhold[1], and •Ciprian Padurariu[1] — [1]Institute for Complex Quantum Systems and IQST, Ulm University — [2]German Aerospace Center (DLR), Institute for Quantum Technologies, Ulm

Conventional optomechanics combines a harmonic cavity mode with a mechanical element that modulates the cavity frequency [1]. The limitation of the method arises due to back-action of the cavity on the mechanical mode. This results in a residual heating effect that sets a limit to the lowest phonon occupation that can be reached via optomechanical cooling.
In this talk, I will show how driving the cavity in a nonlinear fashion can alleviate the residual heating effect, increasing the overall cooling. This method allows cooling down to orders of magnitude lower phonon occupation. As an example, the talk will focus on the case when the nonlinear drive is implemented in a superconducting circuit setup, using a Josephson junction as the nonlinear element.
In the semiclassical regime, our cooling method shows a significant advantage both in the regime where the nonlinearly-driven cavity shows multi-stable states, as well as below the threshold for multi-stability. In the future, a nonlinear cavity drive could be combined with other methods to improve the performance of optomechanical cooling, such as using intrinsically nonlinear cavity modes [2].

[1] F. Marquardt *et al.*, Phys. Rev. Lett. **99**, 093902 (2007).
[2] D. Zoepfl *et al.*, Phys. Rev. Lett. **130**, 033601 (2023).

MON 20.7 Mon 18:00 ZHG009

Amplification and Detection of Single Itinerant Microwave Photons — Lukas Danner[1,2], Ciprian Padurariu[2], Max Hofheinz[3], Joachim Ankerhold[2], and •Björn Kubala[1,2] — [1]German Aerospace Center (DLR), Institute of Quantum Technologies, Ulm (Germany) — [2]Institute for Complex Quantum Systems and IQST, University of Ulm, Ulm (Germany) — [3]Institut Quantique, Université de Sherbrooke, Sherbrooke, Québec (Canada)

The detection of single microwave photons plays a crucial role in a wide range of technological applications using quantum microwaves. Standard readout techniques relying on linear amplification [1] add noise, limiting the chance of identifying single photons. Here, we propose schemes to amplify single itinerant mircowave photons using highly-nonlinear Josephson photonics devices [2]. These devices consist of a dc-voltage biased Josephson junction, connected in series with two microwave cavities. By tuning the dc voltage, various resonances can easily be accessed, such that, e.g., a Cooper pair tunneling through the junction enables a coherent transfer between one excitation in the first cavity and n excitations in the second cavity. Using a recently developed formalism [3], we describe how a single photon pulse is absorbed by the device to trigger the leakage of multiple photons from the second cavity that can subsequently be detected, and calculate performance parameters, such as detection probabilities and dark count rates.

[1] C. M. Caves, Phys. Rev. D 26, 1817 (1982)
[2] J. Leppäkangas et al., Phys. Rev. A 97, 013855 (2018)
[3] AH. Kiilerich and K. Mølmer, Phys. Rev. Lett. 123, 123604 (2019)

MON 20.8 Mon 18:15 ZHG009

Quantum imaging with undetected photons enabled by position correlation — •Balakrishnan Viswanathan[1], Gabriela Lemos[2], and Mayukh Lahiri[3] — [1]Optics and Quantum Information Group, The Institute of Mathematical Sciences, Chennai 600113, India — [2]Instituto de Fisica, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos 149, Rio de Janeiro, CP 68528, Brazil — [3]Department of Physics, 145 Physical Sciences Bldg., Oklahoma State University, Stillwater, OK 74078, USA

Quantum imaging with undetected photons (QIUP) is a novel interferometric technique in which the light that illuminates the object is not detected. The image is constructed from the single-photon interference pattern of the photon that never interacted with the object. The basic ingredients of QIUP are two identical pairs of correlated photons and the Zou-Wang-Mandel interferometer. This imaging technique exploits the absence of path information to induce interference. We develop a theory of QIUP in which both the object and the camera are placed in the near-field with respect to the sources. It turns out that in this configuration, the imaging is enabled by the position correlation between the twin photons. Furthermore, we also investigate the resolution limit in the near-field configuration of QIUP.

MON 21: Quantum Materials

Time: Monday 16:30–18:30 Location: ZHG103

MON 21.1 Mon 16:30 ZHG103

Directional Control of Fermi Arcs via Pseudo-Magnetic Fields — Sachin Vaidya[1], •Alaa Bayazeed[2], Adolfo Grushin[3], Marin Soljačić[1], and Christina Jörg[2] — [1]1Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, USA — [2]Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, Germany — [3]Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, France

Weyl materials are three-dimensional topological systems characterized by Weyl points, which are band crossings in momentum space that act as sources or sinks of Berry curvature. These points give rise to surface states known as Fermi arcs, connecting Weyl points of opposite chirality. Under a magnetic field, the bulk band structure reorganizes into quantized Landau levels (LL), with the zeroth LL inheriting the chirality of the associated Weyl point. We investigate how pseudo-magnetic fields, arising from engineered spatial variations, influence such systems. These fields couple differently to Weyl points of opposite chirality, enabling all zeroth LLs to exhibit the same group velocity. Coating the surfaces with photonic bandgap materials, we suppress this radiation and reveal topological surface states that restore the balance of chirality. We experimentally demonstrate this in a photonic multilayer analogue of Weyl semimetals with tailored layer thicknesses and partially reflective Bragg mirrors. Our system maps complex topological physics of strained Weyl semimetals onto an accessible photonic platform.

MON 21.2 Mon 16:45 ZHG103

Emergent quantum phenomena in a two-dimensional magnet — •Ying-Jiun Chen[1], Tzu-Hung Chuang[2], Jan-Philipp Hanke[1], Markus Hoffmann[1], Gustav Bihlmayer[1], Yuriy Mokrousov[1,3], Stefan Blügel[1], Claus Michael Schneider[1,4], and Christian Tusche[1,4] — [1]Forschungszentrum Jülich — [2]National Synchrotron Radiation Research Center, Taiwan — [3]Johannes Gutenberg University Mainz — [4]University of Duisburg-Essen

Quantum phenomena that result from the breaking of time-reversal symmetry offer an innovative platform for nonvolatile switching of physical properties by controlling the direction of the sample magnetization. Magnetic order serves as an ideal means to create on-demand topological phase transitions and significantly alter the topology of the electronic states. In this talk, we present emergent quantum phenomena and magnetic control in a two-dimensional magnet by momentum microscopy. We show that giant open Fermi arcs are created at the surface of an ultrathin hybrid magnet, composed of two iron monolayers, where the Fermi-surface topology is substantially modified by hybridization with the heavy-metal substrate tungsten [1]. The interplay between magnetism and topology allows us to control the shape and the location of the Fermi arcs by tuning the magnetization direction, which dominates spin and charge transport as well as magneto-electric coupling effects [2]. Our findings not only provide a knob to tune the physical properties in a solid, but also offer a platform for prospective quantum devices. [1] Y.-J. Chen et al., Nat. Commun. 13, 5309 (2022). [2] Y.-J. Chen et al., Appl. Phys. Lett. 124, 093105 (2024).

MON 21.3 Mon 17:00 ZHG103

Strong Spin-Magnon coupling between paramagnetic ion GdW10 and VdW antiferromagnet CrSBr — •Jorge Perez-Bailon, David Garcia-Pons, Xavier del Arco-Fargas, David Zueco, and Maria Jose Martinez-Perez — Instituto de Nanociencia y Materiales de Aragón CSIC-Universidad de Zaragoza, Calle Pedro Cerbuna 12, 50009, Zaragoza, España

Cavity Quantum Electrodynamics (QED) has proven to be a highly powerful platform for manipulating and interrogating qubits. In these systems, strong coupling between qubits and quantized fields, typically photons, forms the basis for applications ranging from quantum sensing of individual spins to coherent qubit interactions. However, the reliance on photons in conventional electromagnetic cavities imposes intrinsic limitations on the maximum achievable coupling strengths and the accessible regimes of quantum physics.

Here we study the magnon-spin interaction between the layered van der Waals antiferromagnet CrSBr and the paramagnetic ion crystal GdW10 using microwave absorption spectroscopy at millikelvin temperatures. Analysis of macroscopic samples revealed multiple CrSBr resonances, attributed to phase differences among its layers, while an anticrossing at low power indicates strong coupling, which disappears at higher power as the paramagnet saturates. These findings suggest that CrSBr and similar materials could serve as magnonic platforms in hybrid quantum systems.

MON 21.4 Mon 17:15 ZHG103

Impurity scattering in one-dimensional cavity QED systems — •Lukas I. Krieger[1] and Peter P. Orth[2] — [1]Department of Physics, Saarland University, 66123 Saarbrücken — [2]Department of Physics, Saarland University, 66123 Saarbrücken

We consider the effects of impurity scattering in materials strongly coupled to high-finesse electromagnetic cavities. We focus on the regimes of deep to extremely strong coupling between light and matter degrees of freedom, where perturbative methods to cavity QED break down. We use an unitary transformation introduced by Ashida et al. [PRL 126, 153603 (2021)], the asymptotic decoupling (AD) transformation, which shifts the minimal coupling of the vector potential to the momentum to the potential terms describing the influence of periodic crystal lattice and impurities. We consider one-dimensional models of electrons subject to the AD frame light-matter interaction and we analyze the influence of the light-matter coupling to the scattering of electron waves at an impurity site. The impurity scattering will be tackled by perturbation theory in the impurity potential at low orders and by a Green's function treatment to sum up the relevant diagrams contributing to scattering.

MON 21.5 Mon 17:30 ZHG103

Orbital Topology of Chiral Crystals for Orbitronics — Kenta Hagiwara[1,2], Ying-Jiun Chen[1], Dongwook Go[3], Xin Liang Tan[1,2], Sergii Grytsiuk[1], Kui-Hon Ou Yang[4], Guo-Jiun Shu[5], Jing Chien[4], Yi-Hsin Shen[4], Xiang-Lin Huang[5], Iulia Cojocariu[1], Vitaliy Feyer[1], Minn-Tsong Lin[4,6], Stefan Blügel[1], Claus Michael Schneider[1,2], Yuriy Mokrousov[1,3], and •Christian Tusche[1,2] — [1]Forschungszentrum Jülich — [2]University of Duisburg-Essen — [3]Johannes Gutenberg University Mainz — [4]National Taiwan University, Taiwan — [5]National Taipei University of Technology, Taiwan — [6]Academia Sinica, Taiwan

Chirality is ubiquitous in nature and manifests in a wide range of phenomena including chemical reactions, biological processes, and quantum transport of electrons. In quantum materials, the chirality of fermions, given by the relative directions between the electron spin and momentum, is connected to the electronic band topology. Here, we show that in structurally chiral materials like CoSi, the orbital angular momentum (OAM) serves as the main driver of a nontrivial band topology in this new class of unconventional topological semimetals, even when spin-orbit coupling is negligible. A nontrivial orbital-momentum locking of multifold chiral fermions in the bulk leads to a pronounced OAM texture of helicoid Fermi arcs at the surface [1]. Our findings highlight the pivotal role of the orbital degree of freedom for the chirality and topology of electron states, in general, and pave the way towards the application of topological chiral semimetals in orbitronic devices. [1] Hagiwara et al., Adv. Mater. 2418040 (2025).

MON 21.6 Mon 17:45 ZHG103

Mechanism of the electrochemical hydrogenation of graphene — •YUCHIAN SOONG — Department of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK

The electrochemical hydrogenation of graphene has been recently shown to induce a robust and reversible conductor-insulator transition, which is of strong interest in logic and memory applications. However, its mechanism remains unknown. Here we show that it proceeds as a reduction reaction in which proton adsorption competes with a process attributable to the formation of H2 molecules. Graphene*s electrochemical hydrogenation is up to 6 orders of magnitude faster than alternative hydrogenation methods and is fully reversible via the oxidative desorption of protons. We demonstrate that the proton reduction rate in defect-free graphene can be enhanced by an order of magnitude by the introduction of nanoscale corrugations in its lattice and that the substitution of protons for deuterons results both in lower potentials for the hydrogenation process and in a more stable compound. Our results pave the way to investigating the chemisorption of ions in 2D materials at high electric fields, opening a new avenue to control these materials* electronic properties.

MON 21.7 Mon 18:00 ZHG103

Shadow Wall Epitaxy - Towards the all-in-situ fabrication of ZnSe-based Quantum Devices — •Christine Falter[1,2], Yurii Kutovyi[1,2], Nils von den Driesch[1,2], Denny Dütz[2,3], Lars R. Schreiber[2,3], and Alexander Pawlis[1,2] — [1]Peter Grünberg Institute, Forschungszentrum Jülich GmbH, 52428 Jülich, Germany — [2]JARA-FIT, Jülich Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany — [3]JARA-Institute for Quantum Information, RWTH Aachen University, 52074 Aachen, Germany

Wide band-gap semiconductors such as ZnSe offer a wide range of unique properties making them well-suited for a variety of quantum devices. However, in standard fabrication schemes, surface states and defects introduced during ex-situ applied processing steps can limit the performance of the final device. With this in mind, we have developed a Shadow Wall technique for molecular beam epitaxy (MBE), which allows for all-in-situ device fabrication making all post processing steps obsolete. The technique relies on the pre-patterning of vertical walls on the substrate and the precise alignment of material fluxes during deposition. In our contribution, we focus on the realization of an all-in-situ ZnSe-based field effect transistor (FET). We demonstrate the MBE growth of high quality ZnSe layers on pre-patterned substrates, the in-situ realization of well-defined spatially separated metal contacts and the electrical characterization of the final device. The optimization of the ZnSe FET platform is a first step towards the realization of qubits based on gate defined quantum dots in ZnSe.

MON 21.8 Mon 18:15 ZHG103

Low-density InAs quantum dots grown by local droplet etching for telecom O-band single-photon emission — •Elias Kersting, Nikolai Spitzer, Severin Krüger, Hans Georg Babin, Andreas Wieck, and Arne Ludwig — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

InAs quantum dots (QDs) grown by molecular beam epitaxy (MBE) are promising candidates for single-photon sources (SPS). Emission in the telecom O-band (1260 - 1360 nm) is particularly desirable due to the low transmission loss in optical fibers. However, conventional Stranski-Krastanov (SK) InAs QDs face challenges in achieving low and well-controlled densities in the suitable range of 0.1-10 QDs/μm^2, as well as in precisely tuning the emission wavelength.

We present an alternative approach based on local droplet etching (LDE), in which nanoholes in a GaAs matrix are filled with InAs to form QDs. The dot density is determined by the nanohole pattern, enabling precise and scalable control. A strain-reducing layer (SRL) enables shifting of the emission wavelength into the telecom O-band. Homogeneous QD growth is achieved through shutter-synchronized deposition, making this approach well-suited for scalable SPS fabrication. We detail the fabrication method and present structural and optical characterization results.

MON 22: Quantum Transport II

Time: Monday 16:30–17:45 Location: ZHG104

MON 22.1 Mon 16:30 ZHG104

Ultralow Lattice Thermal Conductivity and Colossal Thermoelectric Figure of Merit of the Room Temperature Antiferromagnet CsMnBi — •shubham Rakesh Singh[1], Nirpendra Singh[2], and Udo Schwingenschlögl[1] — [1]Physical Science and Engineering Division (PSE), King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia — [2]Department of Physics, Khalifa University of Science and Technology, Abu Dhabi-127788, United Arab Emirates

We study the experimentally synthesized layered material CsMnBi using first-principles calculations and the linearized electron and phonon Boltzmann transport equations. CsMnBi is found to be a semiconductor with a indirect bandgap of 0.9 eV and to realize C-type antiferromagnetism, which is energetically favorable by 187 meV per formula unit over ferromagnetism. Energetical overlap between the acoustic and low-frequency optical phonon modes enhances the phonon-phonon scattering. Combined with low group velocities and high lattice anharmonicity this results in an ultralow lattice thermal conductivity of 0.07 $\mathrm{Wm^{-1}K^{-1}}$ at 300 K. A high thermoelectric figure of merit of 2.2 (1.7) is achieved at 300 K at a hole (electron) density of 6.0×10^{18} (1.0×10^{18}) $\mathrm{cm^{-3}}$.

MON 22.2 Mon 16:45 ZHG104

Transport characteristics of quantum dots for single-electron pumps — •Johannes C. Bayer, Thomas Gerster, Dario Maradan, Niels Ubbelohde, Klaus Pierz, Hans W. Schumacher, and Frank Hohls — Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

An elegant and direct way to generate accurate currents is given by applying a periodic signal to a tunable barrier quantum dot. Such a device is called a single-electron pump (SEP) and emits a well defined number of n electrons per cycle of an external drive, resulting in a current of $I = nef$, with elementary charge e and driving frequency f. While individual SEPs can already achieve sub-ppm accuracy [1], the extension to systems operating multiple well-performing SEPs, e.g. in parallel to achieve larger currents, is still challenging. Our SEP devices are based on quantum dots formed electrostatically in a GaAs/AlGaAs two-dimensional electron gas. Based on multiple quantum dot devices, we characterize the DC transport properties and analyze relations to the dynamic SEP operation toward achieving robust, reproducible and scalable devices [2].

[1] F. Stein, et. al., Metrologia 54, S1-S8 (2017).
[2] T. Gerster, et. al., Metrologia 56, 014002 (2019)

MON 22.3 Mon 17:00 ZHG104

Quantum electrical current sources for metrological application based on silicon qubit technology — •Dustin Wittbrodt[1], Johannes C. Bayer[1], Janne S. Lehtinen[2], Lars R. Schreiber[3], Marcelo Jaime[1], and Frank Hohls[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland — [2]SemiQon Technologies Oy, Espoo, Finnland — [3]3JARA Institute for Quantum Information, Forschungszentrum Juelich,Juelich, Germany

In 2019, the redefinition of the SI system of units introduced fixed values to fundamental constants such as the elementary charge (e) and the Planck constant (h). While the units Ohm and Volt are well established, the ampere has yet to reach the same level of accuracy. The most commonly used concept of Ampere realization has been the Single Electron Pumps (SEPs), which generate quantized currents in the fA-pA range with a precision of as low as 0.2 ppm. To increase the current level of such single electron-based quantum current standards into the nA range, parallelization of several SEPs is required. To explore this task a high level of reproducibility and scalability is necessary, which is available in industrial CMOS processes. As part of the EU-funded AQuanTEC project, different Si and Si-Compound Spin Qubit Technology platforms are being tested as SEPs focusing on their accuracy and pumping behavior. To benchmark their accuracy, AC modulated pumping experiments are conducted. The results of this effort are presented here, offering a perspective into the possible employment of Qubit technology for the broader usage as quantum metrological instruments.

MON 22.4 Mon 17:15 ZHG104

Influence of Electron Density on Giant Negative Magne-

toresistance — •Lina Bockhorn[1], Christian Reichl[2], Werner Wegscheider[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

Ultra-high mobility two-dimensional electron gases often exhibit a remarkably robust negative magnetoresistance at zero magnetic field. Below 800 mK, this phenomenon divides into two distinct parts [1-4]: a temperature-independent narrow peak around $B = 0\,\mathrm{T}$, arising from the interplay of smooth disorder and elastic scattering at macroscopic defects [2, 3], and a temperature-dependent giant negative magnetoresistance (GNMR) at higher magnetic fields. The theoretical understanding of the GNMR remains an open question, as it involves several independent parameters in addition to electron-electron interaction, possibly leading to hydrodynamic transport effects. To gain insights into the nature of GNMR, we investigate this effect as a function of electron density at various temperatures and currents. Our results show a significant dependence of GNMR on electron density [4], suggesting that variations in scattering potentials [5] are not considered appropriately in theoretical models.

[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).

MON 22.5 Mon 17:30 ZHG104

Decoding undesired charge dynamics in gated GaAs quantum dots — •Lena Klar[1], Kai Hühn[1], Arne Ludwig[2], Andreas Wieck[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

Single semiconductor quantum dots (QDs) exhibit high potential as single-photon sources and are promising candidates for solid state qubits [1,2]. However, fluctuations in their charge state and in the surrounding semiconductor matrix significantly affect their optical absorption and emission spectra, even for gated quantum dots. Using two-colour resonance fluorescence spectroscopy, we investigate these fluctuations in a gated GaAs/(AlGa)As-QD in dependence on the QD charge state, temperature, and laser intensity. The experiment reveals not only standard telegraph noise but also subtle noise contributions from the QD's environment, which deteriorate single photon QD sources. Calculations and numerical simulations based on light induced charge dynamics and an alternating occupation of charge traps surrounding the QD are in good agreement with the experimental results and show optimisation perspectives for GaAs QD single photon emitters.

[1] Y. Arakawa, M. J. Holmes, Appl. Phys. Rev. **7**, 021309 (2020).
[2] A. Chatterjee et al., Nat. Rev. Phys. **3**, 157-177 (2021).

MON 23: Poster Session: Fundamental Aspects and Model Systems

Time: Monday 18:30–20:30 Location: ZHG Foyer 1. OG

MON 23.1 Mon 18:30 ZHG Foyer 1. OG

Heisenbergs Artikel von 1925 erklärt von Studierenden für Studierende — •Noah Stiehm[1,2], Bernward Lauterbach[1], Aaron Flötotto[1] und Osamah Sufyan[1] — [1]junge DPG, Regionalgruppe Ilmenau — [2]FFNI e.V., c/o Technische Universität Ilmenau, Weimarer Straße 32, 98693 Ilmenau

Mit seinem Artikel „Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen." legt Heisenberg 1925 den Grundstein für die Formulierung der Quantenmechanik. Der Inhalt ist prinzipiell für Physikstudierende schon früh im Studium (Kenntnisse über Fourier-Reihen und theoretische Mechanik sind nötig) greifbar. Gewissermaßen haben Studierende heute, durch Kenntnisse über Matrizen und Intuition zu diskreten Zuständen und Übergängen, bereits einen Vorsprung.

Dennoch ist der Zugang zu Heisenbergs Argumenten und Folgerungen größtenteils schwierig, z.B. aufgrund ad-hoc eingeführter, ungewohnter und inkonsistenter Notation, verkürzt dargestellten Gedankengängen, sowie fehlendem historischen Kontext. An der TU Ilmenau hat sich eine Gruppe Studierender damit beschäftigt, den Artikel nachzuvollziehen, um ihn im Anschluss ihren Kommiliton:innen nahe zu bringen. Aus diesem Prozess haben wir Kommentare und Gedankenstützen destilliert, und zusammen mit historischem Begleitmaterial zu einer Poster-Ausstellung geformt. Anhand dieser können interessierte Studierende die Entstehung der Quantenmechanik miterleben.

MON 23.2 Mon 18:30 ZHG Foyer 1. OG

A Short Story of Linear Quantum Mechanic AI and Global Relativistic Electrodynamics (1826-1925) — •Ulrich Christian Fischer — Alumni of the MPIBC Göttingen

Riemann's collected papers contain a 5-d Potential $Vehxyz$, with the irreducible dimension ezh of mass eh with the quantization $\alpha(eh)$ of the electron [arXiv:1609.05218]. We consider a finite motion of the hydrogen Molecule H_2, with the order Parameter ($n = 1e$) of one proton and a molecular weight ($m = 2$), against the chemiosmotic Proton motive force $\left[Pmf = \frac{1}{4}eV\right]$. V acts as Activation barrier $A\left(v = \frac{h}{4}\right)$ against the permutation of a Hydrogen molecule in a polymeric String S_n of Hydrogen molecules. A string S_n consists of a number n of Proton - Electron Pairs. The Quaternion $P_{2n} = Q_{eh}^2 he$ [M.Atiah] with a number k of Neutrons has a molecular weight $P_{2n} = P_{m-k} = S(n) = \frac{n}{m} Q_{eh}^{2he}$. With the Prime number P_n, this leads to the Mathematical Proof of the reciprocity principle of Max Born's Q-Physics, or of the Prime numbers P_n, and the order Parameter n, and the proof of Riemann's Hypothesis on the real Part $\left(x_{n0} = \frac{1}{2}\right)$ of the Zero of the [Zeta-function] $Z_0(x + iy) = \left[x_0 = \frac{1}{P_1} = \frac{1}{2} = \frac{n}{2P_n}\right] = x_{0n} = \frac{1}{2} = Z_{0n}^2 - \left[\frac{n}{2P_n}\right]^2 = 0.$

MON 23.3 Mon 18:30 ZHG Foyer 1. OG

Influence of longitudinal laser modes on the generation of time varying interference pattern — •Jelena Jovanović, Saša Ivković, and Bratislav Obradović — University of Belgrade, Faculty of Physics, 11001 Belgrade, Serbia

The primary goal of this work was to explain the interesting effect of time varying interference obtained using a birefringent crystal and an unstabilized He-Ne laser. Used laser operates in two longitudinal modes with mutually orthogonal polarizations. These modes represent the range of allowed discrete frequency values that a laser resonator can support, each corresponding to a quantized energy level within the laser cavity. The intensities of the modes vary in time, resulting that interference patterns also change in time: interference fringes appear, then disappear and appear again, but with changed positions. To explain this phenomenon, a simple analysis of the polarization states of the laser modes, which propagate through the crystal as ordinary and extraordinary rays was performed. This experiment not only demonstrates classical interference and polarization effects, but also offers an accessible way to explore the quantum nature of longitudinal modes. It highlights how quantum principles manifest in seemingly classical optical setups, providing students with a hands-on opportunity to investigate fundamental aspects of quantum optics using an interesting experiment.

MON 23.4 Mon 18:30 ZHG Foyer 1. OG

An educational setup for measuring photons and particles with modern detectors — Anja Bitar, Andrea Brogna, Fabian Piermaier, Steffen Schönfelder, Stefan Schoppmann, and •Quirin Weitzel — PRISMA Detektorlabor, Johannes Gutenberg-Universität Mainz, 55128 Mainz, Germany

In quantum and particle physics, highly sensitive and complex detectors are used, which always reflect the latest technological standards. To introduce students to these, practical experiments for training purposes are required in addition to specialized lectures. In this work, we describe the construction of a small fully working particle detector for demonstration in educational context. It is based on a state of the art scintillator, read out with optical fibers attached to a Silicon Photomultiplier (SiPM), and can be used to detect, for example, muons from cosmic rays. Furthermore, SiPMs are excellent photon counting sensors allowing to explore the quantum nature of light when exposed to repeated fast flashes on the nanosecond scale. An adjustable Light Emitting Diode (LED) pulser is used here for this purpose. Our setup can be constructed with relatively moderate effort, provided that in addition a 3D-printer and suitable readout electronics (at least an oscilloscope) are available.

MON 23.5 Mon 18:30 ZHG Foyer 1. OG

Partial distinguishability in the interference of Gaussian states in linear unitary networks — •Matheus Eiji Ohno Bezerra and Valery Shchesnovich — Universidade Federal do ABC, Santo André, State of São Paulo, 09210-170 Brazil

Partial distinguishability of the photons is a fundamental property of the quantum interference and an important source of noise in photonic quantum information protocols, particularly in Boson Sampling schemes. It originates from the imperfect overlap in the internal degrees of freedom of the photons (polarization, spectral profile, arrival time, etc). This effect was first demonstrated in the Hong-Ou-Mandel experiment, where two single photons interfere in a beam splitter and the coincidence events vanish when they are perfectly indistinguishable. Let $|\psi_k\rangle$ the internal states of the photons, with overlaps given by $\langle\psi_i|\psi_j\rangle = r_{ij}e^{i\theta_{ij}}$. When looking to the partial distinguishability, in the two-photon interference, only the modulus r_{ij} is important; while in the interference of three and more single photons, the phases θ_{ij} play an important role. However, these effects of partial distinguishability have not been fully explored in the interference of Gaussian states. In this work, we investigate how the partial distinguishability and these internal phases influence the interference of Gaussian states, specifically coherent and squeezed states, when the photons from each source are partially distinguishable. We find that the coherent states exhibit a classical dependence on the individual phases θ_{ij}, whereas squeezed states display an additional collective dependence of the phase, reminiscent of the behavior seen in the single-photon interference.

MON 23.6 Mon 18:30 ZHG Foyer 1. OG

Proposed Experiments on Adequate Frames — •Jannik Fiege[1] and Hans-Otto Carmesin[1,2,3] — [1]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade — [2]Bahnhofstraße, 5 — [3]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

The International Astronomical Union, IAU, realized, that the frames provided by general relativity are insufficient for space flight. As a provisional approximate solution, the IAU proposed reference systems for the purpose of space flight. For instance, the IAU proposed a geocentric celestial reference system, GCRS, for space travel near Earth. In contrast, for space travel in the planetary system, the IAU recommended a barycentric (essentially heliocentric) celestial reference system. More generally and fundamentally, the concept of adequate frames has been proposed, adequate frames have been derived, and exact space navigation for each location in spacetime has been developed (Carmesin 2025). These results are predictive and should be tested. For it, we propose various experiments and observations, suited for different equipment.

H.-O. Carmesin (2025): On the Dynamics of Time, Space and Quanta - Essential Results for Space Flight and Navigation. Berlin: Verlag Dr. Köster.

MON 23.7 Mon 18:30 ZHG Foyer 1. OG

Volume Portions Provide the Map of the Exact Quantum Frames of the Planetary System — •Hans-Otto Carmesin — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

A space paradox shows that space is an average of microscopic volume portions. These imply the quantum postulates, as well as gravity and curvature in spacetime. It is very valuable and insightful that the volume portions show how the quantum postulates are derived from spacetime and how they are applied to spacetime: In this manner, exact quantum frames of spacetime are derived for each location in the planetary system (Carmesin 2025). These frames are represented in a new map of the planetary system. Moreover, these frames provide the absolute zero of the kinematic time dilation. Predictions are derived, have been tested empirically, and can additionally be tested by space flights in various manners.

MON 23.8 Mon 18:30 ZHG Foyer 1. OG

Analysis of the Evolution of Universal Time Dilation and Dark Energy — •Jacky David Yang[1] and Hans-Otto Carmesin[1,2,3] — [1]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

We analyze the concept and the universal/global evolution of time. Our elaboration uses the global Euclidean geometry of the universe. We model the universe on the basis of homogeneity (ΛCDM model) and of heterogeneity (linear growth theory). Measurement values of cosmological parameters are used, see Planck Collaboration (2020). Hereby, the model of the heterogeneous universe depends on the volume dynamics (Carmesin 2024). Thereby, we take care of the Hubble tension. The aim is the analysis of the universal time dilation. We transform the calculable H_0 - values into calendar dates. Moreover, differences between respective times of both models are derived, in order to determine the time dilation. The results are presented by graphs, tables and formulas, so our results are visualized intuitively. Therefrom, the time evolution and the age of the universe are obtained, Furthermore, the time evolution of the dark energy Ω_Λ is analyzed and visualized. It is derived from the time evolution of the universal/global time dilation.

H.-O.Carmesin (2024): How Volume Portions Form and Found Light, Gravity and Quanta. Berlin: Verlag Dr. Köster.

Planck Collaboration (2020): Planck 2018 results. VI. Cosmological parameters. Astronomy and Astrophysics, pp 1-73.

MON 23.9 Mon 18:30 ZHG Foyer 1. OG

Comparative Investigation of the Newtonian Gravitational Field and the Exact Gravitational Field — •Amboer Jiaer Li[1] and Hans-Otto Carmesin[1,2,3] — [1]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

Understanding gravitational fields is fundamental to celestial mechanics and space exploration. This project investigates the differences between the classical Newtonian gravitational field and the relativistic exact gravitational field (Carmesin 2024, 2025), using Mercury as a test case. The gravitational acceleration is computed for both models over varying distances, using Python. Preliminary findings aim to assess the validity of Newtonian gravity in practical applications and explore the necessity of relativistic corrections in scenarios requiring high accuracy. This research provides insights into the limitations of classical mechanics in planetary science and informs future computational approaches for interplanetary missions.

MON 23.10 Mon 18:30 ZHG Foyer 1. OG

Factorization of multimeters: a unified view on nonclassical quantum phenomena — •Tim Achenbach[1,2], Andreas Bluhm[3], Leevi Leppäjärvi[2], Ion Nechita[4], and Martin Plávala[5] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — [2]Faculty of Information Technology, University of Jyväskylä, 40100 Jyväskylä, Finland — [3]Univ. Grenoble Alpes, CNRS, Grenoble INP, LIG, 38000 Grenoble, France — [4]Laboratoire de Physique Théorique, Université de Toulouse, CNRS, UPS, France — [5]Institut für Theoretische Physik, Leibniz Universität Hannover, Hannover, Germany

Quantum theory exhibits various nonclassical features, such as measurement incompatibility, contextuality, steering, and Bell nonlocality, which distinguish it from classical physics. These phenomena are often studied separately, but they possess deep interconnections. This work introduces a unified mathematical framework based on commuting diagrams that unifies them. By representing collections of measurements (multimeters) as maps to the set of column-stochastic matrices, we show that measurement compatibility and simulability correspond to specific factorizations of these maps through intermediate systems. We apply this framework to put forward connections between different nonclassical notions and provide factorization-based characterizations for steering assemblages and Bell correlations, including a perspective on the CHSH inequality witnessing measurement incompatibility.

MON 23.11 Mon 18:30 ZHG Foyer 1. OG

Development and Study of an Optical Quantum Processing Unit, OQPU — •Ruder Jannes[1] and Hans-Otto Carmesin[1,2,3] — [1]Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — [2]Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — [3]Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

The ongoing advancement of optical technologies opens new possibilities for enhancing the performance of classical computer architectures. This contribution presents the design and current status of implementation of a novel computer chip called the OQPU. The aim of this chip is to combine the advantages of optical computations, particularly the processing of information through light with quantum mechanical principles, to enable more efficient data processing. The OQPU utilizes laser beams whose states can be precisely manipulated and exhibit properties similar to qubits. Unlike single-photon approaches, this method provides a cost- and resource-efficient alternative while still harnessing quantum effects such as superposition and interference. The OQPU aims to overcome practical limitations in scalability, temperature and stability faced by many quantum devices. The development process focuses on validating the physical principles and optimizing the device structure. Challenges such as maintaining coherence and integrating optical components with classical electronics are addressed. Potential applications range from quantum-enhanced algorithms for complex problem-solving to faster optical data transmission systems. This work represents a significant step towards practical quantum-enhanced computing devices.

MON 23.12 Mon 18:30 ZHG Foyer 1. OG

Higher-dimensional entanglement detection and quantum channel characterization using moments of generalized positive maps — •Bivas Mallick[1], Ananda G. Maity[1,2], Nirman Ganguly[3], and Archan S. Majumdar[1] — [1]S. N. Bose National Centre for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700 106, India — [2]Networked Quantum Devices Unit, Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa 904 0495, Japan — [3]Department of Mathematics, Birla Institute of Technology and Science Pilani, Hyderabad Campus, Hyderabad, Telangana-500078, India

Higher-dimensional entanglement is a valuable resource for several quantum information processing tasks, and is often characterized by the Schmidt number and specific classes of entangled states beyond qubit-qubit and qubit-qutrit systems. We propose a criterion to detect high-dimensional entanglement, focusing on determining the Schmidt number of quantum states and identifying significant classes of PPT and NPT entangled states. Our approach relies on evaluating moments of generalized positive maps which can be efficiently simulated in real experiments without the requirement of full-state tomography. We demonstrate the effectiveness of our detection scheme through various illustrative examples. As an application, we explore the implications of our moment-based detection schemes in identifying useful quantum channels such as non-Schmidt number breaking channels. Finally, we present an operational implication of our proposed moment criterion through its manifestation in channel discrimination tasks.

MON 23.13 Mon 18:30 ZHG Foyer 1. OG

Splitting and connecting singlets in atomic quantum circuits — •Lars Fischer, Zijie Zhu, Yann Kiefer, Samuel Jele, Marius Gächter, Giacomo Bisson, Konrad Viebahn, and Tilman Esslinger — Institute for Quantum Electronics & Quantum Center, ETH Zurich, 8093 Zurich, Switzerland

Large scale quantum computation relies on the configurable connection of qubits by system-wide error free transportation of quantum states. In this talk we present one way to coherently shuttle and manipulate quantum states in optical dynamical superlattices. By preparing atomic spin singlet pairs of fermionic potassium-40 in a lattice potential, we use a bi-directional quantized Thouless pump to transport, coherently split, and separate atomic pairs. We report a single-shift fidelity in our pumping mechanism of 99.78(3)% over 50 lattice sites.

Additionally, we implement tunable $(\mathrm{SWAP})^{\alpha}$-gates with strongly repulsive interactions. When atoms moving in opposite directions meet on a double well, they undergo a superexchange interaction that continuously swaps their internal spin states. We use this gate set to coherently manipulate the quantum states in our system and interconnect large fractions of spin-singlet pairs. By applying a magnetic field gradient we observe multi-frequency singlet-triplet oscillations, which reveal complex final states from controlled quantum circuits. The presented scheme can be used as a tool to study full-system entanglement, quantum processing and sensing, and atom interferometry in optical lattices.

MON 23.14 Mon 18:30 ZHG Foyer 1. OG

Efficient detection of genuine multipartite entanglement using moments of positive maps — •Saheli Mukherjee[1], Bivas Mallick[1], Sahil Gopalkrishna Naik[1], Ananda G. Maity[1,2], and Archan S. Majumdar[1] — [1]S.N. Bose National Centre for Basic Sciences, Kolkata-700106, West Bengal, India — [2]Networked Quantum Devices Unit, Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa 904-0495, Japan

Genuine multipartite entanglement (GME) represents the strongest form of entanglement in multipartite systems, providing significant advantages in various quantum information processing tasks. In this work, we propose an efficient and experimentally feasible scheme for detecting GME, based on the truncated moments of positive maps. Our method avoids the need for full state tomography, making it scalable for larger systems. We provide illustrative examples of both pure and mixed states to demonstrate the efficacy of our formalism in detecting inequivalent classes of tripartite genuine entanglement. Finally, we present a proposal for realising these moments in real experiments.

MON 23.15 Mon 18:30 ZHG Foyer 1. OG

Scalable Entanglement Quantification in Quantum Many-Body Systems with a Graph Neural Network — •Susanna Bräu, Martina Jung, and Martin Gärttner — Institut für Festkörpertheorie und Optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

Entanglement is a fundamental feature of quantum mechanics and plays a central role in quantum computing, quantum communication, and quantum information theory. Quantifying entanglement between different parts of a system - via measures such as entanglement entropy or quantum mutual information - usually requires full knowledge of the quantum state. However, due to the curse of dimensionality, quantum state tomography is infeasible for larger systems, limiting the accessible system sizes. Therefore, we propose a supervised machine learning approach to estimate entanglement features based on a set of measurement snapshots of the system. For that, we develop a permutation invariant graph neural network (GNN) that is parameter-efficient, being linear in the system size. Our scalable GNN incorporates the mini-set architecture, developed by Kim et al. [1], who divided the input into smaller sets which the model processes in parallel. By attending the output of each mini-set in a permutation invariant manner, high order correlations can be extracted. In this way, we aim to improve the scaling such that the GNN can be applied to larger data sets or be used to increase the time over which the model can accurately predict entanglement features in the future.

[1] Kim, H. et al. arXiv:2405.11632 [quant-ph] (Nov. 2024).

MON 23.16 Mon 18:30 ZHG Foyer 1. OG

Quenching on the circle: how compactification curbs entanglement growth in coupled rotors — •Stefan Aimet[1] and Spyros Sotiriadis[2] — [1]Freie Universität Berlin, Berlin, Germany — [2]University of Crete, Heraklion, Greece

Compact topology fundamentally constrains quantum dynamics. After a global frequency quench to zero, coupled harmonic oscillators display unbounded entanglement growth because their position variables live on the real line and the associated metastable zero modes diffuse indefinitely. Recasting these variables instead as angular coordinates compactified on a circle maps the system to coupled quantum rotors whose phase-space support and hence entanglement entropy saturates at late times. We analyse how compactification curbs entanglement growth. Our findings identify compactification as a generic mechanism that tames entanglement divergence and motivate experimental realisations.

MON 23.17 Mon 18:30 ZHG Foyer 1. OG

Photonic simulation optimized for quantum field dynamics — •Robin Alexander Strahlendorf, Mauro D'Achille, and Martin Gärttner — Institut für Festkörpertheorie und Optik, Friedrich-Schiller-Universität Jena, Max-Wien Platz 1 07743 Jena

Photonic multimode systems offer great potential as quantum simulators of quantum field theories. The dynamics of free field theories, corresponding to quadratic Hamiltonians, can be decomposed into a sequence of passive optical elements and squeezing transformation. It is difficult to scale an optical circuit to large number of modes and depths due to the inherent loss of the optical elements.

We tackle this problem by exploiting the freedom in designing an optical circuit for a given unitary evolution. In particular, we aim to minimize the number of gates, thereby reducing the overall simulation error. For this, we simulate realistic noise models and compare the robustness of the different decomposition schemes with respect to common types of errors.

MON 23.18 Mon 18:30 ZHG Foyer 1. OG

Fractal Zeta Universe and Atoms — •Otto Ziep — 13089 Berlin — Independent Research

Fractal universes and atoms are assigned to k-components or stable orbiting laps of simplest cycles of elliptic invariants. Cosmological redshift, expansion of the universe, origin of cosmic rays, cosmic microwave background, quantum entanglement and the cosmological constant problem are resolvable easily by fractal universes of bifurcating spacetime. Quantum entanglement is explainable by a highly correlated pseudo-congruent k-component in bifurcating spacetime. A one-dimensional complex contour around nontrivial zeros of zeta and L-functions is capable to create a zero-energy universe- action functional. Gauge coupling parameter fit into Gaussian periods of fixpoints. Many experiments in natural history support a fractal zeta universe.

[1] O. Ziep, A quantum entangled fractal superfluid universe, Journal of High Energy Physics, Gravitation and Cosmology, vol. 11, 3, (2025)
[2] O. Ziep, Fractal Universe and Atoms, Scholars Journal of Physics, Mathematics and Statistics, Vol.12, No. 4 (2025)
[3] O. Ziep, Cosmic Rays, Aerosol-Photosynthesis and Vegetational Air Ions, Manuscript in preparation, 2025

MON 23.19 Mon 18:30 ZHG Foyer 1. OG

Fully Dynamical Analysis of Coulomb Breakup Experiments for the Determination of the α(d, γ)6Li cross section — •Monica Sanjinez Ortiz and Pierre Capel — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany

In the modelling of Big Bang nucleosynthesis, the cross sections of reactions leading to the formation of light nuclei play a fundamental role. For the synthesis of 6Li, in particular, the radiative capture process α(d, γ)6Li is of utmost importance. From experiments, the direct determination of the cross section is difficult at low energy, and there exists only one set of direct measurements in the energy range of interest. Coulomb breakup has been considered as an alternative method to infer the low-energy cross section of reactions for astrophysics as it corresponds to the time reversed process of radiative captures. In the past, two experiments of 6Li breakup onto 208Pb have been performed: at 26A MeV and at 150A MeV. With a fully dynamical reaction model based on the eikonal approximation, we report here on a new theoretical analysis of this breakup reaction. Our results indicate that the breakup cross section at 150A MeV is nuclear dominated with marked interferences with the Coulomb component. Accordingly, it is difficult to infer radiative capture cross sections from data at this energy. Similarly, the analysis of the reaction at 26A MeV points towards a nuclear dominated contribution at forward angles. Nevertheless, at low beam energy and large scattering angles, the reaction seems Coulomb dominated, suggesting a way to overcome the aforementioned difficulty.

MON 23.20 Mon 18:30 ZHG Foyer 1. OG

Floquet-Engineering of Feshbach Resonances in Ultracold Lithium Gases — •Louisa Marie Kienesberger, Alexander Guthmann, Felix Lang, and Artur Widera — Physics Department and Research Center OPTIMAS, University of Kaiserslautern

Magnetic Feshbach resonances are a key tool for tuning interactions in ultracold atomic systems. In our recent work [1], we demonstrate that periodic modulation of the magnetic field enables the creation of Floquet-Feshbach resonances in a two-component gas of fermionic lithium-6, providing dynamic control over resonance positions.

We experimentally map out the structure of Floquet-dressed scattering states and confirm the theoretical predictions for their positions and widths. Our observations include clear signatures of higher-order resonances, revealing a rich spectrum of interaction control not accessible via static fields alone. Additionally, we show that inelastic atom losses can be strongly suppressed by introducing a second modulation frequency at exactly the second harmonic.

In conclusion, Floquet-Engineering of Feshbach resonances opens new pathways for precise control of scattering in ultracold gases. As a prominent application, it enables the realization of Bound States in the Continuum (BICs) through interference at avoided crossings between Floquet-Feshbach resonances, which will be discussed in a separate talk.

[1] A. Guthmann, F. Lang, L. M. Kienesberger, S. Barbosa, A. Widera , Floquet-Engineering of Feshbach Resonances in Ultracold Gases, arXiv 2503.05454 (2025).

MON 23.21 Mon 18:30 ZHG Foyer 1. OG

Hydrodynamic Effects in Cryogenic Buffer Gas Cells — •Nick Vogeley[1], Bernd Bauerhenne[2], and Daqing Wang[1] — [1]Institut für angewandte Physik, Uni Bonn — [2]Experimentalphysik I, Uni Kassel

We report a screening of design geometries for cryogenic buffer gas beam cells operating in the hydrodynamic extraction regime with moderate throughput $J \approx 50$ sccm. We performed steady-state slip-flow simulations for helium at $T = 4.5$ K and included a localized heat source to represent the ablation or injection point of the species of interest. In a subsequent direct-simulation Monte Carlo diffusion model we tracked the trajectories of these particles to compare the performance for different buffer gas injection geometries. While most prior studies focused on box-like or cylindrical cells, we investigated hydrodynamic effects such as vortex formation within a spherical cell and assessed whether these could be utilized to improve extraction efficiency. In addition to the observed enhancement in extraction yield and reduced deposition on inner walls, we identified indicators for experimental verification of these effects in time-of-flight measurements.

MON 23.22 Mon 18:30 ZHG Foyer 1. OG

Controlling the rotational quantum states of chiral molecules — •Elahe Abdiha, JuHyeon Lee, Shilpa Yadav, Sejun An, Boris G Sartakov, Gerard Meijer, and Sandra Eibenberger-Arias — Fritz-Haber-Institut der Max-Planck-Gesellschaft; Berlin, 14195, Germany

We present recent experimental advances targeted at full enantiomer-specific control of the quantum states of chiral molecules using enantiomer-specific state transfer (ESST). In theory, ESST can reach 100We will also present our ongoing efforts to address the intrinsic limitation of ESST due to orientational degeneracy of the rotational states by incorporating theoretically tailored pulse schemes [4].

[1] Eibenberger et al., Phys. Rev. Lett. 118, 123002 (2017)
[2] Pérez et al., Angew. Chem. Int. Ed. 56, 12512 (2017)
[3] Lee et al., Nat. Commun. 15, 7441 (2024)
[4] Leibscher et al. Commun. Phys. 5, 110 (2022).

MON 23.23 Mon 18:30 ZHG Foyer 1. OG

Hanbury Brown-Twiss interference of electrons in free space — •Florian Fleischmann[1], Mona Bukenberger[2], Anton Classen[3], Marc-Oliver Pleinert[1], and Joachim von Zanthier[1] — [1]Friedrich-Alexander- Universität Erlangen-Nürnberg, Quantum Optics and Quantum Information, 91058 Erlangen, Germany — [2]ETH Zürich, Depart- ment of Environmental Systems Science, 8092 Zürich, Switzerland — [3]University of Utah, Health Science Core, UT 84112 Salt Lake City, USA

We investigate the spatial second-order correlation function of two electrons originating from two nanotips in a Hanbury Brown-Twiss like setup. First, we consider semi-classically the effects of the Pauli exclusion principle and Coulomb repulsion on the expected correlation pattern. This is followed by a full quantum-mechanical treatment of the problem, where we separate the system into relative and center-of-mass coordinates in analogy to the Hydrogen atom ansatz. While the center-of-mass system is described as a free particle, the relative system contains the Coulomb scattering process which translates into an effective one-particle problem. We expand the respective initial state of the electrons in the eigenstates of the corresponding Hamiltonian and evolve the system in time. After the scattering process, the function is evaluated in the far field. We present the formal solution of the problem and discuss the current state of the numerical investigations.

MON 23.24 Mon 18:30 ZHG Foyer 1. OG

Photon Bose-Einstein Condensates: Polarization properties and tailored potential landscapes — •Sven Enns[1], Julian Schulz[1], Kirankumar Karkihalli Umesh[2], Frank Vewinger[2], and Georg von Freymann[1,3] — [1]Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Institute of Applied Physics, University of Bonn, 53115 Bonn, Germany — [3]Fraunhofer Institute for Industrial Mathematics ITWM, 67663 Kaiserslautern, Germany

We experimentally investigate polarization properties of harmonically trapped photon gases in a dye-filled microcavity and their dependence on the polarization of the pump beam. Our results demonstrate the interplay between the timescales of thermalization, rotational diffusion of the dye molecules and photon lifetime in the cavity. In agreement with previous theoretical work [1], we show that symmetry breaking occurs when stimulated emission becomes the dominating process.

Furthermore, we investigate photon gases in potential landscapes using the technology of Direct-Laser-Writing (DLW), a 3D laser lithography technology that enables the fabrication of three-dimensional polymer structures at the sub-micron scale. By printing these structures onto the cavity mirrors potential landscapes for the photon gas are created. This allows for the investigation of many fields, such as quantum thermodynamics [2] and properties of coupled photon gases.

[1] R. I. Moodie, P. Kirton, and J. Keeling, Phys. Rev. A 96 (2017).
[2] Karkihalli Umesh, K., J. Schulz, J. Schmitt, M. Weitz, G. von Freymann and F. Vewinger, Nature Physics 20, 1810-1815, (2024).

MON 23.25 Mon 18:30 ZHG Foyer 1. OG

Rabi-like mode conversion in nonlinear photonic meta atoms — •Oliver Melchert[1,2], Shihao Zhang[1,2], Ihar Babushkin[1,2], Uwe Morgner[1,2], and Ayhan Demircan[1,2] — [1]Institute of Quantum Optics, Leibniz Universität Hannover, Hannover, Germay — [2]PhoenixD, Leibniz Universität Hannover, Hannover, Germay

We investigate the interaction dynamics of optical pulses in the higher-order nonlinear Schrödinger equation with mixed domains of normal and anomalous dispersion. This system enables one-dimensional nonlinear photonic meta atoms, i.e. composite solitary waves that support direct optical analogues of quantum mechanical bound states: the stationary atom potential is defined by the refractive index change induced by a fundamental soliton; its bound modes are realized by a weak co-propagating pulse. Coupling of both pulses is achieved via cross-phase modulation accross a vast frequency gap. Here, we demonstrate Rabi-like transfer of energy between the bound modes, driven by periodic oscillations of the atom potential in terms of a nonfundamental soliton. Coupled-mode theory shows that the underlying resonance phenomenon is reversible and parity maintaing. Beyond the quantum analogy we observe phase-matched coupling to resonant radiation, resulting in exponentially slow decay of the bound energy.

MON 23.26 Mon 18:30 ZHG Foyer 1. OG

The effects of Casimir interactions in experiments on gravitationally-induced entanglement — •Jan Bulling, Marit O. E. Steiner, Julen S. Pedernales, and Martin B. Plenio — Institut für Theoretische Physik, Ulm, Germany

The detection of gravitationally induced entanglement between two macroscopic bodies has recently emerged as a promising approach to probe the non-classical nature of gravity. Experimental proposals typically suggest placing the center-of-mass of two levitated particles in spatially delocalized Schrödinger-cat states or squeezed Gaussian states. According to standard arguments, a quantum theory of gravity is expected to generate entanglement between their positional degrees of freedom due to the gravitational interaction between the two masses. To ensure that the observed entanglement arises solely from gravity, all other interactions - particularly electromagnetic forces - must be suppressed. Therefore, the use of a conductive Faraday shield between the particles is often proposed.

In this work, we investigate the impact of short-range Casimir forces arising between the particles and the newly introduced shield on the entanglement generation. We show that stochastic variations in the initial state preparation across multiple experimental runs, as well as thermal vibrations of the shield, can destroy measurable entanglement.

MON 23.27 Mon 18:30 ZHG Foyer 1. OG

Testing two cornerstones of quantum theory with multi-particle interference — •Marc-Oliver Pleinert and Joachim von Zanthier — Quantum Optics and Quantum Information Group, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 1, 91058 Erlangen, Germany

From the start, quantum mechanics has been questioned due to its counter-intuitive aspects. One example is the use of complex numbers, one building block of quantum theory, which has been criticised already by Schrödinger. Another example is Born's rule relating detection probabilities to the modulus square of the wave function, which initially was only added as a footnote.

Altogether, quantum theory permits interference between indistinguishable paths but, at the same time, restricts its order. Single-particle interference, for instance, is limited to the second order, that is, to pairs of single-particle paths. Recently, we introduced particular multi-particle interference tests of these two cornerstones of quantum mechanics: (i) generalised Sorkin tests of the order of interference and thus Born's rule [1,2] and (ii) generalised Peres tests for the dimensionality of the number system with the aim of questioning whether complex numbers are sufficient for quantum theory [3].

[1] Phys. Rev. Research 2, 012051(Rapid Comm.) (2020)
[2] Phys. Rev. Lett. 126, 190401 (2021)
[3] Phys. Rev. Lett. 134, 060201 (2025)

MON 23.28 Mon 18:30 ZHG Foyer 1. OG

Probing High-Order Susceptibilities of monolayer MoS_2 via High Harmonic Generation: TDDFT approach — Yeganeh Alvankar[1,2], •Elnaz Irani[2], Hamid Talkhabi[2], and Mohammad Monfared[3] — [1]3ICMM, Centro Superior de Investigaciones Cientficas, Sor Juana Ines de la Cruz, 3 Cantoblanco, 28049 Madrid, Spain — [2]Department of Physics, Faculty of Basic Sciences, Tarbiat Modares University, P.O. Box 14115-175, Tehran, Iran — [3]Institute of Theoretical Physics, Leibniz University Hannover, Appelstraße 2, 30167 Hannover, Germany

High-harmonic generation (HHG) is a powerful method for probing high-order nonlinear optical responses in solids, across both perturbative and non-perturbative regimes.

Here, we use time-dependent density functional theory (TDDFT) to calculate the nonlinear susceptibilities $(\chi^{(5)}, \chi^{(7)}, \chi^{(9)})$ of monolayer MoS_2 via HHG. Simulations employ intense ultrafast laser pulses ($\lambda_0 = 600, \text{nm}$) with peak intensities from 0.2-1.2 TW/cm^2.

Our results exhibit power-law scaling $\text{Yield}_N = A_N I^N$ and interband polarization, enabling direct extraction of higher-order susceptibilities. We also observe strong crystal orientation dependence, with anisotropic behavior across harmonic orders, emphasizing the role of polarization control in 2D material characterization.

Unlike previous methods (e.g., attosecond streaking) that inferred lower-order susceptibilities indirectly, HHG directly reveals higher-order responses without broad spectra or indirect analysis. Quantifying such nonlinearities is key to advancing ultrafast photonics.

MON 23.29 Mon 18:30 ZHG Foyer 1. OG

Limits of the anomalous-velocity description for currents in solid state systems driven by ultrafast pulses — •Jelena Schmitz, Adrian Seith, Jan Wilhelm, and Ferdinand Evers — Institute of Theoretical Physics and Regensburg Center for Ultrafast Nanoscopy, University of Regensburg, Germany

The current response of solids to electric fields $\mathbf{E}(t)$ is often described using a quasi-classical current approximation including an anomalous velocity term containing the Berry curvature $\mathbf{\Omega}_n(\mathbf{k})$ [1],

$$\mathbf{j}(t) = \int_{\text{BZ}} \frac{\mathrm{d}\mathbf{k}}{(2\pi)^d}\, \mathfrak{q} \sum_n (\partial\epsilon_n(\mathbf{k})/\partial_{\mathbf{k}} + \mathfrak{q}\, \mathbf{E}(t) \times \mathbf{\Omega}_n(\mathbf{k}))\, f_n^{(0)}(\mathbf{k})\,, \qquad (2)$$

where $f_n^{(0)}(\mathbf{k})$ denote the (initial) band occupations and $\epsilon_n(\mathbf{k})$ the dispersion. To test the limits of the quasi-classical descriptions for ultrafast and strong driving fields, we compare Eq. (1) with results from a quantum mechanical calculation using the Semiconductor Bloch equations (SBE) [2,3]. By deriving Eq. (1) from the SBE, we determine the parametric regime of validity of the quasi-classical description. The small dimensionless parameters that control the domain of applicability are weak fields and slow driving in comparison to the system dependent effective gap. We confirm our analytic predictions by comparing Eq. (1) to numerically exact solutions of the SBE using a two band massive Dirac Hamiltonian as our model system. [1] Xiao, D. et. al., Rev. Mod. Phys. 82, 1959 (2010) [2] Schmitt-Rink, S. et. al., Phys. Rev. B 37, 941 (1988) [3] Wilhelm, J. et. al., Phys. Rev. B 103, 125419 (2021) [4] https://github.com/ccmt-regensburg/CUED/

MON 23.30 Mon 18:30 ZHG Foyer 1. OG

Entering the overcritical regime of nonlinear Breit-Wheeler pair production by superintense, tightly focused laser pulses colliding with bremsstrahlung γ-rays — •Ingo Elsner, Alina Golub, Selym Villalba-Chavez, and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf

Nonlinear Breit-Wheeler pair production in collisions of a tightly focused high-intensity laser pulse with GeV bremsstrahlung photons is theoretically studied in an overcritical field regime, where the quantum nonlinearity parameter substantially exceeds unity [1]. We investigate under which conditions the attenuation of the γ-beam due to the production process must be taken into account and how much the second generation of created pairs contributes to the total yield. In the considered interaction regime, it is shown that the relevant range of bremsstrahlung frequencies is generally very broad and that – for sufficiently large values of the quantum nonlinearity parameter – an optimum domain of frequencies far below the spectral end point emerges. We also demonstrate that it is beneficial for achieving optimum pair yields to increase the interaction volume by a wider laser focus at the expense of decreased field intensity.

[1] I. Elsner, A. Golub, S. Villalba-Chávez and C. Müller, Phys. Rev. D 111, 096012 (2025)

MON 23.31 Mon 18:30 ZHG Foyer 1. OG

Universal Behavior of Tunneling Time and Disentangling Tunneling Time and Barrier Time-Delay in Attoclock Exper-

iments — •Ossama Kullie[1] and Igor Ivanov[2] — [1]Department of Mathematics and Natural Sciences. University of Kassel, 34132 Kassel, Germany. — [2]Department of Fundamental and Theoretical Physics, Australian National University, Australia

In previous work [1,2,3], we have shown in our model that the (tunnel-ionization) time-delay measured in the attoclock experiment can be precisely described in the adiabatic and nonadiabatic field calibrations. Furthermore, the barrier (tunneling) time-delay itself can be determined from the difference between the time-delays of the adiabatic and nonadiabatic tunnel-ionization, which shows excellent agreement with the experimental results. Remarkably, the tunneling time-delay exhibits a universal behavior with disentangled contributions. Furthermore, we find that in the weak measurement limit, the barrier time-delay corresponds to the Larmor-clock time-delay and the interaction time within the barrier region [1]. We further discuss quantum superluminality in the framework of the attoclock [4].

[1] O. Kullie, J. Phys, Commun. 9, 015003 (2025).
[2] O. Kullie and I. Ivanov, Annals of Physics 464, 169648 (2024).
[3] O. Kullie, Annals of Physics 389, 333 (2018).
[4] O. Kullie and I. A. Ivanov, in preparation.

MON 23.32 Mon 18:30 ZHG Foyer 1. OG

Kondo effect with singular baths: the role of electron-phonon interaction — •Max Fischer[1], Emin Moghadas[2], Niklas Witt[1], Alessandro Toschi[2], and Giorgio Sangiovanni[1] — [1]Institut für Theoretische Physik und Astrophysik and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, 97074 Würzburg, Germany — [2]Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria

In the context of dynamical mean-field theories, the hybridization function of the associated impurity model becomes singular at the Fermi level whenever the density of states vanishes at the Fermi level. One examples is the prominent twisted bilayer graphene where the flat bands form a 2D Dirac cone yielding a peak in the bath of the corresponding periodic Anderson model. This is at odds with standard examples of Kondo systems in which the hybridizations are assumed to be regular and well-behaved around the Fermi energy. By means of quantum Monte Carlo and renormalization group we study the crossover from Kondo to the local-moment regime solving an Anderson impurity model which combines a regular part with a tunable peak at the Fermi level. Furthermore, we couple the impurity electrons to a local Holstein-like degree of freedom and analyze the effect of the oscillator on the Kondo feature. We also investigate in which way the singularity in the bath influences the effects of retardation.

MON 23.33 Mon 18:30 ZHG Foyer 1. OG

DMRG on arbitrary geometries using Belief Propagation — •Hendrik Kühne[3] and Christian B. Mendl[1,2] — [1]School of Computation, Information and Technology, Technical University of Munich — [2]Munich Center for Quantum Science and Technology — [3]School of Natural Sciences, Technical University of Munich

Tensor networks have recently attracted much attention as a powerful tool for modeling systems in quantum many-body physics. Their contraction is a significant challenge however, especially in highly connected networks, as memory requirements become prohibitive and the optimal contraction order is increasingly hard to find. The belief propagation algorithm has emerged as an alternative to exact contraction. It offers great flexibility, being completely independent of the geometry in question, however its accuracy suffers in the presence of loops. On the other hand, in Quantum Chemistry, the DMRG algorithm is regarded as the gold standard in solving the ground state problem. Its behavior is well-understood in 1D, however maintaining the necessary canonical forms in higher dimensions becomes increasingly complex. This work proposes to combine Belief Propagation and DMRG, thereby extending DMRG to higher dimensions and arbitrary system geometries. We demonstrate the viability of BP-DMRG on the transverse-field Ising model, where it yields ground states reliably with high fidelity. We also discuss limitations that we incur by using belief propagation, and possible future directions for improving the accuracy and controllability of BP-DMRG.

MON 23.34 Mon 18:30 ZHG Foyer 1. OG

Quantum spin system as reservoir for quantum reservoir computing — •Lara Celine Ortmanns — Deutsches Zentrum für Luft- und Raumfahrt e.V., Linder Höhe, 51147 Köln, Germany

Reservoir computing (RC) is a well-known framework of machine learning, which is used to solve temporal learning tasks, such as temporal pattern recognition and prediction. So far, a variety of physical systems have been considered to implement the reservoir of the RC-scheme [1]. In this project, we investigate a quantum spin system as possible candidate for a quantum reservoir. More specifically, the system is described by the transverse-field Ising model with long-range spin-spin interaction. Additionally, we allow for transverse disorder. Depending on the ratio of involved coupling strengths (interaction and disorder), the system exhibits two dynamical phases, an ergodic and an MBL phase. We raise the question whether counteracting tendencies associated with the vicinity of the phase transition can increase the reservoir performance w.r.t. the ergodic phase for certain tasks.

[1] G. Tanaka et al., Neural Networks 115, 100-123 (2019)

MON 23.35 Mon 18:30 ZHG Foyer 1. OG

Topological insulator single electron transistor — •Omargeldi Atanov, Junya Feng, and Yoichi Ando — Physics Institute II, University of Cologne, Cologne, Germany

When a topological insulator (TI) Josephson junction is driven through a topological phase transition, the ground-state parity of the system is expected to change, potentially due to the fusion of Majorana bound state (MBS) pairs. Measuring the individual parity of MBS pairs is a critical step in understanding the mechanisms behind these parity changes and for more complex braiding operations. We present the successful fabrication and characterization of single electron transistors (SETs) based on bulk-insulating BiSbTeSe2 flakes, which also serve as the material for TI Josephson junctions. This approach simplifies the process flow of the devices and improves fabrication yield. Initial characterization of devices demonstrates well-formed Coulomb diamonds that confirms the robust charge quantization and SET performance. These results pave the way for integrating SETs with TI Josephson junctions and measuring MBS parity in the near future.

MON 23.36 Mon 18:30 ZHG Foyer 1. OG

Realization of topological Thouless pumping in a synthetic Rydberg dimension — •Johannes Deiglmayr[1], Martin Trautmann[1], and Inti Sodemann Villadiego[2] — [1]Felix-Bloch Institute, Leipzig University, Linnéstraße 5, 04103 Leipzig, Germany — [2]Institute for Theoretical Physics, Leipzig University, Brüderstraße 16, 04103 Leipzig, Germany

Synthetic dimensions provide the opportunity to investigate regimes outside those of more traditional quantum many-body platforms. Rydberg states of atoms are a particularly promising platform to engineer Hamiltonians in such synthetic dimensions due to the large number of states and the readily available technologies for manipulating their couplings and for detecting them.

We will present the realization of topological quantum pumping in a synthetic dimension by engineering a one-dimensional Rice-Mele chain within the Rydberg states of cesium atoms [1]. The Thouless protocols for topological pumping is implemented, and the adiabaticity of transport is investigated.

[1] M. Trautmann, I. Sodemann Villadiego, and J. Deiglmayr, Phys. Rev. A **110**, L040601 (2024)

MON 23.37 Mon 18:30 ZHG Foyer 1. OG

Illumination dependent hot polaron photovoltaics in strongly correlated perovskite manganites — •Annika Dehning, Birte Kressdorf, Jörg Hoffmann, and Christian Jooss — Institute of Materials Physics, University of Göttingen, Germany

Highly correlated materials offer new pathways to stabilize hot-carriers after optical excitation and thus might enable overcoming the Shockley-Queisser (SQ) limit. In metal-oxide perovskites excited polaronic states can be stabilized up to ns-lifetime through the enhanced coupling between phonons and charges in the charge/orbital (CO) ordered state. Understanding the mechanisms behind hot polaron photovoltaics (PV) challenges because of the complex interplay between electronic degrees of freedom and structure. It requires knowledge about the cold quantum ground state and how it is affected by lattices, temperature and excitations. Light induced excitations are studied here in dependence of temperature, photon energy and power in $Pr_{1-x}Ca_xMnO_3$ and Ruddlesden-Popper $Pr_{1-x}Ca_{1+x}MnO_4$ (RP-PCMO). Single-crystalline epitaxial thin films are prepared on Nb:$SrTiO_3$ substrates with ion beam sputtering. XRD, AFM, SEM, EDX and TEM are employed to characterize the films, their ordering and the p-n junction. It is demonstrated that the PV response correlates with the appearance of CO order and it is measured up to 320K in RP-PCMO. The characteristic PV-parameters reveal spectral and power density dependencies that do not follow the SQ-theory. An approach to describe the PV-response based on hot carrier contributions via scaling laws is presented.

MON 23.38 Mon 18:30 ZHG Foyer 1. OG

Testing Nonlinear Quantum Theories with PHIP-Based Nuclear Spin Ensembles — •Xiaoyi Yang, Martin Korzeczek, and Martin B. Plenio — Ulm University, Institute of Theoretical Physics, Albert-Einstein-Allee 11, 89081 Ulm, Germany

We propose and analyze a quantum simulation of nonlinear quantum dynamics inspired by gravitational interaction models and a mathematical framework due to Weinberg, using parahydrogen-induced polarization (PHIP) NMR. The platform leverages hyperpolarized hydrogen and carbon-13 nuclei to realize an effective Hamiltonian incorporating both linear J-coupling and nonlinear mean-field self-interaction. Under specific initial conditions and symmetry constraints, the system reproduces the dynamics predicted by a nonlinear quantum gravity-inspired model. The resulting evolution exhibits Duffing-type behavior and transitions between dynamical topologies, with solutions described by Jacobi elliptic functions. Notably, the presence of controlled nonlinearity reveals an amplified sensitivity to small differences between quantum states, offering a potential mechanism for distinguishing nonorthogonal states within a closed quantum system. Our results highlight PHIP NMR as a viable experimental testbed for probing nonlinear extensions to quantum mechanics, with potential applications in quantum information processing, metrology, and foundational tests of quantum theory.

MON 23.39 Mon 18:30 ZHG Foyer 1. OG

Towards low-energy structured coherent electron and ion beams — •Prosenjit Majumder, Matias Eriksson, and Robert Fickler — Physics Unit, Photonics Laboratory, Tampere University, Tampere, Finland

In recent years, structured matter waves particularly structured electron beams have attracted growing interest due to their potential in advanced microscopy and quantum experiments. Spatially coherent field-emission electron sources are well-established, enabling precise control over electron beam wavefronts and facilitating developments in electron microscopy and spectroscopy. Our research focuses on developing a tunable low-energy source capable of structuring both electron and ion beams. The setup features a cryogenically cooled nanotip field/gas field ion emission source followed by a 2-meter free propagation region. This configuration is designed to generate transversely coherent beams, with coherence lengths of several micrometers for ions suitable for shaping with nanofabricated electrostatic elements.

We aim to investigate the physics of low-energy vortex electrons and ions using electrostatic chopsticks as a minimally invasive shaping tool. Housed in a custom-built vacuum chamber, the setup includes electrostatic lenses, deflectors, and full-length magnetic shielding to suppress ambient magnetic interference. Realizing a spatially coherent ion source would mark a major advance, enabling new studies in composite charged wave systems and pushing the frontiers of ion-based microscopy and quantum technologies.

MON 23.40 Mon 18:30 ZHG Foyer 1. OG

Cavity QED experiments and lasing with cold trapped Yb atoms — •Ke Li[1], Saran Shaju[1], Gabriel Dick[1], Simon B. Jäger[2], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Physik, 66123 Saarbrücken, Germany — [2]Universität Bonn, Physikalisches Institut, 53115 Bonn,Germnay

Cavity quantum electrodynamics with cold atoms enables the controlled interactions between atoms and photons, providing advanced applications in quantum technologies and fundamental science. In our research, 10^4 to 10^6 Ytterbium-174 atoms are magneto-optically trapped, using the $^1S_0$-$^1P_1$ transition at 399 nm, inside a high-finesse cavity that couples to the $^1S_0$-$^3P_1$ intercombination transition. We have observed lasing action in both single- and multi-mode emission [1]. Additionally, the collective strong coupling leads to complex atom-field dynamics and scattering phenomena, including vacuum Rabi splitting accompanied by additional fluorescence at atomic resonance [2]. Future research will be extended to studying the quantum dynamics of atom-cavity interactions on the $^1S_0$-$^3P_0$ clock transition.

[1] H. Gothe et al., Physical Review A 99.1 (2019) 013415.
[2] S. Shaju et al. , arXiv:2404.12173 (2024).

MON 23.41 Mon 18:30 ZHG Foyer 1. OG

Coherent interactions of quantum emitters in a dielectric waveguide — •Grigory Kornilov, Alok Gokhale, Gregor Pieplow, Tim Schröder, Kurt Busch, and Francesco Intravaia — Humboldt-Universität zu Berlin, Berlin, Germany

Robust theoretical modeling of quantum emitters in dielectric media is crucial for predicting their behavior in practical applications. Existing models often simplify the system to a one-dimensional regime, thereby failing to accurately capture the influence of quantum noise and radiative losses on the emitters' intrinsic properties and overall system performance. Especially in nanoscopic devices, such as photonic integrated circuits with embedded solid-state quantum emitters, these effects can significantly impact measurement outcomes.

Utilizing a Green's-tensor approach in combination with the theory of open quantum systems, we present a fully three-dimensional quantum electrodynamics description of a quantum emitter embedded in a dielectric structure. Specifically, we investigate negatively charged nitrogen vacancy centers (NVs) in a cylindrical diamond waveguide. We explore the interaction of a single NV with an incident light field as well as waveguide-mediated coherent interactions between multiple emitters. In particular, the latter analysis may inform future experiments seeking to harness such collective effects. We also show how our explicit treatment of phonon-mediated NV decay affects simulated experiments beyond a simple modification of the NV-waveguide coupling strength.

MON 23.42 Mon 18:30 ZHG Foyer 1. OG

Spin and energy dynamics in the disordered spin-1/2 XX ladder — •Lukas Peinemann, Kadir Çeven, and Fabian Heidrich-Meisner — Institut für Theoretische Physik, Georg-August-Universität Göttingen, Germany

Understanding the relaxation dynamics of closed many-body quantum systems is a central goal in the study of non-equilibrium quantum physics. Within linear response theory, we numerically calculate the spin and energy diffusion coefficients in the disordered two-leg spin-1/2 XX ladder at infinite temperature, employing the concept of quantum typicality. Using exact diagonalization, we determine the disorder-induced finite-size crossover from delocalized to many-body localized regime by analyzing the gap ratio and the von Neumann entanglement entropy. We examine how the hierarchy of spin and energy diffusion constants in the delocalized regime compares to that in other non-integrable spin models, such as the XXZ chain with a staggered magnetic field. Our numerical findings reveal an atypical hierarchy in the XX ladder, where spin diffusion exceeds energy diffusion - in contrast to the behavior observed in the other studied models. This reversed hierarchy persists throughout the entire delocalized regime, with both diffusion constants decreasing systematically as disorder is increased. Moreover, our results suggest that increasing the inter-leg coupling leads to a convergence of the spin and energy diffusion coefficients.

We acknowledge funding from the Deutsche Forschungsgemeinschaft (German Research Foundation) within the research unit FOR5522 (Project No. 499180199)

MON 23.43 Mon 18:30 ZHG Foyer 1. OG

Ultrastrong coupling limit to quantum mean force Gibbs state for anharmonic environment — •Prem Kumar and Sibasish Ghosh — Optics and Quantum Information Group, The Institute of Mathematical Sciences, C.I.T. Campus, Taramani, Chennai 600113, India.

The equilibrium state of a quantum system can deviate from the Gibbs state if the system-environment (SE) coupling is not weak. An analytical expression for this mean force Gibbs state (MFGS) is known in the ultrastrong coupling (USC) regime for the Caldeira-Leggett (CL) model that assumes a harmonic environment. Here, we derive analytical expressions for the MFGS in the USC regime for more general SE models. For all the generalized models considered here, we find the USC state to be diagonal in the basis set by the SE interaction, just like in the CL case. While for the generic model considered, the corresponding USC-MFGS is found to alter from the CL-result, we do identify a class of models more general than the CL model for which the CL-USC result remains unchanged. We also provide numerical verification for our results. These results provide key tools for the study of strong coupling quantum thermodynamics and several quantum chemistry and biology problems under more realistic SE models, going beyond the CL model.

MON 23.44 Mon 18:30 ZHG Foyer 1. OG

Minimal quantum models and non-standard heat transport — Helen Dorausch and •Carsten Henkel — Universität Potsdam,

Institut für Physik und Astronomie

As the building blocks of coupled thermodynamical systems get smaller, quantum physics introduces curious challenges. We study simple examples based on oscillators coupled to heat baths. (1) A single, strongly damped oscillator driven by a laser provides a model for the plasmon resonance of a single particle. We study it with a quantum jump simulation that provides a quite different steady-state picture with strong spikes in the local bath temperature (the electron gas in the particle itself). (2) A two-site oscillator chain connected to baths with different temperatures permits to dis-spell a purported violation of the second law [1, 2]. We analyse carefully the role of the rotating-wave approximation adopted in the coupling (or not). The symplectic (canonical) group Sp(4) is instrumental in getting a global picture.

[1] A. Levy and R. Kosloff, Europhys. Lett. 107 (2014) 20004
[2] C. Henkel, Ann. Phys. (Berlin) 533 (2021) 2100089

MON 23.45 Mon 18:30 ZHG Foyer 1. OG

Accessing Metastable Triplet States of Aromatic Molecular Emitters — •Max Masuhr, Bo Deng, Babak Behjati, Hazem Hajjar, and Daqing Wang — Institute of Applied Physics, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany

Aromatic hydrocarbon molecules embedded in solid-state matrices have been shown to be an excellent platform for quantum optics applications. The triplet states of these molecules offer additional magnetic degrees of freedom, which are potentially interesting for quantum sensing and information. Here, we present our recent work focused on combined optical and microwave characterization of metastable triplet states of several molecule-host combinations.

MON 23.46 Mon 18:30 ZHG Foyer 1. OG

Exploring Electrical Transport in the 2D Quantum Material $FePSe_3$ — •Paul Perl[1], Lars Thole[1], Sonja Locmelis[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Anorganische Chemie, Leibniz Universität Hannover, 30167 Hannover, Germany

Thin-layer systems of the quantum 2D material iron phosphorus triselenide ($FePSe_3$) exhibit promising potential for use in innovative devices [1]. In this study, we investigate the electrical properties of flakes with thicknesses ranging from 14 nm to 28 nm, including activation energy and Schottky barriers with various contact materials, to develop a deeper understanding of the material's behavior. The bulk crystals were synthesized via chemical vapor transport, and the thin flakes were then exfoliated using the scotch tape method. Electrical contacts for the exfoliated flakes were created using electron beam lithography followed by physical vapor deposition. Additionally, we observe a memory effect induced by the application of a backgate voltage, suggesting potential for $FePSe_3$ in memory devices.

[1] Z. Zhao et al., npj 2D Mater. Appl. 9, 30 (2025)

MON 23.47 Mon 18:30 ZHG Foyer 1. OG

Novel Medium- and High-Entropy Telluride Thin Films via Hybrid Pulsed Laser Deposition — •Niklas Kohlrautz, Pia Henning, Helmut Klein, Heidrun Sowa, and Jasnamol Palakkal — Institute of Materials Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Medium- and high-entropy materials (MEMs and HEMs) are known for their great multifunctional properties, ranging from catalytic activity to magnetic order [1]. Moreover, tellurides (e.g., CrTe, FeGeTe, and CrGeTe) have gained large interest for their highly tunable magnetic properties, including room-temperature ferromagnetism and perpendicular magnetic anisotropy [2]. Toward the goal of synthesizing novel HEMs, we designed a hybrid Pulsed Laser Deposition (PLD) technique with Te molecular beam source attached. After primarily establishing the growth of $Cr_{(1+\delta)}Te_2$, we synthesized a novel MEM telluride, FeCrNiTe (FCNT), using a PLD target containing the transition metals and supplying Te via the beam source. Growth parameter optimization yielded high-quality epitaxial thin films. We present a detailed structural and physical characterization of a series of FCNT thin films deposited on $SrTiO_3(100)$ substrates. Orthorhombic crystal structure, highly homogeneous surface, semiconducting behavior, and a low magnetoresistance at low temperatures were identified in these novel MEM tellurides. This work pioneers the synthesis of many novel MEM and HEM tellurides that have potential in future spintronics devices.

[1] N. Oueldna, Materials Horizons 2024, 11(10), 2323-2354.
[2] A. Tschesche et al., R.S., doi.org/10.21203/rs.3.rs-4861088/v1.

MON 23.48 Mon 18:30 ZHG Foyer 1. OG

Deterministic single ion-implantation of Er into thin film lithium niobate — •Maranatha Andalis, Reiner Schneider, and Klaus D. Jöns — Institute for Photonic Quantum Systems (PhoQS), Center for Optoelectronics and Photonics Paderborn (CeOPP) and Department of Physics, Paderborn University, 33098 Paderborn, Germany

Incorporating rare earth ions (REIs) into lithium niobate-on insulators (LNOI) is of great interest in scalable photonic integrated circuits (PIC), enhancing the potential of LNOI with added functionalities enabled by the REIs. Erbium ions can be incorporated into LNOI using ion implantation and implemented at telecom wavelengths. Together with Ionoptika Ltd., we have customized a single ion implantation system called Q-One with up to 40 kV acceleration voltage. For most quantum applications, the site-selective implantation of a single REI is required. Our results show single Er ion implantation into LNOI with 85% efficiency using secondary electron emission detection. The Q-One single ion implanter, with its high-resolution mass-filtered focused ion beam, nanometer-precision stage, and choice of ion source, holds significant potential in deterministic ion implantation, crucial for scalable quantum technologies with REIs.

MON 23.49 Mon 18:30 ZHG Foyer 1. OG

Probing Ultrafast Lattice Dynamics of Quantum Material Surfaces — •Alp Akbiyik[1], Felix Kurtz[1], Hannes Böckmann[1], and Claus Ropers[1,2] — [1]Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Germany

Correlated phenomena among quantum materials have attracted considerable interest in recent decades. However, their potential applications require a better understanding of and ability to manipulate the lattice dynamics coupled to electronic phenomena. Ultrafast LEED probes the surfaces of bulk or two-dimensional materials to observe structural phase transitions and lattice thermalization with a time resolution down to 1 ps [1]. While some bulk CDW systems, such as TaS2 and TiSe2 have been studied extensively in ULEED, our ongoing studies focus more on mono- and few-layer van der Waals (vdW) materials to investigate intriguing phonon dynamics and novel structural changes owing to dimensionality effect.

[1] G. Storeck et al., Structural Dynamics 7, 034304 (2020).

MON 23.50 Mon 18:30 ZHG Foyer 1. OG

Controlling Indistinguishability of cascaded emissions from QDs through an Open Cavity system — •Francesco Salusti[1], Mark Hogg[2], Timon Luca Baltisberger[2], Malwina Anna Marczak[2], Nils Heinisch[1], Rüdiger Schott[3], Sascha René Valentin[3], Andreas Dirk Wieck[3], Arne Ludwig[3], Stefan Schumacher[1], Richard Warburton[2], and Klaus Jöns[1] — [1]PhoQS Institute, CeOPP, and Department of Physics, Paderborn University, Paderborn, Germany — [2]Philosophisch-Naturwissenschaftliche Fakultät, Departement Physik, Basel, Switzerland — [3]Ruhr Universität Bochum, Faculty of Physics and Astronomy, Bochum, Germany

Cavity structures are effective tools for enhancing quantum light emitters. Tunable open cavities can be adapted to emitters like quantum dots, supporting key features for quantum communication such as on-demand emission, low multiphoton probability, and indistinguishable photons. Here we show that a tunable microcavity enhances photon pair generation from the biexciton exciton cascade, overcoming the limits of poor indistinguishability due to non-separability and time-correlation. We control exciton and biexciton emission rates via selective Purcell enhancement of the transitions using our tunable cavity. By imbalancing the lifetime ratio between biexciton and exciton photons (as suggested in E. Schöll et al. Phys.Rev.Lett.125, 233605(2020)), we achieve high Hong-Ou-Mandel visibility values for both photons emitted in the cascade. We show that the HOM visibility follows $V{=}(\tau_X)/(\tau_X{+}\tau_{XX})$, matching with theoretical predictions.

MON 23.51 Mon 18:30 ZHG Foyer 1. OG

Topological Phenomena in Folded Bilayer Graphene Heterostructures — •Hannes Kakuschke, Lina Bockhorn, and Rolf 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 work, folded graphene [1, 2] heterostructures exhibit fascinating phenomena. This is due to the topology of the folded region, causing effects such as snake states and zero line modes. However, in transport measurements of self-assembled, folded graphene [3, 4, 5], multiple effects occur simultaneously, complicating the analysis of individual contributions. To solve this problem, we use the dry transfer method to fold graphene around hBN, decoupling the overlapping graphene regions. In such heterostructures we observe topologically protected transport behaviour in the folded region.

[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).

MON 23.52 Mon 18:30 ZHG Foyer 1. OG

Giant Stark-shift of a defect emitter in a strained WSe_2 monolayer — Felix Schaumburg[1], Fabian Stechemesser[1], Hendrik Mannel[1], Jeniffer König[2], Cornelius Dietrich[2], Corinne Steiner[3], Patricia Pesch[3], Axel Lorke[1], •Günther Prinz[1], Martin Geller[1], and Annika Kurzmann[2] — [1]Universität Duisburg-Essen, Duisburg, Deutschland — [2]Universität zu Köln, Köln, Deutschland — [3]RWTH Aachen, Aachen, Deutschland

The search for quantum emitters for quantum technologies is one of today's fastest-growing fields in research worldwide. Here, we investigate the electrical-field dependent optical emission of a two-dimensional (2D) heterostructure, based on tungsten diselenide (WSe_2). Hexagonal boron nitride layers provide electrical isolation, and few-layer graphene acts as a backgate electrode. The heterostructure was placed on a silicon substrate with SiO_2 nanopillars to create local strain. In the WSe_2 layer, defects have been introduced by 100 kV electron irradiation. μ-Photoluminescence (PL) measurements of single emitters show narrow emission lines and single photon emission.

By applying voltages to the graphene and the metallic top gate, an electric field can be introduced across the WSe_2. We will present μ-PL spectra of emitters depending on the gate voltage and observe a giant shift in wavelength up to 6 nm, when the gate voltage is changed by 1.5V. Additionally, the intensity of the emitters is strongly dependent on the absolute value of the gate voltage. The combination of defect engineering, strain-induced localization, and electric field control offers a promising route toward scalable quantum emitter platforms.

MON 23.53 Mon 18:30 ZHG Foyer 1. OG

Epitaxial Growth of Van der Waals Magnets $Cr_{1+\delta}Te_2$ — •Pia Henning, Anna Tschesche, Laura Pflügl, Tobias Meyer, and Jasnamol Palakkal — Institute of Material Physics, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077, Göttingen

Tunable magnetic materials in 3D and as well as in lower dimensions, exhibiting ferromagnetism and perpendicular magnetic anisotropy (PMA) are highly desired for application in future spintronic devices. In the course of that, thin films of transition metal dichalcogenides $Cr_{1+\delta}Te_2$ gained an increased interest, due to their highly tunable magnetic anisotropy and ferromagnetism with T_C ranging from 150 K to 350 K [1]. The stoichiometry, i.e. the intercalation of Cr species (δ) in between $CrTe_2$ layers, is the reason for the highly variable magnetic properties [1]. This makes the need for a sensitive control of δ in combination with a high-quality thin film growth critical. A hybrid deposition was used for growing $Cr_{1+\delta}Te_2$ thin films with various δ, combining Pulsed Laser Deposition (PLD) and Molecular Beam Epitaxy (MBE). Structural, magnetic and transport properties of the samples were evaluated, whereby Room-temperature ferromagnetism, PMA, anisotropic magnetoresistance and anomalous Hall effect are observed, showing a high tunability of properties relative to δ. This work emphasizes the potential of this hybrid deposition technique for growing transition metal dichalcogenide thin films paving the way for possible device applications.

[1] A. Tschesche, P. Henning, et al., Preprint on Research Square, https://doi.org/10.21203/rs.3.rs-4861088/v1

MON 23.54 Mon 18:30 ZHG Foyer 1. OG

Quantum Dynamics of Spin Polarization Transfer in NV-diamond Systems Probed by In-Situ ^{13}C NMR — •Tilen Knaflič, Mario Grüneberg, Enrique Sánchez-Ibáñez, Claudius Mullen, and Jaka Pribošek — Silicon Austria Labs, Villach, Austria

Dynamic nuclear polarization (DNP) is a powerful technique that significantly boosts nuclear spin polarization in solids, amplifying the sensitivity of nuclear magnetic resonance (NMR), which can serve as a foundation for new-generation quantum sensors. Several DNP mechanisms - such as the Overhauser effect, the solid effect and the cross effect - rely on quantum interactions between electron and nuclear spins, mediated by microwave-driven transitions and spin diffusion. These processes exploit the large thermal polarization of electron spins and efficient polarization transfer to nuclear spins, enabling quantum control over spin ensembles and enhancing signal detection in high-resolution spectroscopy and imaging.

In this work, we explore DNP in negatively charged nitrogen-vacancy (NV^-) centers in diamond, a quantum system with optically addressable spin states and long coherence times. We study the field dependence of the DNP process by performing hyperpolarization and in-situ inductive NMR detection of ^{13}C nuclei at different magnetic fields in the range between 10 mT and 1 T. Our results provide insights into the quantum dynamics of spin polarization transfer in NV-diamond systems and demonstrate the potential of DNP for enhancing NMR sensitivity across a range of magnetic field strengths.

MON 23.55 Mon 18:30 ZHG Foyer 1. OG

Geometrically Constrained Quantum Dynamics: A Numerical Study on a Comb — •Ognen Kapetanoski and Irina Petreska — Ss. Cyril and Methodius University in Skopje, Faculty of Natural Sciences and Mathematics, Institute of Physics, Skopje, Macedonia

We investigate the quantum dynamics of a particle constrained by a two-dimensional comb-like geometry using the time-dependent Schrödinger equation. This structure consists of a backbone and branching fingers, which models transport phenomena in heterogeneous and anisotropic media. Geometric constraints are implemented by implementing a Dirac delta function into the kinetic energy operator, approximated by a Gaussian. Spatial discretization is done using a finite-difference scheme and time evolution is computed with a fourth-order Runge-Kutta method. We compare Gaussian and comb-like wave functions to study how initial conditions affect the evolution of the probability density. The comb-like initial state shows strong localization near the backbone in early stages of time evolution. At later times, this localization disappears and the resulting probability distribution becomes similar to that of the Gaussian case. Numerical results are compared with analytical solutions, showing excellent agreement for short to intermediate time intervals. This method allows quantum transport modeling in finite domains and complex initial conditions where analytical solutions do not exist.

[1] O. Kapetanoski and I. Petreska, *Phys. Scr.* **100**, 025254 (2025).

MON 23.56 Mon 18:30 ZHG Foyer 1. OG

Geometrically Constrained Quantum Dynamics: A Numerical Study on a Comb — •Ognen Kapetanoski and Irina Petreska — Ss. Cyril and Methodius University in Skopje, Faculty of Natural Sciences and Mathematics, Institute of Physics, Skopje, Macedonia

We investigate the quantum dynamics of a particle constrained by a two-dimensional comb-like geometry using the time-dependent Schrödinger equation. This structure consists of a backbone and branching fingers, which models transport phenomena in heterogeneous and anisotropic media. Geometric constraints are implemented by implementing a Dirac delta function into the kinetic energy operator, approximated by a Gaussian. Spatial discretization is done using a finite-difference scheme and time evolution is computed with a fourth-order Runge-Kutta method. We compare Gaussian and comb-like wave functions to study how initial conditions affect the evolution of the probability density. The comb-like initial state shows strong localization near the backbone in early stages of time evolution. At later times, this localization disappears and the resulting probability distribution becomes similar to that of the Gaussian case. Numerical results are compared with analytical solutions, showing excellent agreement for short to intermediate time intervals. This method allows quantum transport modeling in finite domains and complex initial conditions where analytical solutions do not exist.

[1] O. Kapetanoski and I. Petreska, *Phys. Scr.* **100**, 025254 (2025).

MON 23.57 Mon 18:30 ZHG Foyer 1. OG

Towards a Quantitative Framework for Capacitance-Voltage Spectroscopy in Quantum Dot Ensembles — •Phil Julien Badura[1], Nico Frédéric Brosda[1], Ismail Bölükbaşi[1], Ibrahim Engin[1], Patrick Lindner[1], Sascha René Valentin[1], Andreas Dirk Wieck[1], Björn Sothmann[2], and Arne Ludwig[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität

Bochum, D-44780 Bochum, Germany — [2]Fakultät für Physik and CENIDE, Universität Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany

This study investigates an inhomogeneous ensemble of quantum dots coupled to a charge reservoir using capacitance-voltage spectroscopy. Experimental measurements reveal shifts in capacitance peak positions influenced by AC frequency and temperature, with frequency-dependent shifts remaining unexplained by existing models. To address this, we develop a master equation-based theoretical model incorporating energy-dependent tunneling effects, which successfully reproduces the experimental data. Our findings emphasize the role of energy-dependent tunneling in distinct regimes: at low temperatures, energy level dispersion dominates, while at high temperatures and frequencies, shifts arise from optimized sequences of in- and out-tunneling events.

MON 23.58 Mon 18:30 ZHG Foyer 1. OG

Magnetotransport measurements of magic angle twisted bilayer graphene — •Monica Kolek Martinez de Azagra and Thomas Weitz — 1. Institute of Physics, Georg-August University of 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] R.Bistritzer, A. H. MacDonald, PNAS 108, 12233(2011).
[2] Y. Cao et al., Nature 556, 80 (2018).
[3] Y. Cao et al., Nature 556, 43 (2018).

MON 23.59 Mon 18:30 ZHG Foyer 1. OG

Autonomous conversion of particle exchange to quantum self-oscillations — •Sofia Sevitz[1], Federico Cerisola[2], Karen Hovhannisyan[1], and Janet Anders[1,2] — [1]University of Potsdam, Germany — [2]University of Exeter, UK

Particle-exchange autonomous machines continuously convert electronic transport into heat transfer between fermionic reservoirs. In typical set-ups, to collect the generated electrical power, an external resistive load is connected that inevitably yields some dissipation. To overcome these losses, we couple a mechanical resonator as an internal degree of freedom to the particle exchange machine hosted in a quantum dot. This way, part of the exchanged energy can be converted into self-oscillations. Here we explore the slow transport regime making use of a recently developed quantum model. Our analysis goes well beyond all previous work, which was limited to semiclassical treatment of the fast transport regime. First, we show that quantum self-oscillations are present in this slow regime and can be measured via the electrical particle current acting as a witness. Next, we study the thermodynamics of the setup and find that, under realistic conditions, self-oscillations occur only when the machine operates as a heater. Lastly, we establish an experimentally measurable performance metric which reveals that, counterintuitively, strong coupling between dot and resonator is detrimental to the conversion quality. The framework developed in this work can be readily implemented in a variety of nanoscale devices such as a suspended carbon nanotube with an embedded quantum dot.

MON 23.60 Mon 18:30 ZHG Foyer 1. OG

Electronic Phase Diagram of Rhombohedral-Stacked Thin Graphene Layers — •Sirri Batuhan Kalkan, Caroline Scheper, David Urbaniak, Monica Kolek Martinez de Azagra, Isabell Weimer, and Thomas Weitz — I. Institute of Physics, Georg-August University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Twisted bilayer graphene has emerged as a powerful system for studying flat band induced exotic quantum phase transitions, offering valuable insights into quantum phenomena [1]. However, the fixed angle between layers in this system limits the tunability of electronic correlations, prompting researchers to explore alternative approaches. Naturally occurring few-layer graphene systems provide a promising solution, as stacking failures in these systems can result in rhombohedral stacking. This configuration enables continuous control of interactions through external electric fields, offering a versatile platform for studying quantum phase transitions [2-3]. By identifying rhombohedral domains, fabricating devices, and conducting electrical characterization, in this work we discuss its electronic phase diagram that encompasses both superconducting and magnetic phase transitions.

[1] Yuan Cao et al. , Nature 556.7699 (2018): 43
[2] Haoxin Zhou et al., Nature 598.7881 (2021): 434
[3] Tonghang Han et al. , arXiv preprint arXiv:2408.15233 (2024).

MON 23.61 Mon 18:30 ZHG Foyer 1. OG

Towards magnetotransport measurements in rhombohedral multi-layer graphene — •David Paul Urbaniak, Christian Eckel, Sirri Batuhan Kalkan, and Thomas Weitz — 1st Institute of Physics, Faculty of Physics, Georg-August University Göttingen, Germany

The flat bandstructure of rhombohedral multilayer graphene enables the investigation of a variety of correlation-driven effects, including the fractional quantum Hall effect and its anomalous counterpart, recently observed in rhombohedral pentalayer graphene [1]. Recent observations have additionally revealed signatures of chiral superconductivity in rhombohedral tetra- and pentalayer graphene, along with the unprecedented discovery of a superconductor phase within an anomalous Hall phase in rhombohedral hexalayer graphene [2, 3]. This work presents the necessary steps for the fabrication of an in hexagonal boron nitride (hBN) encapsulated, dual gated device for the investigation of the aforementioned effects during magnetotransport measurements in the milli Kelvin regime. The fabrication techniques employed consist of Raman spectroscopy, scattering near field optical microscopy (SNOM), a nanolithography technique based on an atomic force microscope (AFM), and a dry transfer technique. Conclusively, preliminary measurements are presented.

[1] Zh. Lu et al., Nature 626, 759 (2024).
[2] T. Han et al., arXiv:2408.15233 (2024).
[3] E. Morissette et al., arXiv:2504.05129 (2025).

MON 23.62 Mon 18:30 ZHG Foyer 1. OG

Vacancies and Stone-Wales Defects in Twisted Bilayer Graphene: A Comparative Theoretical Study — •Fabian Dietrich and Eduardo Cisternas — Departamento de Ciencias Físicas, Universidad de La Frontera, Temuco, Chile

Twisted bilayer graphene (TBG) has emerged as a cornerstone in the exploration of strongly correlated electronic systems, exhibiting tunable quantum phenomena such as superconductivity and Mott insulating states. In this study, we present a comparative theoretical investigation of two key classes of structural defects - monovacancies and Stone-Wales (SW) defects - introduced into a TBG system with different twist angles.

Using density functional theory (DFT), we analyze the energetic stability, local geometric reconstruction, and electronic structure of these defects. Our results show that both types of defects significantly alter the local density of states (LDOS), introducing mid-gap states and modifying the flat bands characteristic of TBG. Notably, the influence of the defect type is highly sensitive to its registry within the Moiré supercell, with SW defects inducing less mid-gap perturbation than vacancies but more extensive topological rearrangements.

Our findings offer new insights into defect engineering in twisted van der Waals systems and have implications for designing quantum devices based on TBG with tailored electronic properties.

[1] F. Dietrich, U. Guevara, A. Tiutiunnyk, D. Laroze, E. Cisternas, Flatchem. 41 (2023) 100541.

MON 23.63 Mon 18:30 ZHG Foyer 1. OG

Parent State Modeling of Correlated and Topological Quantum Phases in Rhombohedral Multilayer Graphene — •Robert Schneider[1], David Urbaniak[1], Chiho Yoon[2], Sirri Batuhan Kalkan[1], Fan Zhang[2], and Thomas Weitz[1] — [1]1st Physical Institute, Faculty of Physics, University of Göttingen, Göttingen, Germany — [2]Department of Physics, University of Texas at Dallas, Richardson, TX, USA

Recently, a number of novel correlated and topological quantum phases in N-layer ABC-stacked graphene systems have been identified. Among them are anomalous Hall crystals with a non-trivial Chern number at vanishing magnetic field (Nature 608, 298-302), as well as chiral p-wave superconducting states that persist to unconventionally high magnetic fields (arXiv: 2408.15233). Even though they are fundamentally many-body quantum phenomena, the theoretical determination of the single-particle bands hosting these quantum phases is important in understanding the interplay between quantum geometry and many-body interactions. Examples of relevant effects are the formation of flat bands, the generation of a tunable band gap, and the possibility of a topological Lifshitz transition due to trigonal warping. This work shows how the parent states of these correlated and topological quantum phases can be accurately modeled using various computational methods including tight-binding models and density functional theory (arXiv: 2502.17555v1). Finally, an outlook into the interpretation of the obtained results for different rhombohedral multilayer graphene systems is presented.