Magnetism Division
Fachverband Magnetismus (MA)

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Overview of Invited Talks and Sessions

(Lecture halls H33, H37, H38, H39, H48, H52, and H53; Poster C and E)

Invited Talks

MA 3.1	Mon	9:30–10:00	H38	**Three-dimensional solitons in magnetism, nuclei and particle physics** — •Paul Sutcliffe
MA 3.2	Mon	10:00–10:30	H38	**Simulations of particlelike states in three-dimensional magnets: chiral skyrmions, bobbers and hopfions** — •Filipp N. Rybakov
MA 3.4	Mon	10:45–11:15	H38	**Quantitative measurements of three dimensional magnetic textures using off-axis electron holography** — •András Kovács, Nikolai Kiselev, Jan Caron, Thibaud Denneulin, Fengshan Zheng, Dongsheng Song, Stefan Blügel, Rafal E Dunin-Borkowski
MA 3.5	Mon	11:30–12:00	H38	**Three-dimensional nanomagnetism: Present and future** — •Amalio Fernandez-Pacheco
MA 3.7	Mon	12:15–12:45	H38	**Revealing magnetic configurations with X-ray magnetic nanotomography** — •Valerio Scagnoli
MA 7.1	Mon	15:00–15:30	H37	**The Surface Spin Flop in Synthetic Antiferromagnets with Perpendicular Magnetic Anisotropy** — •Benny Böhm, Nikolai Kiselev, Darius Pohl, Lorenzo Fallarino, Leopold Koch, Bernd Rellinghaus, Kornelius Nielsch, Olav Hellwig
MA 11.1	Mon	15:45–16:15	H38	**Microstructure optimization for rare-earth efficient permanent magnets** — •Thomas Schrefl, Johann Fischbacher, Alexander Kovacs, Lukas Exl, Kazuya Yokota, Tetsuya Shoji
MA 11.2	Mon	16:15–16:45	H38	**Advanced methods for the development of high performance hard and soft magnetic materials** — •Dagmar Goll, Gerhard Schneider
MA 11.4	Mon	17:15–17:45	H38	**Compositionally graded films as model systems to study magnetic materials for energy applications** — •Nora Dempsey
MA 11.5	Mon	17:45–18:15	H38	**Dissecting the magneto-structural transformation in materials with first-order field-induced transitions** — •Konstantin Skokov
MA 20.1	Tue	14:00–14:30	H37	**Magnetoelectric Inversion of Domain Patterns** — •Naëmi Leo, Vera Carolus, Jonathan White, Michel Kenzelmann, Matthias Hudl, Pierre Toledano, Takashi Honda, Tsuyoshi Kimura, Sergey Ivanov, Matthias Weil, Thomas Lottermoser, Dennis Meier, Manfred Fiebig
MA 27.1	Wed	9:35–10:15	H38	**Magnetism in biomedicine: basics and applications** — •Kannan Krishnan
MA 27.2	Wed	10:15–10:45	H38	**Spin-dynamics of a magnetic nanoparticle chain.** — •Michael Winklhofer
MA 27.3	Wed	11:15–11:35	H38	**Magnetic materials for biodetection** — •Galina V. Kurlyandskaya, Alexander P. Safronov
MA 27.4	Wed	11:35–11:55	H38	**From synthetic to biological magnetic microswimmers** — •Damien Faivre
MA 34.1	Wed	15:00–15:30	H37	**Reservoir Computing with Random Skyrmion Fabrics** — •Daniele Pinna, George Bourianoff, Karin Everschor-Sitte
MA 37.1	Wed	15:45–16:15	H38	**Magnon Transport and Magnonic Topological Insulators** — •Daniel Loss
MA 37.2	Wed	16:15–16:45	H38	**Implementation of the Stimulated-Raman-Adiabatic-Passage mechanism in magnonics** — •Burkard Hillebrands

MA 37.4	Wed	17:15–17:45	H38	**Spintronics at interfaces of insulators and non-magnetic metals - magnon Bose-Einstein condensation and induced superconductivity** — •Niklas Rohling, Eirik Løhaugen Fjaerbu, Arne Brataas
MA 37.5	Wed	17:45–18:15	H38	**Magnon Transport and Dynamics in Magnetic Insulator** — •Jing Liu
MA 37.7	Wed	18:30–19:00	H38	**Tunable long distance spin transport in antiferromagnetic insulators** — •Mathias Kläui
MA 42.1	Thu	9:30–10:00	H38	**Magnetic nanomembranes: From flexible magnetoelectronics to remotely controlled microrobotics** — •Oliver G. Schmidt
MA 42.2	Thu	10:00–10:30	H38	**Curvature-induced chiral effects in nanomagnets** — •Oleksandr Pylypovskyi
MA 42.3	Thu	10:30–11:00	H38	**Chiral magnetoresistance in curved and noncurved geometries** — •Pietro Gambardella
MA 42.4	Thu	11:00–11:30	H38	**Domain Wall Dynamics in Curved Geometries** — •Robert M. Reeve, Mohamad-Assaad Mawass, Kornel Richter, Andre Bisig, Benjamin Krüger, Markus Weigand, Hermann Stoll, Andrea Krone, Florian Kronast, Gisela Schütz, Mathias Kläui

Invited talks of the joint Symposium SKM Dissertation-Prize 2019

See SYSD for the full program of the symposium.

SYSD 1.1	Mon	9:30– 9:50	H2	**Synchronization and Waves in Confined Complex Active Media** — •Jan Frederik Totz
SYSD 1.2	Mon	9:50–10:10	H2	**Spin scattering of topologically protected electrons at defects** — •Philipp Rüßmann
SYSD 1.3	Mon	10:10–10:30	H2	**Beyond the molecular movie: Revealing the microscopic processes behind photo-induced phase transitions** — •Chris W. Nicholson
SYSD 1.4	Mon	10:30–10:50	H2	**Thermodynamic bounds on current fluctuations** — •Patrick Pietzonka
SYSD 1.5	Mon	10:50–11:10	H2	**Lightwave-driven quasiparticle acceleration** — •Fabian Langer
SYSD 1.6	Mon	11:10–11:30	H2	**Ultrafast plasmon-driven point-projection electron microscopy** — •Jan Vogelsang
SYSD 1.7	Mon	11:30–11:50	H2	**Helimagnets, sand patterns and fingerprints linked by topology** — •Peggy Schönherr

Invited talks of the joint Symposium Geometry, Topology, and Condensed Matter

See SYGT for the full program of the symposium.

SYGT 1.1	Tue	9:30–10:00	H1	**Thermal Properties of Vortices on Curved Surfaces** — •José Lorenzana
SYGT 1.2	Tue	10:00–10:30	H1	**Curvature–induced effects in manomagnets** — •Denis Sheka
SYGT 1.3	Tue	10:30–11:00	H1	**Magnetization configurations and reversal of individual ferromagnetic nanotubes** — •Martino Poggio
SYGT 1.4	Tue	11:15–11:45	H1	**An experimental perspective on topology and nanoelectronics in graphene and related 2D materials.** — •Ivan J. Vera-Marun
SYGT 1.5	Tue	11:45–12:15	H1	**Roles of the curvature in two-dimensional nematic films** — •Gaetano Napoli

Invited talks of the joint Symposium Hydrodynamic Electronics: Transport in ultra-pure Quantum Systems

See SYHE for the full program of the symposium.

SYHE 1.1	Wed	9:30–10:00	H1	**Hydrodynamic theory of dissipative magnetophonons** — •Sean Hartnoll
SYHE 1.2	Wed	10:00–10:30	H1	**Unconventional transport in mesostructures of ultra-pure delafossite metals** — •Andrew Mackenzie
SYHE 1.3	Wed	10:30–11:00	H1	**Topological Materials with liquid electrons** — •Claudia Felser
SYHE 1.4	Wed	11:15–11:45	H1	**Hydrodynamic approach to electronic transport** — •Boris Narozhny
SYHE 1.5	Wed	11:45–12:15	H1	**Electron hydrodynamics in graphene: introduction and status** — •Denis Bandurin

Invited talks of the joint Symposium Interaction Effects and Correlations in twodimensional Systems - New Challenges for Theory

See SYTS for the full program of the symposium.

SYTS 1.1	Wed	15:00–15:30	H1	**Spectra of layered semiconductors from many-body perturbation theory** — •Michael Rohlfing
SYTS 1.2	Wed	15:30–16:00	H1	**Dark exciton dynamics in 2D materials** — •Ermin Malic
SYTS 1.3	Wed	16:00–16:30	H1	**Excitons versus electron-hole plasma in monolayer transition metal dichalcogenide semiconductors** — •Alexander Steinhoff
SYTS 1.4	Wed	16:45–17:15	H1	**Theory of near K-point optical properties of TMDC multilayers** — •Tineke Stroucken
SYTS 1.5	Wed	17:15–17:45	H1	**High-throughput modeling and discovery of novel 2D materials** — •Kristian Thygesen

Invited talks of the joint Symposium Czech Republic as Guest of Honor

See SYCZ for the full program of the symposium.

SYCZ 1.1	Thu	9:30–10:00	H4	**Crystal symmetries and transport phenomena in antiferromagnets** — •Tomas Jungwirth
SYCZ 1.2	Thu	10:00–10:30	H4	**Terahertz subcycle charge and spin control** — •Rupert Huber
SYCZ 1.3	Thu	10:30–11:00	H4	**1D molecular system on surfaces** — •Pavel Jelinek
SYCZ 1.4	Thu	11:15–11:45	H4	**Tunneling microscopy on insulators provides access to out-of-equilibrium charge states** — •Jascha Repp
SYCZ 1.5	Thu	11:45–12:15	H4	**Occam's razor and complex networks from brain to climate** — •Jaroslav Hlinka
SYCZ 1.6	Thu	12:15–12:45	H4	**Long range temporal correlations in complex systems** — •Holger Kantz

Invited talks of the joint Symposium Interactions and Spin in 2D Heterostructures

See SYIS for the full program of the symposium.

SYIS 1.1	Thu	15:00–15:30	H1	**Magic Angle Graphene: a New Platform for Strongly Correlated Physics** — •Pablo Jarillo-Herrero
SYIS 1.2	Thu	15:30–16:00	H1	**Bilayer Graphene Quantum Devices** — •Klaus Ensslin
SYIS 1.3	Thu	16:00–16:30	H1	**Light-Matter interaction in van der Waals heterostructures** — •Tobias Korn
SYIS 1.4	Thu	16:45–17:15	H1	**Spin transport in Van der Waals materials and heterostructures** — •Bart Van Wees
SYIS 1.5	Thu	17:15–17:45	H1	**Flipping the valley in graphene quantum dots** — •Markus Morgenstern

Invited talks of the joint Symposium Identifying Optimal Physical Implementations for beyond von Neumann Computing Concepts

See SYCC for the full program of the symposium.

SYCC 1.1	Fri	9:30–10:00	H1	**On the Link Between Energy and Information for the Design of Neuromorphic Systems** — •Narayan Srinivasa
SYCC 1.2	Fri	10:00–10:30	H1	**Encoding neural and synaptic functionalities in electron spin: A pathway to efficient neuromorphic computing** — •Kaushik Roy
SYCC 1.3	Fri	10:30–11:00	H1	**Neuromorphic computing with spintronic nano-oscillators** — •Philippe Talatchian
SYCC 1.4	Fri	11:15–11:45	H1	**Artifcial Intelligence and beyond von Neumann architectures, a mutual opportunity** — •Mirko Prezioso
SYCC 1.5	Fri	11:45–12:15	H1	**Brain-inspired approaches in ultrafast magnetism** — •Johan H. Mentink

Sessions

MA 1.1–1.13	Mon	9:30–13:00	Theater	**Topological Insulators (joint session TT/MA)**

MA 2.1–2.14	Mon	9:30–13:15	H37	**Ultrafast magnetization effects and magnetization dynamics**
MA 3.1–3.9	Mon	9:30–13:15	H38	**Focus Session: Novel 3D magnetic spin textures**
MA 4.1–4.14	Mon	9:30–13:15	H52	**Topological insulators and spin-dependent transport phenomena**
MA 5.1–5.14	Mon	9:30–13:15	H53	**Surface magnetism and magnetic coupling phenomena (joint session MA/O/TT)**
MA 6.1–6.14	Mon	15:00–18:45	Theater	**Frustrated Magnets - Spin Liquids (joint session TT/MA)**
MA 7.1–7.15	Mon	15:00–19:15	H37	**Magnetic Textures: Statics and Imaging I**
MA 8.1–8.14	Mon	15:00–18:45	H52	**Magnonics**
MA 9.1–9.8	Mon	15:00–17:00	H53	**Cooperative phenomena: Spin structures and magnetic phase transitions**
MA 10.1–10.13	Mon	15:00–18:30	Poster D	**Poster Session: Topological Topics (joint session TT/MA)**
MA 11.1–11.7	Mon	15:45–18:45	H38	**Focus Session: Magnetic materials for energy efficient applications**
MA 12.1–12.5	Mon	17:15–18:30	H53	**Spincaloric transport**
MA 13.1–13.13	Tue	9:30–13:00	Theater	**Frustrated Magnets - General 1 (joint session TT/MA)**
MA 14.1–14.4	Tue	9:30–11:30	H48	**INNOMAG e.V. Dissertationspreis 2019 / Ph.D. Thesis Prize**
MA 15.1–15.86	Tue	10:00–13:00	Poster E	**Magnetism Poster A**
MA 16.1–16.10	Tue	10:30–13:00	H37	**Surface Magnetism (joint session O/MA)**
MA 17.1–17.3	Tue	11:30–12:30	H48	**INNOMAG e.V. Diplom-/Master Prize 2019**
MA 18.1–18.8	Tue	14:00–16:00	Theater	**Frustrated Magnets - General 2 (joint session TT/MA)**
MA 19.1–19.8	Tue	14:00–16:00	H23	**Spintronics (joint session TT/MA/DY)**
MA 20.1–20.6	Tue	14:00–15:45	H37	**Multiferroics and Magnetoelectric coupling I (joint session MA/KFM)**
MA 21.1–21.6	Tue	14:00–15:30	H38	**Magnetic textures: Transport and dynamics I**
MA 22.1–22.7	Tue	14:00–15:45	H52	**Terahertz spintronics**
MA 23.1–23.7	Tue	14:00–15:45	H53	**Soft and hard permanent bulk magnets**
MA 24.1–24.6	Tue	14:15–15:45	H46	**Miscellaneous: Biomaterials, Magnetic Shape Memory Alloys, Sensors and Actuators (joint session MM/MA)**
MA 25.1–25.11	Wed	9:30–12:30	H22	**Topological Semimetals - Theory (joint session TT/MA)**
MA 26.1–26.13	Wed	9:30–13:00	H37	**Spin dynamics and transport**
MA 27.1–27.4	Wed	9:30–12:40	H38	**PhD Focus Session: Biogenic spin phenomena (joint session MA/AKjDPG)**
MA 28.1–28.8	Wed	9:30–11:30	H52	**Bio- and molecular magnetism including biomedical applications**
MA 29.1–29.4	Wed	9:30–10:30	H53	**Quantum information systems**
MA 30.1–30.4	Wed	10:45–11:45	H53	**Magnetic instrumentation and characterization**
MA 31.1–31.4	Wed	11:45–12:45	H52	**Spin dynamics: Magnetic relaxation and Gilbert damping**
MA 32.1–32.4	Wed	12:00–13:00	H53	**Magnetic recording, sensors and other devices**
MA 33.1–33.7	Wed	15:00–18:15	H2	**Focus Session: Topology in 3D Reciprocal Space: Beyond Dirac and Weyl Quasiparticles (joint session TT/MA)**
MA 34.1–34.14	Wed	15:00–19:00	H37	**Magnetic textures: Transport and dynamics II**
MA 35.1–35.8	Wed	15:00–17:00	H52	**Caloric effects in ferromagnetic materials**
MA 36.1–36.12	Wed	15:00–18:15	H53	**Spin transport**
MA 37.1–37.8	Wed	15:45–19:15	H38	**Focus Session: Insulator Spintronics**
MA 38.1–38.7	Wed	17:15–19:00	H52	**Spin hall effects**
MA 39.1–39.1	Thu	9:30–10:15	H15	**Overview Talk: Christopher Lutz (joint session O/MA)**
MA 40.1–40.13	Thu	9:30–13:00	Theater	**Frustrated Magnets - Strong Spin-Orbit Coupling (joint session TT/MA)**
MA 41.1–41.14	Thu	9:30–13:15	H37	**Magnetic Textures: Statics and Imaging II**
MA 42.1–42.7	Thu	9:30–12:30	H38	**Focus Session: Curvilinear magnetism**
MA 43.1–43.7	Thu	9:30–11:15	H52	**Micro- and nanostructured magnetic materials**
MA 44.1–44.6	Thu	9:30–11:00	H53	**Magnetic imaging (Experimental techniques)**
MA 45.1–45.9	Thu	10:30–13:00	H15	**Focus Session: Spins on Surfaces I (joint session O/MA)**
MA 46.1–46.7	Thu	11:30–13:15	H52	**Magnetic particles and clusters**
MA 47.1–47.6	Thu	11:30–13:00	H53	**Magnetic anisotropy in thin films**
MA 48.1–48.10	Thu	15:00–17:45	H2	**Topological Semimetals - Experiment (joint session TT/MA)**
MA 49.1–49.11	Thu	15:00–18:00	H15	**Focus Session: Spins on Surfaces II (joint session O/MA)**
MA 50.1–50.9	Thu	15:00–17:45	H24	**Topology and Symmetry-Protected Materials (joint session O/MA/TT)**
MA 51.1–51.70	Thu	15:00–18:00	Poster C	**Magnetism Poster B**

MA 52	Thu	18:00–19:00	H48	**Annual General Meeting of the MA division**
MA 53.1–53.12	Fri	9:30–12:45	H33	**Magnetic Heuslers, half-metals and oxides**
MA 54.1–54.11	Fri	9:30–12:30	H37	**Magnetic textures: Transport and dynamics III**
MA 55.1–55.14	Fri	9:30–13:15	H38	**Electron theory and micromagnetism**
MA 56.1–56.9	Fri	9:30–11:45	H39	**Multiferroics and Magnetoelectric coupling II (joint session MA/KFM)**
MA 57.1–57.9	Fri	10:30–13:00	H24	**Focus Session: Spins on Surfaces III (joint session O/MA)**

Annual General Meeting of the Magnetism Division

Thursday 18:00–19:00 H48

MA 1: Topological Insulators (joint session TT/MA)

Time: Monday 9:30–13:00 Location: Theater

MA 1.1 Mon 9:30 Theater

Coexistence of trivial and topological edge states in two-dimensional topological insulators — T. L. van den Berg[1,2], M. R. Calvo[3,4], and •D. Bercioux[1,4] — [1]Donostia International Physics Center, Paseo Manuel de Lardizbal 4, E-20018 San Sebastián, Spain — [2]Centro de Física de Materiales (CFM-MPC) Centro Mixto CSIC-UPV/EHU,E-20018 Donostia-San Sebastián, Spain — [3]CIC nanoGUNE, 20018 Donostia – San Sebastián, Spain — [4]IKERBASQUE, Basque Foundation of Science, 48011 Bilbao, Spain

In this work, we show how the coexistence of trivial and topological edge states for the case of two-dimensional topological insulators (2DTIs) can occur in two different scenarios. In one case, we consider a space modulation of the gap parameter from topological to trivial. This scenario results in the so-called Volkov-Pankratov states (VPSs) [1]. In a second case, we consider the modulation of the chemical potential in an inverted gap 2DTI, similar to the traditional band pinning of semiconductors [2]. Also within this method, we obtain trivial edge states similar to the VPSs. In both cases, the trivial states lead to an enhancement of the edge conductance over the nominal maximum values of $2e^2/h$ expected in the presence of topological edge states. We propose several experiments that could demonstrate the presence of such trivial states in 2DTIs.

[1] B.A. Volkov & O.A. Pankratov, JETP Lett. **42**, 178 (1985).
[2] R. T. Tung, Appl. Phys. Rev. **1**, 011304 (2014).

MA 1.2 Mon 9:45 Theater

An anomalous higher-order topological insulator — •Selma Franca — Institute for Theoretical Solid State Physics, IFW Dresden, 01171 Dresden, Germany

Topological multipole insulators are a class of higher order topological insulators (HOTI) in which robust fractional corner charges appear due to a quantized electric multipole moment of the bulk. This bulk-corner correspondence has been expressed in terms of a topological invariant computed using the eigenstates of the Wilson loop operator, a so called "nested Wilson loop" procedure. We show that, similar to the unitary Floquet operator describing periodically driven systems, the unitary Wilson loop operator can realize "anomalous" phases, that are topologically non-trivial despite having a trivial topological invariant. We introduce a concrete example of an anomalous HOTI, which has a quantized bulk quadrupole moment and fractional corner charges, but a vanishing nested Wilson loop index. A new invariant able to capture the topology of this phase is then constructed. Our work shows that anomalous topological phases, previously thought to be unique to periodically driven systems, can occur and be used to understand purely time-independent HOTIs.

MA 1.3 Mon 10:00 Theater

Quantum Phase Transitions between $\mathbb{Z}_n \times \mathbb{Z}_n$ Symmetry Protected Topological Phases — •Julian Bibo[1], Ruben Verresen[1,2], and Frank Pollmann[1] — [1]Technische Universität München — [2]Max-Planck-Institut für komplexe Systeme, Dresden

Symmetry protected topological (SPT) phases are phases of matter without local order parameters. Instead, they are characterized by how a global symmetry G acts projectively on the edges. The projective transformations at the boundaries are in turn classified by the second cohomology group $H^2(G, U(1))$. Given this classification scheme, we can construct so called „fixed-point" models describing the universal features of these phases. For $G = \mathbb{Z}_n \times \mathbb{Z}_n$, there are $n-1$ non-trivial SPT phases and hence $n-1$ „fixed-point" models. For $n \leq 4$, it has been proven that the corresponding „fixed-point" models have direct transitions between adjacent phases. For $n \geq 5$, however, the expectation was that there are intermediate gapless phases instead of direct transitions. Contrary to this expectation, we use local symmetries to construct a path, proving that there are indeed direct transitions in cases, where n is divisible by 2, 3 or 4. We numerically confirm these arguments and show that these transitions are not fine-tuned.

MA 1.4 Mon 10:15 Theater

Quasiparticle interference and spin momentum locking of topological insulator surface states — •Henry Legg[1], Wouter Jolie[2], Timo Knispel[2], Nick Borgwardt[2], Zhiwei Wang[2], Markus Grüninger[2], Yoichi Ando[2], Thomas Michely[2], and Carsten Busse[2] — [1]Institut für Theoretische Physik, Universität zu Köln, Germany — [2]II. Physikalisches Institut, Universität zu Köln, Germany

In a normal Schrödinger material, with quadratic dispersion, the Fourier-transform of an STM quasi-particle interference (QPI) image is strongly enhanced close to momenta corresponding to $2k_F$ backscattering. In constrast, the surface states of 3D topological insulators are protected from back-scattering due to spin-momentum locking and this protection suppresses the otherwise divergent QPI signal at $2k_F$.

Performing a self-consistent T-matrix calculation for several different scattering potentials, we demonstrate that spin-momentum locking leads to only a smooth dependence of QPI intensity as function of momentum, in particular no sharp features occur close to $2k_F$.

Our theory will be quantatively compared to measurements on compensated $BiSbTeSe_2$ allowing us to perform a detailed and precise characterisation of the topological insulator surface by extracting the full dispersion, scattering rates, and screening length of charged impurities. Intriguingly the experimental QPI intensity close to $2k_F$ shows a slight deviation from that expected due to perfect protection from backscattering, we will discuss the potential scattering mechanism that results in this effect.

MA 1.5 Mon 10:30 Theater

Topological insulator - ferrimagnet interface: Bi_2Te_3 on Fe_3O_4 — •Vanda M. Pereira[1], Chi-Nan Wu[1,2], Cariad Knight[1,3], Simone G. Altendorf[1], and Liu Hao Tjeng[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Department of Physics, National Tsing Hua University, Hsinchu, Taiwan — [3]University of British Columbia, Vancouver, Canada

Breaking the time reversal symmetry (TRS) of a topological insulator (TI) can lead to exotic phenomena such as the quantum anomalous Hall effect. In order to break the TRS, one can dope the system with transition metal elements. An alternative way to introduce magnetic order is to interface the TI with a magnetic layer, for instance a ferrimagnetic insulator (FI), making use of the proximity effect. This approach can be more advantageous, since it avoids the non-uniformity and disorder of the doping process. Here we present the study on the growth of TI/FI heterostructures, namely Bi_2Te_3/Fe_3O_4, making use of our expertise in growing high quality thin films of these materials [1,2]. The preparation of the films by molecular beam epitaxy and their *in-situ* structural and spectroscopic characterization will be discussed. We were able to achieve a good quality interface, indicated by the minimal chemical reaction observed by X-ray photoelectron spectroscopy. Furthermore, angle-resolved photoemission spectroscopy indicates the presence of a sharp Dirac cone and the consequent preservation of the top topological surface states of the TI layer.

[1] K. Hoefer *et al.* PNAS, **111(42)**, 14979 (2014)
[2] X.H. Liu *et al.*, Phys. Rev. B **90**, 125142 (2014)

MA 1.6 Mon 10:45 Theater

Transport properties of MBE grown Bi_2Te_3 on Fe_3O_4 thin film heterostructure — •Chi-Nan Wu[1,2], Vanda M. Pereira[1], Cariad Knight[1,3], Simone G. Altendorf[1], Minghwei Hong[4], Jueinai Kwo[2], and Liu Hao Tjeng[1] — [1]MPI CPfS, Dresden, Germany — [2]Dept. of Phys., NTHU, Hsinchu, Taiwan — [3]UBC, Vancouver, Canada — [4]Dept. of Phys., NTU, Taipei, Taiwan

Quantum anomalous Hall effect (QAHE) is expected to be observed when magnetic ordering is introduced in a topological insulator (TI) system. This effect is due to time reversal symmetry breaking and can be experimentally achieved by doping transition metals into the TI or by using the magnetic proximity effect (MPE) in TI/ferromagnetic insulator (FI) heterostructures to magnetize the topological surface state (TSS) at the interface. The MPE in TI/FIs has the advantage of less defects in the TI, and it might have a higher T_c to exhibit the QAHE. However, the QAHE has not yet been experimentally observed for TI/FI heterostructures. We have successfully grown heterostructures of Bi_2Te_3/Fe_3O_4 thin films by molecular beam epitaxy with minimum chemical reaction at the interface which is crucial for the short ranged MPE. In order to study the MPE induced gap opening of the TSSs, we conducted electrical transport measurements. The temperature dependent resistance shows a sharp Verwey transition of Fe_3O_4 at 122K indicating very good quality of the FI layer. From magnetoresistance measurement at low temperature, we observed the suppression of the weak antilocalization in the TI layer, indicating a TSS gap opening by the MPE.

MA 1.7 Mon 11:00 Theater

Towards Topological Quasi-Freestanding Stanene via Substrate Engineering — •Philipp Eck[1], Domenico Di Sante[1], Maximilian Bauernfeind[2], Marius Will[2], Ronny Thomale[1], Jörg Schäfer[2], Ralph Claessen[2], and Giorgio Sangiovanni[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, D-97074 Würzburg — [2]Physikalisches Institut and Röntgen Research Center for Complex Material Systems, Universität Würzburg, D-97074 Würzburg

Although two-dimensional (2D) Kane-Mele-type group-IV (C-, Si-, Ge-, Sn-) honeycomb lattices have been successfully grown on a vast number of substrates, strain, deformation and/or hybridization often destroy their topological properties. Utilizing heavy atoms (Sn, Pb) increases the SOC strength and stabilizes the non-trivial phase but comes at the prize of low-buckled structurally unstable monolayers. Here we present a systematic density functional study of stanene (Sn) on group-III and -V adatom buffered SiC(0001) and shed light on the buffer-stanene interaction physics by investigating the impact of covalent and Van-der-Waals-type bonding on the topological phase of stanene and its structural stability. We find for some buffer layers weakly interacting configurations which preserve the freestanding stanene geometry and its non-trivial phase while rendering the low-buckled structure stable. The theoretical study is supported by experimental data on an Al buffer.
[1)] D. Di Sante et al., arXiv:1807.09006

15 min. break.

MA 1.8 Mon 11:30 Theater

VLS-Growth and characterization of bulk-insulating topological insulator nanowires — •Felix Münning[1], Oliver Breunig[1], Zhiwei Wang[1], Mengmeng Bai[1], Stefan Roitsch[2], Klaus Meerholz[2], Thomas Fischer[3], Sanjay Mathur[3], and Yoichi Ando[1] — [1]Physics Institute II, University of Cologne — [2]Institute of Physical Chemistry, University of Cologne — [3]Institute of Inorganic Chemistry, University of Cologne, Germany

We report on the growth of $Bi_2Te_xSe_{3-x}$ and $Bi_xSb_{2-x}Te_3$ nanowires and their characterization in terms of morphology, material composition and electronic transport at low temperatures. Growth is performed using the vapour-liquid-solid (VLS) method on Si/SiO_2 substrates decorated with 20-nm Au nanoparticles. Growth parameters such as temperature distribution, mass and ratio of source materials, inert gas flow, pressure and growth time are optimized and the results are examined using scanning and transmission electron microscopy (SEM, TEM) and electron dispersive X-ray spectroscopy (EDX). Devices featuring ohmic contacts to the nanowires are fabricated using electron-beam lithography. Subsequently, the electronic transport properties of the nanowires are measured for their dependencies on temperature, magnetic field and electrostatic gating at temperatures down to 1.7 K.

MA 1.9 Mon 11:45 Theater

Crossed Andreev reflection in Superconductor-TI nanowire junctions — •Michael Barth, Jacob Fuchs, Cosimo Gorini, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, Germany

Topological Insulators (TIs) are materials with an ordinary bulk band gap and metallic surface/edge states. The latter are helical, meaning that we have spin-momentum-locking, and they are topologically protected by time-reversal symmetry [1]. Topologically non-trivial superconducting states can be obtained by putting a TI in close proximity to a normal superconductor. This kind of system is characterized by modifications of phenomena such as crossed Andreev reflection [2], which for example can be fully suppressed in 2-dimensional TIs [3]. We consider instead a hybrid 3-dimensional TI - superconductor T-junction, where crossed Andreev reflection is in principle tunable via external magnetic fields. This is confirmed by our 3D numerical simulations for T-junctions, showing clear signatures of tunable crossed-Andreev reflection.
[1] X.-L. Qi and S.-C. Zhang, Rev. Mod. Phys. 83, 1057 (2011)
[2] G. Falci, D. Feinberg, and F. W. J. Hekking, EPL 54, 255 (2001)
[3] P. Adroguer et al., Phys. Rev. B 82, 081303 (2010)

MA 1.10 Mon 12:00 Theater

Coulomb Blockade in Topological Insulator Quantum Dots — Klaus Richter, Cosimo Gorini, Raphael Kozlovsky, •Ansgar Graf, and Andreas Hackl — Universität Regensburg, Institut für Theoretische Physik, 93053 Regensburg

Three-dimensional topological insulator (3DTI) nanowires host topologically non-trivial surface states wrapped around an insulating bulk. We model these states by two-dimensional effective Dirac Hamiltonians. A coaxial magnetic field is known to produce Aharonov-Bohm (AB) type oscillations in the conductance. The corresponding AB phase and a Berry phase originating from spin-momentum locking affect the angular momentum wave number. We investigate 3DTI nanowires where additionally the longitudinal wave number gets quantized by size confinement, such that a '3DTI quantum dot' exhibiting a fully discrete energy spectrum is obtained. Such confinement is not possible by electrostatic means (Klein tunneling) but can be achieved via the interplay between non-trivial geometry (shaped nanowire) and a homogeneous coaxial magnetic field. We are looking for signatures of Berry phase and Dirac states in the single-electron transport regime (in particular in the Coulomb diamonds) of such a 3DTI quantum dot.

MA 1.11 Mon 12:15 Theater

On-demand thermoelectric generation of equal-spin Cooper pairs — •Felix Keidel[1], Pablo Burset[2], Sun-Yong Hwang[3], Björn Sothmann[3], and Björn Trauzettel[1] — [1]Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany — [2]Department of Applied Physics, Aalto University, 00076 Aalto, Finland — [3]Theoretische Physik, Universität Duisburg-Essen and CENIDE, D-47048 Duisburg, Germany

A central goal for the application of superconductors in spintronics is the on-demand generation of spin-polarized supercurrents or, analogously, of equal-spin Cooper pairs. Most proposals rely on a careful manipulation of magnetic materials to electrically generate equal-spin Cooper pairs in ferromagnet (F)-superconductor (S) hybrid junctions.

Here, we propose a quantum heat engine that utilizes the helicity of the edge states of a quantum spin Hall insulator instead, where nonlocal transport necessarily takes place through equal-spin channels. We demonstrate that a temperature bias applied to an S-F-S junction can drive a nonlocal polarized supercurrent, while the normal contribution from electron tunneling is suppressed. Remarkably, the relative phase between the superconductors serves as a switch to turn the thermoelectric current on and off, allowing for the creation of equal-spin Cooper pairs on demand.

MA 1.12 Mon 12:30 Theater

Edge plasmons in topological 2D materials — •Luca Vannucci[1], Nicola Marzari[2], and Kristian S. Thygesen[1] — [1]CAMD, Technical University of Denmark, 2800 Kongens Lyngby, Denmark — [2]THEOS, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

We discuss topologically-protected collective excitations in 1D systems formed at the edge of novel 2D materials, combining both theoretical models and first-principles simulations. With the help of newly-developed computational 2D materials databases [1, 2], containing thousands of 2D materials and forming the ideal starting point for the investigation of unexplored topological materials, we focus both on known quantum spin Hall systems and new interesting candidates [3]. We then explore the electronic and plasmonic band structures in different nanoribbon geometries, highlighting the emergence of plasmonic excitations from the inspection of the dielectric function and discussing the influence of topological protection on their properties. This topological plasmonics [4] may lead to several important applications in the context of opto-electronics, where the coupling of electromagnetic fields to collective edge excitations of topological 2D materials could pave the way to new and innovative recipes for transmitting information in a robust, protected way.
[1] N. Mounet et al., Nat Nanotechnol. 13, 246 (2018)
[2] S. Haastrup et al., 2D Mater. 5, 042002 (2018)
[3] A. Marrazzo et al., Phys. Rev. Lett. 120, 117701 (2018)
[4] D. Jin et al., Phys. Rev. Lett. 118, 245301 (2017)

MA 1.13 Mon 12:45 Theater

Topological Devil's staircase in atomic two-leg ladders — Simone Barbarino[1,2], Davide Rossini[3], •Matteo Rizzi[4], Rosario Fazio[5,6], Giuseppe E. Santoro[1,5,7], and Marcello Dalmonte[1,5] — [1]SISSA, Trieste, Italy — [2]Technische Universität Dresden, Germany — [3]Università di Pisa and INFN, Italy — [4]Johannes Gutenberg-

Universität, Mainz, Germany — [5]ICTP, Trieste, Italy — [6]NEST, SNS & Istituto Nanoscienze-CNR, Pisa, Italy — [7]CNR-IOM Democritos, Trieste, Italy

We show that a hierarchy of symmetry-protected topological (SPT) phases in 1D –a topological Devil's staircase – can emerge at fractional filling fractions in interacting systems, whose single-particle band structure describes a (crystalline) topological insulator. Focusing on a specific example in the BDI class, we present a field-theoretical argument based on bosonization that indicates how the system phase diagram, as a function of the filling fraction, hosts a series of density waves. Subsequently, based on a numerical investigation of spectral properties, Wilczek-Zee phases, and entanglement spectra, we show that these phases can support SPT order. In sharp contrast to the non-interacting limit, these topological density waves do not follow the boundary-edge correspondence, as their edge modes are gapped. We then discuss how these results are immediately applicable to models in the AIII class, and to crystalline topological insulators protected by inversion symmetry. Our findings are immediately relevant to cold atom experiments with alkaline-earth atoms in optical lattices, where the band structure properties we exploit have been recently realized.

MA 2: Ultrafast magnetization effects and magnetization dynamics

Time: Monday 9:30–13:15 Location: H37

MA 2.1 Mon 9:30 H37

Ultrafast electron dynamics in the first-order phase transition of FeRh — •Federico Pressacco[1], Dmytro Kutnyakhov[2], Vojtech Uhlir[3], Jon Ander Arregi[3], Michael Heber[2], Steinn Agustsson[4], Davide Sangalli[5], Andrea Marini[5], Matteo Gatti[6,7], Guenter Brenner[2], Dmitry Vasilyev[4], Fausto Sirotti[6], and Wilfried Wurth[1,2] — [1]CFEL, Universität Hamburg, Germany — [2]DESY,Hamburg, Germany — [3]CEITEC BUT, Czech Republic — [4]JGU Mainz, Germany — [5]CNR-ISM,Roma, Italy — [6]École Polytechnique, CNRS, France — [7]European Theoretical Spectroscopy Facility (ETSF)

Time resolved photo-electron spectroscopy is one of the most powerful techniques to directly investigate the role of the electronic structure in phenomena such as superconductivity, and magnetization dynamics. It greatly benefits from recent developments of high repetition rate Free Electron Lasers (FLASH at DESY Hamburg) and advances in electron detectors such as momentum microscopes. Here we present a time-resolved study carried out at FLASH of the metamagnetic phase transition induced by laser excitation in FeRh with femtosecond resolution. We monitor the changes in the valence band related to the phase transition which at equilibrium takes place at 400 K from an antiferromagnetic to a ferromagnetic phase. The dynamics show a subpicosecond transition of the electronic structure to the FM, pointing to a primary role of the electronic system in triggering the magnetic phase transition. Ab-initio calculation of the non-equilibrium electronic structure show good agreement with the observed phenomena.

MA 2.2 Mon 9:45 H37

Ultrafast Demagnetization by Extreme Ultraviolet Light — •Leonard Müller[1,3], André Philippi-Kobs[1], Magnus H. Berntsen[2], Wojciech Roseker[1], Matthias Riepp[1], Kai Bagschik[1], Jochen Wagner[3], Robert Frömter[3], Miltcho B. Danailov[4], Flavio Capotondi[4], Emanuele Pedersoli[4], Michele Manfredda[4], Maya Kiskinova[4], Michal Stránský[6], Vladimir P. Lipp[1,5], Beata Ziaja[1,5], Hans Peter Oepen[3], and Gerhard Grübel[1,3] — [1]Deutsches Elektronen Synchrotron, Hamburg, Germany — [2]KTH Royal Institute of Tecchnology, Kista, Sweden — [3]Universität Hamburg, Hamburg, Germany — [4]Elettra-Sincrotrone Trieste, Basovizza, Italy — [5]Center for Free-Electron Laser Science, Hamburg, Germany — [6]Academy of Science of the Czech Republic, Prague, Czech Republic

One of the most intriguing topics within research on magnetism, ultrafast demagnetization [1], has greatly benefited from the advent of free-electron Lasers (FEL). Following a previous campaign [2], we report on a breakdown of the magnetic scattering cross section in Co/Pt multilayers for extreme ultraviolet (XUV) fluences $> 1\text{mJ/cm}^2$ defining the threshold fluence for FEL experiments where the FEL is meant to be a non-invasive probe. XUV-induced demagnetization is identified to be the major mechanism behind the breakdown. Besides revealing the existence of ultrafast demagnetization in the XUV regime, our results demonstrate that it proceeds much faster than the demagnetization when using IR radiation. [1] Phys. Rev. Lett. **76**, 4250 (1996), [2] Phys. Rev. Lett. **110**, 234801 (2013).

MA 2.3 Mon 10:00 H37

Magnetization dynamics due to femtosecond spin current pulses — •Karel Carva[1], Pavel Baláž[1], Ulrike Ritzmann[2], Pablo Maldonado[2], and Peter M. Oppeneer[2] — [1]Charles University, DCMP, Ke Karlovu 5, CZ-12116, Prague, Czech Republic — [2]Uppsala University, PO Box 516, 75120 Uppsala, Sweden

Ultrafast demagnetization induced by femtosecond lasers is accompanied by spin current pulses, which arise and decay on timescales unprecedent in spintronics. These originate from migration of nonequilibrium hot charge carriers in a magnetic layer excited to bands with higher mobilities by a laser [1]. These spin currents may exert torque on adjacent perpendicularly oriented magnetic layers [2]. First we calculate this torque, and model the magnetization dynamics described by the Landau-Lifshitz-Gilbert equation within macrospin appproach. We also find an optimal thickness of the excited layer that maximizes the torque [3].

Since the perturbation of magnetization is localized on the scale of several nm [4], we also perform a more accurate atomistic spin dynamics simulations to study the magnon dynamics induced by the spin current. In particular we investigate the induced magnon population, its subsequent temporal evolution on ps timescale, and the formation of standing waves in confined systems.

[1] M. Battiato, K. Carva, P.M. Oppeneer, PRL 105, 027203 (2010)
[2] A.J. Schellekens et al., Nat. Comm. 5, 4333 (2014)
[3] P. Baláž et al., J. Phys.: Cond. Matter 30, 115801 (2018)
[4] I. Razdolski et al., Nat. Comm. 8, 15007 (2017)

MA 2.4 Mon 10:15 H37

Dynamics of laser-excited nickel: an ultrafast look at the lattice side — Daniela Zahn[1], •Thomas Vasileiadis[1], Tim Butcher[2], Yingpeng Qi[1], Hélène Seiler[1], Jan Vorberger[2], and Ralph Ernstorfer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany

The behavior of ferromagnets after laser excitation is governed by the interplay of electrons, lattice and spins. In the case of 3d-ferromagnets, strong coupling between electrons and spins leads to ultrafast demagnetization on the femtosecond time scale [1]. Since the lattice drains energy from the electrons on similar timescales, it plays an important role in the magnetization dynamics. A method to study the lattice response directly is femtosecond electron diffraction (FED) [2]. We present FED results on nickel for a variety of excitation conditions. We compare the experimental data with ab-initio calculations of the spin-polarized electron-phonon coupling in combination with a two-temperature model. We find that the experimental results can only be described by the model if energy transfer to the spin system is taken into account.

[1] Beaurepaire et al., PRL 76, 4250 (1996).
[2] Waldecker et al., JAP 117, 044903 (2015).

MA 2.5 Mon 10:30 H37

Induced vs. intrinsic magnetic moments in ultrafast magnetization dynamics — •Simon Häuser[1], Moritz Hofherr[1,2], Simone Moretti[3], Nataliia Safonova[4], Henry Kapteyn[5], Margaret Murnane[5], Mirko Cinchetti[6], Daniel Steil[7], Stefan Mathias[7], Benjamin Stadtmüller[1,2], Manfred Albrecht[4], Ulrich Nowak[3], and Martin Aeschlimann[1] — [1]Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Mainz, Germany — [3]Universität Konstanz, Konstanz, Germany — [4]University of Augsburg, Augsburg, Germany — [5]University of Colorado, Boulder, USA — [6]Technische Universität Dortmund, Dortmund, Germany — [7]Georg-August-

Universität Göttingen, Göttingen, Germany

Technologically important ferromagnetic alloys consisting of several magnetic sublattices exhibit often both intrinsic and induced magnetic moments. Here, we study the ultrafast response of the element-specific magnetization dynamics for thin film systems based on purely intrinsic (CoFeB) and partially induced (FePt) magnetic moments using HHG-TMOKE as an element-sensitive probe. In FePt, on the one hand, we observe an identical normalized transient magnetization for Fe and Pt throughout both the ultrafast demagnetization and the subsequent remagnetization. On the other hand, Co and Fe show a clear difference in the asymptotic limit of the remagnetization process in CoFeB. This observation is supported by calculations for the temperature-dependent behavior of the equilibrium magnetization using a dynamic spin model [1]. [1] Phys. Rev. B 98, 174419 (2018)

MA 2.6 Mon 10:45 H37

Theory of ultrafast demagnetization in noncollinear spin valves — •Pavel Baláž[1,2], Karel Carva[1], Maciej Zwierzycki[3], Dominik Legut[2], Pablo Maldonado[4], and Peter M. Oppeneer[4] — [1]Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Ke Karlovu 5, CZ 121 16 Prague, Czech Republic — [2]IT4Innovations Center, VSB Technical University of Ostrava, 17. listopadu 15, CZ 708 33 Ostrava-Poruba, Czech Republic — [3]Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179 Poznań, Poland — [4]Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden

When a sample made of conducting metal is exposed to a femtosecond laser pulse, ultrafast demagnetization of the sample can be observed. One of the possible mechanisms is superdiffusive spin-dependent transport [1] of hot electrons excited by laser from the localized *d* band to the *s* one above the Fermi level. Here, we generalize this model for the case of a magnetic multilayer with noncollinear magnetizations. The spin-dependent transport through the interfaces between the layers is described by energy-dependent reflections and transmissions taking into account spin mixing. It is shown that laser-induced demagnetization of the multilayer depends on the magnetic configuration. Moreover, the angular dependence of spin transfer torque [2] acting on the magnetizations is estimated. [1] M. Battiato, et al., Phys. Rev. Lett. 105, 027203 (2010). [2] P. Baláž et al., J. Phys.: Cond. Matter 30, 115801 (2018).

MA 2.7 Mon 11:00 H37

tuning femtoseconds magnetization dynamics of FePt by Mn doping — •Yuting Liu[1], Ute Bierbrauer[1], Cinja Seick[2], Moritz Hofherr[1], Nataliia Safonova[3], Manfred Albrecht[3], Daniel Steil[1], Benjamin Stadtmuller[1], Stefan Mathias[2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS,University of Kaiserslautern, Germany — [2]Institute of Physics, University of Gottingen, Germany — [3]Institute of Physics, University of Augsburg, Germany

Understanding the ultrafast response of magnetic materials after interaction of fs light pulses provides abundant topics for fundamental science, as well as new opportunities for ultrafast manipulation of magnetization in storage devices. In this work, the ultrafast magnetization dynamics of Mn doped FePt prepared by a rapid thermal annealing (RTA) process have been studied by employing the magneto optical Kerr effect using visible as well as fs-XUV radiation. The speed of demagnetization and degree of quenching can be tailored by Mn doping. In particular, we find a local minimum of the demagnetization time constant with increasing strength of the optical excitation, i.e., with increasing laser fluence, leading to an unusual camel-like demagnetization vs. quenching curve in this material system. These results provide a prominent example in which way the implantation of magnetic impurity atoms into a magnetic host material can severely alter and manipulate the ultrafast magnetization dynamics of complex materials.

15 min. break

MA 2.8 Mon 11:30 H37

Ultrafast terahertz-driven spin switching in an antiferromagnet — •Stefan Schlauderer[1], Christoph Lange[1], Sebastian Baierl[1], Thomas Ebnet[1], Christoph P. Schmid[1], Anatoly K. Zvezdin[2,3], Alexey V. Kimel[4,5], Rostislav V. Mikhaylovskiy[5], and Rupert Huber[1] — [1]Department of Physics, University of Regensburg, 93053 Regensburg, Germany — [2]Prokhorov General Physics Institute and P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow 119991, Russia — [3]Moscow Institute of Physics and Technology (State University), Dolgoprudny 141700, Russia — [4]Moscow Technological University (MIREA), Moscow 119454, Russia — [5]Radboud University, Institute for Molecules and Materials, Nijmegen 6525 AJ, The Netherlands

Switching magnetization with maximal speed and minimal energy loss is essential for future information processing and data storage. Here, we use intense THz pulses with meV photon energies to switch electron spins between two states separated by a potential barrier, in the fastest and least dissipative way, and we reveal the corresponding temporal and spectral fingerprint. This goal is achieved by coupling the locally enhanced THz electric field of custom-tailored antennas with antiferromagnetic $TmFeO_3$. Within their duration of 1 ps, single-cycle THz pulses abruptly change the magnetic anisotropy and trigger a large-amplitude ballistic spin motion. A characteristic phase flip, an asymmetric splitting of the magnon resonance, and a long-lived offset of the Faraday signal hallmark coherent spin switching into adjacent potential minima.

MA 2.9 Mon 11:45 H37

Uncovering the magnetic origin of the contractive stress in laser-excited FePt by ultrafast X-ray diffraction — •Alexander von Reppert[1], Jan-Etienne Pudell[1], Steffen Zeuschner[1,2], Lisa Willig[1], Matthias Rössle[2], Marc Herzog[1], Fabian Ganss[3], Olav Hellwig[3,4], and Matias Bargheer[1,2] — [1]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany — [2]Helmholtz-Zentrum Berlin, Berlin, Germany — [3]Institut für Physik, Technische Universität Chemnitz, Chemnitz, Germany — [4]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Here we present a systematic study of the previously observed contraction of laser-excited granular FePt by ultrafast X-ray diffraction. Double-pulse excitation experiments show that the contractive stress is suppressed when the FePt is transiently demagnetized and it recovers as the magnetization reestablishes. The saturation of the observed contraction in a fluence study and the timescale for the remagnetization in time-resolved MOKE measurements corroborate this finding. The comparison between the lattice response of continuous and granular FePt films shows that the in-plane geometry of the sample is crucial for the observed lattice dynamics, although we can exclude the anisotropic phonon and electron expansion coefficients as the only origin of the out-of-plane contraction. In this work we demonstrate how double-pulse excitation experiments can disentangle competing mechanisms at phase transitions, which are difficult to access.

MA 2.10 Mon 12:00 H37

Electron dynamics driving ultrafast magnetization dynamics in alloys — •Sebastian T. Weber[1], Benjamin Stadtmüller[1,2], Moritz Hofherr[1,2], Martin Aeschlimann[1], and Baerbel Rethfeld[1] — [1]Department of Physics and Research Center Optimas, TU Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudinger Weg 9, 55128 Mainz, Germany

Irradiating ferromagnetic films with an ultrashort laser pulse leads to a quenching of the magnetization on a subpicosecond timescale [1]. Our spin-resolved Boltzmann description allows to describe the out-of-equilibrium electrons and their microscopic collision processes [2].

Recent experiments in an exchange coupled ferromagnetic Fe-Ni alloy (Permalloy) have revealed element-specific dynamics right after the optical excitation [3]. To reveal the mechanisms responsible, we have set up a model to trace the spin-resolved electron dynamics in dependence on both magnetic sublattices of the alloy. Our results show the influence of the involved coupling mechanisms on the different relaxation processes.

[1] E. Beaurepaire *et al.*, PRL **76**, 4250 (1996)
[2] B. Y. Mueller *et al.*, PRL **111**, 167204 (2013)
[3] S. Mathias *et al.*, PNAS **109**, 4792 (2012)

MA 2.11 Mon 12:15 H37

Stroboscopic imaging using Lorentz TEM at radio frequencies — •John H. Gaida, Marcel Möller, Sascha Schäfer, and Claus Ropers — 4th Physical Institute, Georg-August-University, Göttingen, Germany

Lorentz microscopy is a widely applied technique for the nanoscale mapping of magnetization structures. Its time-resolved implementation offers fascinating prospects for a spatiotemporal imaging of ultrafast magnetism.

The Göttingen Ultrafast Transmission Electron Microscope (UTEM) is a recently developed instrument to study ultrafast structural, electronic and spin dynamics, driven by optical pump pulses or radiofrequency currents [1].

In this contribution, we present stroboscopic Lorentz microscopy with photoelectron pulses at high MHz-repetition rates. We use a permalloy ($Ni_{80}Fe_{20}$) nanoisland as a model system to benchmark the new instrument by mapping time-resolved current-driven vortex gyration. The trajectory of the vortex core is tracked with a high precision of better than 3 nm, which allows us to identify subtle deviations from an idealized gyrotropic motion. Systematic deformations of the elliptical orbit and a changing angular velocity indicate the influence of pinning centers on the trajectory. Our method can help in the design of nanoscale magnetic materials by time-resolved imaging of the dynamics of magnetic quasiparticles such as vortices or skyrmions with high spatial and temporal resolutions.

[1] A. Feist *et al.*, Ultramicroscopy **176** (2016)

MA 2.12 Mon 12:30 H37

Linking spectroscopy calculations with the underlying time-dependent DFT electronic structure — •Voicu Popescu, Sergiy Mankovskiy, Jürgen Braun, Alberto Marmodoro, and Hubert Ebert — Department Chemie, Ludwig Maximilian University, Munich, Germany

Recent developments in time-dependent density functional theory (TD-DFT) paved the way towards investigating and quantitatively interpreting, on *ab initio* level, the ultrafast demagnetisation processes in ferromagnetic systems caused by a strong laser pulse [1]. These time-dependent phenomena can in principle be monitored by standard spectroscopic techniques such as angle-resolved photoemission (ARPES) and/or magnetic circular X-ray dichroism (MCXD), with the latter having the additional advantage of being element-specific.

The present contribution tries to answer the question how much of information, and how accurately, do such spectroscopy experiments actually convey? We do this by calculating, within the framework of the spin-polarised relativistic Korringa-Kohn-Rostoker method, the ARPES and MCXD spectra for several transition metals employing the self-consistently determined TD-DFT potentials. We make a side-by-side comparison between the theoretically determined spectra and the time evolution of the underlying electronic structure and find that, while correctly reproducing the qualitative trends, quantitative estimations based on the MCXD sum rules have a limited range of validity.

[1] K. Krieger *et al.*, J. Chem. Theory Comput. **11**, 4870 (2015)

MA 2.13 Mon 12:45 H37

Long-distance ultrafast spin transfer processes through carbon chain structure — •Jing Liu[1], Georgios Lefkidis[1], Wolfgang Hübner[1], and Chun Li[2] — [1]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Northwestern Polytechnical University, Xi'an, China

Ultrafast spin flip and transfer processes between near magnetic centers have already been theoretically demonstrated on various realistic, or even synthesized molecular systems [1]. Motivated by the delicate spin interaction between the encapsulated magnetic atoms and the atoms of the cage of endohedral fullerenes [2,3] as well as the calculability of such large structures with high precision quantum chemical methods, we use C atoms as spin channels to optically transfer the spin over distances comparable to the actual CMOS scale.

First we transfer the spin across a finite 2D graphene sheet, on which we induce spin localization by attaching two Ni atoms on opposite sites. However, our to-date record distance of 4.428 nm is achieved over a 40-atom-long zig-zag carbon chain, again with two Ni attached. The spins of the two Ni atoms couple due the combination of local and global symmetry, with the nonlinear geometry of the chain (which gives rise to what we term dynamical Goodenough-Kanamori rules). The processes typically finish within 600 fs.

[1] D. Dutta, *et al.*, Phys. Rev. B **97**, 224404 (2018).
[2] C. Li, *et al.*, Carbon **87**, 153 (2015).
[3] C. Li, *et al.*, Phys. Chem. Chem. Phys. **19**, 673 (2017).

MA 2.14 Mon 13:00 H37

Effect of ultrashort laser pulse on the magnetic and chemical state of individual Co nanoparticles probed by X-PEEM — •Tatiana M. Savchenko, Michele Buzzi, Jaianth Vijayakumar, Martin Timm, Ludovic Howald, David Bracher, Carlos A. F. Vaz, Frithjof Nolting, and Armin Kleibert — Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland

The discovery of all-optical switching (AOS) in ferrimagnetic alloys such as FeGdCo using ultrashort laser pulses has stimulated immense activities in the field of magnetism. More recently, AOS was also observed in 3d transition metal thin film systems. In this work, we combine X-ray photoemission electron microscopy (X-PEEM) with X-ray magnetic circular dichroism (XMCD) and X-ray absorption spectroscopy (XAS) to observe the response of the magnetization and the chemical state of individual and well separated Co nanoparticles with sizes between 8 and 25 nm deposited on silicon wafers upon excitation with single 50 fs laser pulses with a wavelength of 800 nm. We find that the laser pulses with fluences up to about 7 mJ/cm2 have no noticeable effect on the magnetic state of the particles, irrespective of the laser polarization. At higher fluences, we find that the nanoparticles undergo a chemical reaction with the Si substrate and lose magnetic contrast. Calculations indicate that Rayleigh scattering significantly reduces the number of absorbed photons in a nanoparticle due to the large wavelength relative to its diameter. Thus, much higher laser fluences as compared to thin films together with laser transparent substrates are required to achieve all-optical switching in individual nanoparticles.

MA 3: Focus Session: Novel 3D magnetic spin textures

Theoretical modelling, synthesis and experimental characterization

Time: Monday 9:30–13:15 Location: H38

Invited Talk MA 3.1 Mon 9:30 H38

Three-dimensional solitons in magnetism, nuclei and particle physics — •Paul Sutcliffe — Durham University, Durham, UK.

Magnetic Skyrmions are two-dimensional topological solitons that are analogous to the three-dimensional Skyrmions introduced by Skyrme in the context of high energy particle physics. I shall discuss the similarities and differences between these two kinds of Skyrmions, together with recent progress on using three-dimensional Skyrmions to describe nuclei. Finally, I shall discuss the possibility of three-dimensional topological solitons in magnetism, called Hopfions, and explain their relation to both types of Skyrmion.

Invited Talk MA 3.2 Mon 10:00 H38

Simulations of particlelike states in three-dimensional magnets: chiral skyrmions, bobbers and hopfions — •Filipp N. Rybakov — KTH-Royal Institute of Technology, Stockholm, Sweden

Magnetization vector field of skyrmions in the crystals of chiral magnets look like vortex strings passing through the sample. Skyrmions exhibit particlelike properties and are free to move in the film plane and interact each other as ordinary particles [1]. As the size of the sample grows, skyrmion strings become longer as they are bounded by surfaces. Because of that, they cannot be considered wholly localized in three dimensions (3D). The situation is different for chiral bobbers which represent spin textures entirely localized in 3D and located on the surfaces of volumetric samples or films [2]. They behave like particles, but similar to skyrmions their mobility is restricted to two dimensions because the surface is two-dimensional. The progress in the theory of magnetic solitons, advanced computer simulations together with the development of various experimental techniques providing a full reconstruction of 3D spin textures in crystals allow one to hope for the discovery of truly 3D and intrinsically stable particles which can move in any spatial direction. Such 3D topological solitons are known as hopfions [3].

I will present an overview of recent progress in micromagnetic simulations of all the above solitons.

[1] H. Du et al., PRL 120, 197203 (2018).
[2] F. Zheng et al., Nat. Nanotechnol. 13, 451 (2018).
[3] http://hopfion.com

MA 3.3 Mon 10:30 H38

Interplay of chirality and spin-orbit coupling in the anomalous Hall effect of non-collinear magnets — •Fabian R. Lux[1], Matthias Redies[1], Frank Freimuth[1], Stefan Blügel[1], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

We discuss the emergence of a novel anomalous Hall effect, which is driven by the interplay of spin-orbit coupling and the presence of a non-collinear magnetic structure. The predicted effect is linear in the real-space gradients of the underlying magnetic texture and therefore chiral in nature. Within a semiclassical language, therefore, its origin is neither the emergent field which is responsible for the topological Hall effect, nor is it the pure momentum-space Berry curvature. Rather, it is the same effective magnetic field that is responsible for the emergence of a chiral contribution to the orbital magnetization [1]. This direction opens up new perspectives for the all-electrical detection of non-collinear magnetic structures such as skyrmions, hopfions and chiral bobbers [2].

[1] F. R. Lux *et al.*, Communications Physics **1**, 60 (2018)
[2] M. Redies *et al.*, arXiv:1811.01584 (2018)

Invited Talk MA 3.4 Mon 10:45 H38

Quantitative measurements of three dimensional magnetic textures using off-axis electron holography — •András Kovács[1], Nikolai Kiselev[2], Jan Caron[1], Thibaud Denneulin[1], Fengshan Zheng[1], Dongsheng Song[1], Stefan Blügel[2], and Rafal E Dunin-Borkowski[1] — [1]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Peter Grünberg Institute, Forschungszentrum Jülich, Germany — [2]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich, Germany

Nanoscale particle-like magnetization textures, such as skyrmion [1], chiral bobbers [2], and magnetic hopfions have generated considerable interest, both because of their fundamental physical properties and because they are candidates for future energy efficient recording and storage applications. However, measurements of their magnetic properties and magnetic imaging are challenging as a result of their small dimensions and three-dimensional magnetic field distributions. We use off-axis electron holography [3] in an aberration-corrected TEM to record electron optical phase images of chiral bobbers, Bloch- and Néel-type skyrmions. The phase images are analysed using a model-based iterative reconstruction algorithm to determine the magnetic moment distribution in each sample. Prospects for characterising more complex magnetic textures are discussed. [1] A. Kovacs et al, APL 111, 192410 (2017) [2] F. Zheng et al, Nat. Nanotech. 13, 451 (2018) [3] A. Kovacs and R.E. Dunin-Borkowski, Handbook of Magnetic Materials, vol. 27, p.59-153 (Ed. E.Brueck, Elsevier), 2018

15 min. break

Invited Talk MA 3.5 Mon 11:30 H38

Three-dimensional nanomagnetism: Present and future — •Amalio Fernandez-Pacheco — School of Physics and Astronomy, University of Glasgow, G12 8SU, Scotland, United Kingdom — Cavendish Laboratory, University of Cambridge, CB3 0HE, United Kingdom

Three-dimensional nanomagnetism is a new and exciting area of research focused on investigating nanomagnets that extend beyond the standard planar configuration. In these systems, with unconventional geometries and spin interactions, new physical effects emerge, with interlinked geometry, topology and chirality, paving the way to novel devices with functionalities beyond the substrate plane. However, the leap to 3D is complex, demanding for new fabrication and characterisation tools.

In this talk, I will review recent progress in this area, particularly on results of my group and collaborators. These include the development of "3D nano-printing" processes for advanced nanofabrication, which have allowed us to carry out pioneering experiments where magnetic information in the form of domain walls can be injected into 3D Permalloy nanowires. In these systems, the use of soft X-Ray magnetic microscopy techniques enables the reconstruction of their magnetic configuration in great detail. The extension to 3D also includes multilayered systems, where the interlayer Dzyaloshinskii-Moriya interaction opens a new route to create 3D spin chiral textures.

MA 3.6 Mon 12:00 H38

Magnetic ground states of perfect Py nanotubes and rings — •Elisabeth Josten[1], András Kovács[1], Felix Oertel[2], Artur Glavic[3], Thomas Jansen[1], Trevor P. Almeida[4], Attila Kákay[5], Teresa Wessels[1], Manuel Langer[3], Jörg Raabe[3], Daniel E. Bürgler[1], Katja Höflich[2], and Rafal E. Dunin-Borkowski[1] — [1]Forschungszentrum Jülich, Jülich, Germany — [2]Helmholtz-Zentrum Berlin for Materials and Energy, Berlin, Germany — [3]Paul Scherrer Institut, Villigen PSI, Switzerland. — [4]University of Glasgow, Glasgow, United Kingdom — [5]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Magnetic nanotubes (MNTs) have unique static and dynamic magnetic properties due to their size, aspect ratio, curvature and hollow structure. It is important to optimize the magnetic ground states of such 3D curved nano-objects for their successful implementation in novel devices. Recently, the synthesis of MNTs with perfectly circular cross-sections was achieved. The MNTs were fabricated by coating a carbon core template with a magnetron-sputtered permalloy (Py) shell. Here, we focus on the characterization of magnetic states in individual Py nanotubes and their cross-sections, which take the form of magnetic rings (MRs). The MRs were prepared by slicing individual MNTs using focused ion beam milling. For the investigation, we make use of scanning transmission X-ray microscopy and off-axis electron holography performed in a transmission electron microscope. The MRs are found to support novel magnetic states such as double vortices.

Invited Talk MA 3.7 Mon 12:15 H38

Revealing magnetic configurations with X-ray magnetic nanotomography — •Valerio Scagnoli — Laboratory for Mesoscopic Systems, Department of Materials, ETH Zurich, 8093 Zurich, Switzerland — Laboratory for Multiscale Materials Experiments, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

Three dimensional magnetic systems hold the promise to provide new functionality associated with greater degrees of freedom. Over the last years we have worked towards developing methods to fabricate and characterise three dimensional magnetic structures. Specifically, we have fabricated an artificial magnetic In order to determine the magnetic configuration in such three dimensional systems, we have combined X-ray magnetic imaging with a new iterative reconstruction algorithm to achieve X-ray magnetic tomography [1,2,3]. In a first demonstration, we determine the three dimensional magnetic nanostructure within the bulk of a soft GdCo2 magnetic micropillar, observing a complex magnetic configuration consisting of vortices and antivortices that form cross-tie and vortex walls. By determining the magnetic structure surrounding singularity points found at the intersections of these magnetic structures we have identified the presence of Bloch points of different types [3]. X-ray magnetic nanotomography will enable to unravel complex three dimensional magnetic structures for a range of magnetic systems with high spatial resolution [4].

[1] C. Donnelly et al., PRL 114, 115501 (2015) [2] C. Donnelly et al., PRB 94, 064421 (2016) [3] C. Donnelly et al., Nature 547, 328 (2017) [4] C. Donnelly et al., New J. Phys. 20, 083009 (2018).

MA 3.8 Mon 12:45 H38

Mesoscale Dzyaloshinskii-Moriya interaction: geometrical tailoring of the magnetochirality — •Oleksii Volkov[1], Denis Sheka[2], Yuri Gaididei[3], Volodymyr Kravchuk[3,4], Ulrich Rössler[4], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany — [2]Taras Shevchenko National University of Kyiv, Kyiv, Ukraine — [3]Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine, Kyiv, Ukraine — [4]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW Dresden), Dresden, Germany

Magnetic crystals with broken chiral symmetry possess intrinsic spin-orbit driven Dzyaloshinskii-Moriya interaction (DMI). Geometrically broken symmetry in curvilinear magnetic systems also leads to the appearance of extrinsic to the crystal exchange driven effective DMI [1,2]. The interplay between the intrinsic and geometrical-induced DMI paves the way to a mesoscale DMI, whose symmetry and strength depend on the geometrical and material parameters [3]. We demonstrate this approach on the example of a helix with intrinsic DMI.

Adjusting the helical geometry allows to create new artificial chiral nanostructures with defined properties from standard magnetic materials. For instance, we propose a novel approach towards artificial magnetoelectric materials, whose state is controlled by means of the geometry.

[1] Y. Gaididei et. al, Phys. Rev. Lett. 112, 257203 (2014).
[2] R. Streubel et. al, J. Phys. D: Applied Physics 49, 363001 (2016).
[3] O. Volkov et. al, Scientific Reports 8, 866 (2018).

MA 3.9 Mon 13:00 H38

Prediction of a novel chiral magnetic interaction originating from the coupling of spin and topological orbital moment in B20 compounds — •S. Grytsiuk, M. Hoffmann, J.-P. Hanke, G. Bihlmayer, Y. Mokrousov, and S. Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

It is believed that the complex magnetic structure of B20 materials, such as FeGe and MnGe, can be explained exclusively in terms of the Heisenberg exchange and antisymmetric Dzyaloshinskii-Moriya (DM) interaction. We demonstrate that this assumption is wrong. We discovered that the spin-spin interactions in MnGe are strongly influenced by the Berry phase effect of carriers hopping in a nontrivial spin background. We show that without SOI the non-coplanar magnetic structure in B20 materials gives rise to a topological orbital moment [1-2]. Moreover, we reveal that in case of MnGe the spin-orbit coupling between the local spins and topological orbital moment dominates over DMI in favoring a magnetic state of certain chirality even without external magnetic field. Together with the biquadratic coupling, that we found important in B20 compounds, we speculate that the corresponding novel chiral magnetic interaction can be a key element in resolving the puzzle of the complex 3D magnetic state of MnGe, and suggest that it can present a platform for realizing new classes of chiral magnetic materials and textures.

[1] M. Hoffmann, at. el., Phys. Rev. B 92, 020401(R) (2015).
[2] J.-P. Hanke, at. el., Sci. Rep. 7, 41078 (2017)

MA 4: Topological insulators and spin-dependent transport phenomena

Time: Monday 9:30–13:15 Location: H52

MA 4.1 Mon 9:30 H52

Properties of Majorana Fermions in a Planar Josephson Junction — •Aidan Wastiaux and Falko Pientka — Max-Planck Institute for the Physics of Complex Systems, Dresden

As topologically protected quasi-particles, Majorana fermions are of great interest for the future of quantum information. The most promising experimental platform for Majorana states is based on heterostructures of superconductors and semiconductor nanowires in a magnetic field. In Ref. [1], an alternative platform based on a 2D Josephson junction in a 2d semiconductor with spin-orbit coupling has been proposed. The topological phase can be controlled by an in-plane magnetic field and the phase difference across the junction. Motivated by recent experimental progress [2], we investigate properties of the topological phase and Majorana states in this platform.

MA 4.2 Mon 9:45 H52

Laser induced DC photocurrents in 3D topological insulators Hall bar and nanowire devices — •Nina Meyer[1], Thomas Schumann[1], Eva Schmoranzerová[2], Kevin Geishendorf[3], Gregor Mussler[4], Jakob Walowski[1], Petr Nemec[2], Andy Thomas[3], Kornelius Nielsch[3], Detlev Grützmacher[4], and Markus Münzenberg[1] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic — [3]IFW Dresden, Institute for Metallic Materials, Dresden, Germany — [4]Inst. for Semiconductor Nanoelectronics, PGI-9, Forschungszentrum Jülich, Germany

It has been demonstrated experimentally that spin-polarized currents can be generated by illuminating a topological insulator (TI) with circularly polarized light [1]. In this talk, we will sum up our results for (Bi, Sb)$_2$Te$_3$ thin films Hall bar structures and Bi$_2$Se$_3$ core-shell nanowires. During the photocurrent measurements, the laser light polarisation is changed at every laser spot position. Due to the polarisation dependence, the different contribution to the photocurrent are separated and displayed as spatially resolved 2D maps. For the Hall bar structure a lateral accumulation of spin polarization at the TIs edges due to the spin Nernst effect is found [2]. For the nanowires, the interaction between nanowire and Au contact due to the Schotky effect and a constant spin polarized current far off the contacts is found.

[1] J.W. McIver et al., Nature Nanotechnology 7, 96-100 (2012)
[2] T. Schumann et al., arXiv:1810.12799 (submitted)

MA 4.3 Mon 10:00 H52

Characterization of topological band structure features away from the Fermi level via the anomalous Nernst effect — •Jonathan Noky, Johannes Gooth, Claudia Felser, and Yan Sun — Max Planck Institute for Chemical Physics of Solids, Dresden, Deutschland

Resolving the structure of energy bands in transport experiments is a major challenge in condensed matter physics and material science. Sometimes, however, when traditional electrical measurements only provide very small signals, it has been proven beneficial to employ thermoelectric measurements which are sensitive to the first derivative of the electrical property with respect to energy, rather than to its value itself. Due to the large interest in topological effects these days, it is important to identify a similar concept for detecting the Berry curvature (BC) in a band structure. The BC can be created by different mechanisms like Weyl points or the gapping of nodal lines due to symmetry breaking. Nowadays, the common way to access the BC directly via measurements is the anomalous Hall effect, but the corresponding signal can be too small to be detected when the topological features of the band structure lie too far off the Fermi level.

We investigate the strong BC due to nodal line gappings in regular Heusler compounds for different positions of the Fermi level. From this we derive a way to resolve topological band structure features which are elusive to see in anomalous Hall measurements utilizing the anomalous Nernst effect.

MA 4.4 Mon 10:15 H52

The Z_2 topology of bismuth — •Irene Aguilera, Christoph Friedrich, Gustav Bihlmayer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The Z_2 topology of bulk and thin films of pure bismuth has been a matter of debate in the last few years. Whereas all first-principles calculations with different levels of sophistication predict a trivial Z_2 invariant, a couple of photoemission experiments display surface states that look non-trivial. The discrepancies between theory and experiment were originally attributed to the failure of density functional theory (DFT) in the prediction of band gaps, because the topological or trivial character of Bi depends only on the "sign" of the tiny ($\sim$15 meV) direct band gap at the L point. In [1] we showed that quasiparticle self-consistent GW (QSGW) calculations support the trivial character. These are, to date, the most accurate calculations for bulk Bi in the literature. However, this did not explain the discrepancy with experiments. In this talk, I will explain, based on QSGW calculations, why the apparent contradiction between theory and experiment is, as a matter of fact, no contradiction, and that the "topologically-looking" experimental surface states are actually compatible with a trivial Z_2 invariant. We note that we focus on the Z_2 topological character only and not on the high-order topology, recently predicted for Bi.

[1] I. Aguilera *et al.*, Phys. Rev. B **91**, 125129 (2015).

Financial support from the Virtual Institute for Topological Insulators of the Helmholtz Association.

MA 4.5 Mon 10:30 H52

Transport and scanning tunneling microscopy study on layered Dirac material EuMnBi2 — •Xinglu Que[1,2], Qingyu He[1,2], Claus Mühle[1], Jürgen Nuss[1], Lihui Zhou[1], and Hidenori Takagi[1,2,3] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Germany — [3]Department of Physics, University of Tokyo, Japan

The interplay of correlation and topology could give rise to novel properties. In this presentation we report our investigation of a layered magnetic Dirac material EuMnBi2, by using transport and STM. EuMnBi2 exhibits rich magnetic textures, by controlling which distinct electronic structures are accessible. Antiferromagnetically ordered Eu ions decouple the Bi layers which host Dirac fermions, leading to the emergence of multilayer Quantum Hall effect as revealed by our transport data. The application of an external magnetic field drives the material into different states. The STM reveals well defined steps after low temperature cleavage. Local spectroscopy finds features derived from Bi, in good agreement with band structure calculations.

MA 4.6 Mon 10:45 H52

First-principles study of electrical transport with phonons and magnons — •David Wagenknecht[1,2], Dominik Legut[2], Karel Carva[1], and Ilja Turek[1] — [1]Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Czechia — [2]IT4Innovations & Nanotechnology Centre, VŠB-Technical University of Ostrava, Czechia

We will present first-principles calculations of magnetic materials with a combined influence of chemical disorder (impurities) and finite-temperature effects (phonons and spin fluctuations). The alloy analogy model (AAM) within the fully relativistic tight-binding linear muffin-tin orbital (TB-LMTO) method and the coherent potential approximation (CPA) was successfully used to describe transition metals and simple alloys [1, 2], an effect of spin disorder in the Earth's core [3], and spin-resolved conductivities in half-metallic half-Heusler NiMnSb [4]. Special attention will be paid to a comparison of phenomenological methods (Debye theory or fitting experimental data) and proper ab initio calculations. For systems, where the former ones may be used, computational effort may be greatly reduced. Our efficient AAM within TB-LMTO method with the CPA can describe even complex structures such as multi-sublattice magnetic materials where the properly described disorder is essential for, e.g., a spin polarization of the electrical current.

[1] D. Wagenknecht et al. T-MAG 53 11 (2017); [2] D. Wagenknecht et al. Proc. SPIE 10357, 103572W (2017); [3] V. Drchal et al. PRB 96, 024432 (2017); [4] D. Wagenknecht et al. JMMM 747, 517-521 (2019)

MA 4.7 Mon 11:00 H52

Spin Hall magnetoresistance in metals on antiferromagnetic α-Cr_2O_3 — •Tobias Kosub[1], Asser Elsayed[1], Richard Schlitz[2], Jürgen Fassbender[1], Sebastian Gönnenwein[2], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [2]TU Dresden, Dresden, Germany

Spin Hall magnetoresistance (SMR) is a crucial phenomenon for insulator spintronics as it enables regular metals to be used to drive and sense magnetic effects in the insulators. While the effect has been thoroughly studied for ferrimagnetic insulators [1], antiferromagnetic [2] and paramagnetic insulators are interesting materials for future spintronics applications.

We present a thorough study of both longitudinal and transverse magnetotransport signatures of the spin Hall magnetoresistance, for various metals on Cr_2O_3. We monitor the system above and beyond the Nèel temperature - in the antiferromagnetic and paramagnetic phases. The magnetotransport effects are generally larger in the paramagnetic phase, highlighting the potential importance of paramagnets for spintronic applications.

Several inconsistencies with established SMR theory are reported and we offer different explanations taking into account the paramagnetic nature of the material.

[1] H. Nakayama et al., *Phys. Phys. Lett.* **110**, 206601 (2013)

[2] R. Schlitz et al., *Appl. Phys. Lett.* **112**, 132401 (2018).

15 min. break

MA 4.8 Mon 11:30 H52

Magnonic Weyl states in Cu_2OSeO_3 — •L. Zhang[1], Y. A Onykiienko[2], P.M. Buhl[1], Y. V Tymoshenko[2], P. Čermák[3,4], A. Schneidewind[3], S. Blügel[1], D.S. Inosov[2], and Y. Mokrousov[1,5] — [1]PGI and IAS, FZ Jülich and JARA, 52425 Jülich, Germany — [2]IFMP, TU Dresden, D-01069 Dresden, Germany — [3]JCNS, FZ Jülich GmbH, Outstation at Heinz MLZ, Lichtenbergstraße 1, D-85747 Garching, Germany — [4]Charles University, Faculty of Mathematics and Physics, Ke Karlovu 5, 121 16, Praha, Czech Republic — [5]Institute of Physics, JGU Mainz, 55099 Mainz, Germany

The multiferroic ferrimagnet Cu_2OSeO_3 with a chiral crystal structure has recently attracted significant attention due to the emergence of a skyrmion order in this material [1]. Here the topological properties of its magnon excitations were investigated by linear spin-wave theory and inelastic neutron scattering. Considering only the Heisenberg exchange interactions, two Weyl points are observed at high symmetry points with topological charges ±2. Each Weyl point splits into two as the symmetry of the system is further reduced, if in addition the nearest neighbor Dzyaloshinsky-Moriya interaction is taken into consideration, which is decisive for obtaining an accurate fit to the experiment results. The predicted topological properties are verified by surface state and Chern number analysis. In addition, we predict that a sizeable thermal Hall conductivity can be associated with the emergence of the Weyl points, the position of which can be tuned by changing the crystal symmetry of the material. [1] Portnichenko, P. Y. et al., Nat. Commun. 7, 10725 (2016)

MA 4.9 Mon 11:45 H52

Symmetry aspects of spin-filtering in molecular junctions: hybridization and quantum interference effects — •Dongzhe Li[1] and Alexander Smogunov[2] — [1]Department of Physics, University of Konstanz, D-78457 Konstanz, Germany — [2]Service de Physique de l'Etat Condensé, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif-sur-Yvette F-91191, France

Control and manipulation of electric current and especially its degree of spin polarization across single molecules is currently of great interest in the field of molecular spintronics. Using state-of-the-art *ab initio* transport calculations, we explore one of possible strategies based on the modification of nanojunction symmetry which can be realized, for example, by a mechanical strain. Such modification can activate new molecular orbitals which were inactive before due to their orbital mismatch with electrode's conduction states. This can result in several important consequences such as: i) a significant suppression of the majority spin conductance was found in low symmetry configurations due to quantum interference effects seen as Fano-like features in electron transmission functions and ii) strongly enhanced conductance of minority spin due to increased molecule-metal hybridization when the symmetry is lowered. We illustrate the idea on two basic molecular junctions: Ni/Benzene/Ni (perpendicular vs tilted orientations) and Ni/Si chain/Ni (zigzag vs linear chains). We believe that our results may offer new potential route for creating molecular devices with a large on/off spin polarization via quantum interference effects.

MA 4.10 Mon 12:00 H52

Reconfigurable spin tunnel diode based on stacked two-dimensional materials — •Ersoy Sasioglu[1], Stefan Blügel[2], and Ingrid Mertig[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, 06099 Halle (Saale) Germany — [2]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany

Tunnel diodes and transistors are considered as one of the most promising candidates for the future high-speed, low-power nanoelectronic devices due to their predicted ultra-high frequency operation in the THz range. Recently we proposed a reconfigurable spin tunnel diode and transistor concept using spin gapless semiconductors (SGSs) and half metallic magnets (HMMs) [1]. The two-terminal spin tunnel diode is comprised of a SGS electrode and a HMM electrode separated by a thin insulating tunnel barrier and allows electrical current to pass either in one direction or in other direction depending of the relative orientation of the magnetization direction of the electrodes. Two-dimensional stacked van der Waals materials, which form high-quality heterointerfaces due to absence of dangling bonds, offer a unique platform for realization of such a spin diode concept. By employing the nonequilibrium Green's function method combined with density functional theory we demonstrate the reconfigurable rectification characteristics of the spin tunnel diode based on two-dimensional stacked transition-metal dichalcogenides and dihalides. Funding by the European Union (EFRE) is greatly acknowledged.

[1] Ersoy Şaşıoğlu and Stefan Blügel, (2017), PCT Patent No. WO 2017076763(A1).

MA 4.11 Mon 12:15 H52

Nonmagnet-Barrier Interface Drives Tunnelling Anisotropic Magnetoresistance — •Philipp Risius, Carsten Mahr, Michael Czerner, and Christian Heiliger — Institut für theoretische Physik, Justus-Liebig-Universität Gießen, Gießen

Tunnel junctions with a single ferromagnetic layer (semi-magnetic tunnel junction, SMTJ) may show magnetoresistance if spin-orbit interaction (SOI) is present in the ferromagnetic layer. This effect is called tunneling anisotropic magnetoresistance (TAMR). SMTJs employing a thin iron layer, magnesium oxide as tunnel barrier, and vanadium as leads (V|Fe|MgO|V) show TAMR and an appreciable spin-orbit torque at room temperature [1]. We investigate the origins of TAMR by calculating the transport across SMTJs from first principles, and investigate the effect of disorder at the Fe|V interface. For this, we utilized a fully relativistic Korringa-Kohn-Rostoker non-equilibrium Green's function method including the coherent potential approximation and vertex corrections [2]. We recovered the k-resolved transmission and temperature-dependent TAMR ratio. Crucially, we show that the effect depends on a subtle interplay of the interfaces on both sides of the tunnel barrier, and that the magnitude of SOI at the ferromagnet-insulator interface can even be secondary to the choice of materials.

[1] S. Miwa, J. Fujimoto, P. Risius et al., *Phys. Rev. X* **7**(3), 031018 (2017).
[2] C. Franz, M. Czerner and C. Heiliger, *J. Phys. Condens. Matter* **25**, 425301 (2013).

MA 4.12 Mon 12:30 H52

Current induced Néel-order switching in antiferromagnetic CuMnAs deposited by magnetron sputtering — •Tristan Matalla-Wagner, Matthias Rath, Jan-Michael Schmalhorst, Günter Reiss, and Markus Meinert — Center for Spinelectronic Materials and Devices, Bielefeld University, Germany

Antiferromagnets which fulfill certain symmetry properties allow for an intrinsic relativistic Néel-order spin-orbit torque (NSOT) driven by an electrical current [1]. The antiferromagnetically coupled sublattices of tetragonal CuMnAs are inversion partners and, thus, can experience a NSOT which can reorient the Néel-vector $\boldsymbol{L}$ perpendicular to the applied charge current [2]. Therefore, this material is suitable to manufacture novel antiferromagnetic memory devices that are extraordinarily robust against external influences [3]. Here, we report on our experiments on the electrical switching of the Néel-order using short current pulses in highly oriented films of CuMnAs, deposited using dc-magnetron sputtering. The dependence of the switching efficiency on the sample temperature, current density and pulse width is examined. Our findings corroborate the hypothesis of a thermally activated switching of $\boldsymbol{L}$ in sputtered CuMnAs, similar to the switching of sputtered Mn_2Au [4].

[1] J. Železný *et al.*, Phys. Rev. Lett. **113**, 157201 (2014)
[2] P. Wadley *et al.*, Science **351**, 587 (2016)
[3] T. Jungwirth *et al.*, Nat. Nanotechn. **11**, 231 (2016)
[4] M. Meinert *et al.*, Phys. Rev. Applied **9**, 064040 (2018)

MA 4.13 Mon 12:45 H52

Multifunctional Antiperovskites driven by Strong Magnetostructural Coupling — •Harish Kumar Singh, Ilias Samathrakis, Nuno Fortunato, and Hongbin Zhang — Institute of Materials Science, TU Darmstadt, Otto-Berndt-Straße 3, 64287 Darmstadt, Germany

Magnetic antiperovskites (APVs) show various stable magnetic ordering and among which noncollinear antiferromagnetic (AFM) states display many intriguing magnetic properties such as barocaloric, piezomagnetic, etc. In this work, we performed density functional theory calculations to evaluate the magnetic ground state, magnetocystalline anisotropy energy, piezomagnetic effect (PME), and intrinsic anomalous Hall conductivity (IAHC) of 57 APVs with chemical formula M_3XZ (M= Cr, Mn, Fe, Co and Ni, Z= C and N). It is found that 20 compounds have noncollinear AFM state. By imposing 1% tensile and compressive biaxial strain, large piezomagnetic and piezospintronic effects are observed. For instance with 1% strain, the IAHC of Cr_3PtN increased by 251 S/cm and Cr_3IrN shows a strong PME with net magnetization of 0.21 μB/f.u. Detailed analysis on the electronic structure and lattice properties reveal that the underlying driving force can be attributed to strong magnetostructural coupling.

MA 4.14 Mon 13:00 H52

Origin of anomalous Hall effect in magnetic antiperovskites — •Ilias Samathrakis, Harish Kumar Singh, and Hongbin Zhang — Theory of Magnetic Materials, TU Darmstadt, Darmstadt, Germany

Antiferromagnet materials have recently become a hot research topic for spintronic applications. Being a special class of antiferromagnets, noncollinear magnets have also attracted a lot interest. In this work, we investigated how to induce finite anomalous Hall conductivity in antiperovskite Mn_3GaN and Mn_3NiN by tuning the magnetization direction between the Γ_{5g} and Γ_{4g} configurations, as well as by applying biaxial strain. The origin of the resulting anomalous Hall conductivity is elucidated by analyzing the electronic structure in detail. It is observed that the spatial position and the energy splitting of the Weyl points give rise to the non-vanishing conductivity values.

MA 5: Surface magnetism and magnetic coupling phenomena (joint session MA/O/TT)

Time: Monday 9:30–13:15 Location: H53

MA 5.1 Mon 9:30 H53

Magneto-Seebeck Tunneling on the Atomic Scale — Cody Friesen, •Hermann Osterhage, Johannes Friedlein, Anika Schlenhoff, Roland Wiesendanger, and Stefan Krause — Department of Physics, University of Hamburg, Germany

The tunneling of spin-polarized electrons in a magnetic tunnel junction driven by a temperature gradient is a fundamental process for the thermal control of electron spin transport. As we have shown recently, scanning Seebeck tunneling microscopy is a technique that enables spin-averaged thermopower measurements in a metal-vacuum-metal tunnel junction with atomic-scale lateral resolution [1]. Using a magnetic tip and sample allows for the experimental investigation of the details of the magneto-Seebeck tunneling, with vacuum serving as the tunneling barrier. Heating the tip with a laser and measuring the thermopower of the junction while scanning across the spin texture of the sample leads to spin-resolved Seebeck coefficients that can be determined and mapped with atomic-scale lateral resolution [2].

The experiments on Fe/W(110) and Fe/Ir(111) will be presented and discussed in terms of spin-averaged, magneto-Seebeck and anisotropic magneto-Seebeck thermopower in an ideal single atom tunnel junction. Based on the experimental findings we propose a spin detector for spintronics applications that is solely driven by waste heat, utilizing magneto-Seebeck tunneling to convert spin information into a voltage that can be used for further data processing.

[1] C. Friesen *et al.*, J. Phys. D: Appl. Phys. **51**, 324001 (2018).
[2] C. Friesen *et al.*, Science (accepted).

MA 5.2 Mon 9:45 H53

Tunable spin-superconductor coupling of spin 1/2 molecules — •Luigi Malavolti[1,2,3], Matteo Briganti[4], Max Hänze[1,2,3], Giulia Serrano[4], Irene Cimatti[4], Gregory McMurtie[1,2,3], Edwige Otero[5], Philippe Ohresser[5], Federico Totti[4], Matteo Mannini[4], Roberta Sessoli[4], and Sebastian Loth[1,2,3] — [1]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Stuttgart, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [3]Max Planck Institute for Solid State Research, Stuttgart, Germany — [4]Università degli Studi di Firenze, Sesto Fiorentino (Firenze), Italy — [5]Synchrotron SOLEIL, Gif-sur-Yvette, France

Assemblies of magnetic molecules with long coherence time are being investigated as quantum bits that may be embedded in superconducting resonators [1]. Bringing the spin center into contact with the superconducting surface maximizes coupling to the resonator but may also reduce the spin's coherence time by increased scattering of quasiparticles. Here we report the capability to tune the exchange coupling of spin 1/2 vanadyl phthalocyanine molecules (VOPc) with a Pb superconducting surface. This system offers a fully tunable spin superconductor coupling from uncoupled spin to strongly coupled, screened spin [2]. These findings highlight the possibility to scale superconducting resonator experiments down to single molecule sensitivity.

[1] M. D. Jenkins, et al., Dalt. Trans. 2016, 45, 16682.
[2] L. Malavolti, et al., Nano Letters DOI: 10.1021/acs.nanolett.8b03921

MA 5.3 Mon 10:00 H53

Reduced magnetic moment in polycrystalline Co thin films — •Sabine Pütter[1], Amir Syed Mohd[1], Artur Glavic[2], Stefan

Mattauch[1], and Thomas Brückel[3] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at MLZ, Garching, Germany — [2]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen PSI, Switzerland — [3]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science (JCNS) and Peter Grünberg Institute (PGI): JCNS-2, PGI-4: Quantum Materials and Collective Phenomena, Jülich, Germany

The variation of the magnetic moment with dimensionality of magnetic materials, i. e. from atoms to bulk, is a longtime studied issue. For thin films, a constant magnetic moment is often assumed in modelling, however, intermixing and surface roughness may also have an impact.

With the help of polarised neutron reflectometry (PNR) we study the magnetic moment of polycrystalline Co/20 nm Pt/MgO(001). The samples were grown by molecular beam epitaxy and subsequently measured with PNR at room temperature and in saturation in UHV.

Our results reveal the vertical depth profile of the magnetic moment of the Co films. In fact, the magnetisation is not constant but smeared out at the edges, due to roughness. Measurements at different film thicknesses reveal the evolution of the magnetic moment which is separated in a bulk and a surface contribution and discussed with respect to published results.

This project has received funding from the EU's H2020 research and innovation programme under grant agreement n. 654360.

MA 5.4 Mon 10:15 H53

Investigation of the structural and magnetic properties of self-organized MnO_2 chains on Pt(001) — •Chong-Heeon Park, Martin Schmitt, Matthias Vogt, and Matthias Bode — Physikalisches Institut, Experimentelle Physik II, Universität Würzburg, Am Hubland, Würzburg, Germany

Recently, the self organized growth of 3d transition metal oxide (TMO) chains on Ir(001) and Pt(001) was investigated by STM, LEED, and DFT calculations [1,2]. Along with the structural (3×1) phase of the MnO_2 chains, antiferromagnetic (AFM) coupling on Ir(001) was predicted along and between adjacent chains. In this study, we investigate the structural and magnetic properties of self-organized MnO_2 chains, grown on Pt(001), with low temperature spin-polarized scanning tunneling microscopy (SP-STM). Similar to Ir(001), we observe a perfectly ordered $(3{\times}1)$ structural phase with an inter-chain periodicity of $3a_{\mathrm{Pt}}$. When these chains are scanned with either an in-plane or out-of-plane polarized tip (Cr-coated W tip), we observe a spin structure that can be modeled by a (15×2) magnetic unit cell. It is formed by AFM coupling along the MnO_2 chains and 72° spin spiraling across the chains.

[1] P. Ferstl, *et. al.*, Phys. Rev. B. **96**, 085407 (2017)
[2] P. Ferstl, *et. al.*, Phys. Rev. Lett. **120**, 089901 (2018)

MA 5.5 Mon 10:30 H53

Coexistence of RW-AFM and 3Q state in the Mn/Re(0001) monolayer investigated with SP-STM — •Jonas Spethmann, Jonas Sassmannshausen, André Kubetzka, Roland Wiesendanger, and Kirsten von Bergmann — Institut für Nanostruktur- und Festkörperphysik, Hamburg

Exciting new physics is predicted to arise at the interface of noncollinear magnetic and superconducting materials. In order to study this subject, promising model systems need to be found. Therefore, we investigated the growth and the magnetism of a monolayer of Mn on Re(0001) using spin-polarized scanning tunneling microscopy.

Re becomes superconducting below a critical temperature of 1.69 K, which is a temperature well accessible with modern cryogenics. Mn typically prefers an antiferromagnetic order. If it is forced into a hexagonal atomic lattice, like the (0001) surface of Re, complex magnetic structures might arise due to geometric frustration. Furthermore, it is known that differently stacked monolayers of the same material can show different magnetic ground states. By adding Co to the Re surface prior to the Mn deposition, we managed to grow the Mn in two different stackings. We show that the fcc stacking exhibits a row-wise antiferromagnetic state with three symmetry-equivalent rotational domains. The hcp-stacked area shows a magnetic texture that is compatible with a so-called 3Q state [1], which is a non-collinear state with four spins in the unit cell that have an angle of 109.4° between each other.

[1] Ph. Kurz, G. Bihlmayer, K. Hirai, and S. Blügel. Phys. Rev. Lett., 86:1106-1109, Feb 2001.

MA 5.6 Mon 10:45 H53

Zero field sub-10 nm skyrmions and antiskyrmions in ultrathin Co films — •Sebastian Meyer[1], Stephan von Malottki[1], Marco Perini[2], André Kubetzka[2], Roland Wiesendanger[2], Kirsten von Bergmann[2], and Stefan Heinze[1] — [1]Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel — [2]Department of Physics, University of Hamburg

Non-collinear spin structures such as skyrmions are being intensively studied due to their promise for spintronic devices [1]. For applications it is envisioned to use isolated skyrmions with diameters below 10 nm that are stable at zero magnetic field [2]. Here, we use density functional theory and atomistic spin dynamics simulations [3] to show how we can stabilize magnetic skyrmions and antiskyrmions in ultrathin Co films in zero external magnetic field. In contrast to Co being a ferromagnetic material with a strong exchange stiffness we obtain very large frustration effects in the magnetic interactions of ultrathin Co films which imperatively requires an atomistic spin model. We find that the frustration enhances the energy barriers for skyrmions and antiskyrmions against collapse into the ferromagnetic ground state.

[1] A. Fert, V. Cros, and J. Sampaio, Nat. Nanotech. **8**, 152 (2013)
[2] A. Fert, N. Reyren, and V. Cros, Nat. Rev. Mater. **2**, 17031 (2017)
[3] S. Haldar, *et al.*, Phys. Rev. B **98**, 060413 (2018)

MA 5.7 Mon 11:00 H53

Scanning Seebeck Tunneling Microscopy — Cody Friesen, Hermann Osterhage, Johannes Friedlein, Anika Schlenhoff, Roland Wiesendanger, and •Stefan Krause — Department of Physics, University of Hamburg, Germany

The field of spin caloritronics is specifically concerned with effects that arise in the presence of a temperature gradient, and their effect on spin-dependent electronic transport. The advent of increasingly detailed techniques for nano-scale fabrication, measurement, and manipulation have led to an improved understanding of spin caloritronic effects, and their potential uses in engineering sensors and devices at all size scales, e.g. waste-heat recycling and efficient computing.

Within this field, the thermally induced Seebeck tunneling of electrons is a fundamental effect. In our experiments, it is studied in a metal-vacuum-metal junction using scanning tunneling microscopy (STM). Selective heating of the tip with a laser generates a well-defined temperature difference at the tunnel junction. The thermovoltage between the tip and the sample is measured with atomic-scale lateral resolution and related to the band structure of the junction, as revealed by local tunneling spectroscopy. Tunnel current rectification experiments in compensated conditions allow for a direct measurement of the Seebeck coefficient without the need for tip heating, thereby realizing Seebeck mapping on the atomic scale. The STM studies will be presented and discussed in terms of thermally induced tunneling across a single-atom ideal vacuum barrier.

C. Friesen *et al.*, J. Phys. D: Appl. Phys. **51**, 324001 (2018).

15 min. break

MA 5.8 Mon 11:30 H53

***Ab initio* simulations of 2D-materials interacting with magnetic clusters and surfaces** — •Nicolae Atodiresei, Vasile Caciuc, and Stefan Blügel — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich, Germany

Using density functional theory calculations we elucidate how the subtle interplay between the electrostatic, the weak van der Waals and the strong chemical interactions determines the geometric, electronic and magnetic structure of hybrid systems formed by magnetic substrates and atomic clusters with 2D materials as transition metal dichalcogenites (TMDs) monolayers and graphene (Gr). More precisely, the interaction between 2D and magnetic materials (i.e. surfaces, atomic clusters) shapes the (i) spin-polarization, (ii) magnetic exchange couplings, (iii) magnetic moments and (iv) their orientation of the hybrid systems. This work has been supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Project number 277146847 - CRC 1238 (C01).

[1] R. Brede *et al.*, Nature Nanotech. **9**, 1018 (2014).
[2] F. Huttmann *et al.*, Phys. Rev. Lett. **115**, 236101 (2015).
[3] F. Huttmann *et al.*, Phys. Rev. B **95**, 075427 (2017).
[4] V. Caciuc *et al.*, Phys. Rev. Mat. **2**, 084001 (2018).

MA 5.9 Mon 11:45 H53

Electronic and magnetic structure of monolayer and double layer GdFe/W(100) surface alloy — •Vikas Kashid, Gustav

Bihlmayer, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The rare earth-transition metal alloy films are attractive materials for high density mageto-optic storage due to their magnetic recording and magneto-optical anisotropy. We investigate by virtue of spin density functional theory (DFT) as realized in the FLEUR code [1], the structural and magnetic properties of the monolayer and double layer film of GdFe on the W(100) substrate in c(2×2) unit cell, where highly localized Gd-4f orbitals are treated within GGA+U method. Gd buckles outward by 0.96 Å and 0.88 Å with respect to Fe atoms in the monolayer and double layer surfaces, respectively. The calculated monolayer and double layer GdFe/W(100) exhibits a checkerboard antiferromagnetic ground state configurations between Fe and Gd atoms. The Fe atoms in the double layer GdFe/W(100) exhibit large magnetic moment of 2.30 μ_B, larger than that of 1.45 μ_B in the monolayer film. The easy axes for the spin quantization arising from spin-orbit coupling in both the surfaces lie in the surface plane and along the diagonal of c(2×2) cell with the magneto-crystalline anisotropy energy larger for the double layer than for the monolayer.

We acknowledge discussions with Prof. Alexander Ako Khajetoorians.
[1] www.flapw.de

MA 5.10 Mon 12:00 H53

Nonlocal electron correlations in an itinerant ferromagnet — •Christian Tusche[1,2], Martin Ellguth[3], Vitaliy Feyer[1], Alexander Krasyuk[3], Carsten Wiemann[1], Jürgen Henk[4], Claus M. Schneider[1,2], and Jürgen Kirschner[3,4] — [1]Forschungszentrum Jülich GmbH, Peter Grünberg Institut (PGI-6), Jülich — [2]Fakultät für Physik, Universität Duisburg-Essen, Duisburg — [3]Max-Planck-Institut für Mikrostrukturphysik, Halle — [4]Martin-Luther-Universität Halle-Wittenberg, Halle

A fundamental concept in solid state physics describes the electrons in a solid by the relation of the energy E vs. the crystal momentum $\boldsymbol{k}$ in a band structure of independent quasi particles. However, even for the most simple elemental ferromagnets, electron correlations are prevalent, requiring descriptions of their electronic structure beyond this simple single-electron picture. Our comprehensive measurements of the spectral-function by spin-resolved momentum microscopy show that in itinerant ferromagnets like cobalt these electron correlations are of nonlocal origin. This manifests in a complex self-energy $\Sigma_\sigma(E,\boldsymbol{k})$ that disperses as function of spin σ, energy E, and momentum $\boldsymbol{k}$. Combining the experiments with one-step photoemission calculations, we quantify the dispersion of the self-energy over the whole Brillouin zone [1]. The observation of nonlocal electron correlations in cobalt substantially affects our understanding of electron interactions, and makes itinerant ferromagnets a paradigmatic test case for the interplay between band structure, magnetism, and correlations.

[1] C. Tusche et al., Nat. Commun. 9, 3727 (2018)

MA 5.11 Mon 12:15 H53

Magnetic coupling of ferromagnetic $SrRuO_3$ epitaxial layers separated by ultrathin spacers with large spin-orbit coupling — •Lena Wysocki[1], Michael Ziese[2], Lin Yang[1], Jörg Schöpf[1], Rolf Versteeg[1], András Kovács[3], Lei Jin[3], Felix Gunkel[4], Regina Dittmann[4], Paul H.M. van Loosdrecht[1], and Ionela Lindfors-Vrejoiu[1] — [1]University of Cologne, Institute of Physics II, Germany — [2]Felix Bloch Institute for Solid State Physics, University of Leipzig, Germany — [3]Forschungszentrum Jülich, PGI-5, Germany — [4]Forschungszentrum Jülich, PGI-7, Germany

$SrRuO_3$, a 4d ferromagnet exhibiting several Weyl nodes in proximity of the Fermi level, offers a rich playground to tailor its physical properties in epitaxial heterostructures and superlattices. Interfacing $SrRuO_3$ with large spin-orbit coupling perovskite oxides, as $SrIrO_3$, results in intriguing physical phenomena like pronounced anomalies in the Hall resistivity, attributed either to the existence of Néel type skyrmions or to modifications of the Berry curvature of electronic bands with non-trivial topology. The nature of the coupling between the magnetic layers in such superlattices is an important component influencing the global multilayer properties. We present the investigation of the magnetic coupling between ferromagnetic $SrRuO_3$ layers separated by ultrathin spacers of perovskite oxides exhibiting strong spin-orbit coupling[1]. The type and strength of the magnetic interlayer coupling was determined by major and minor magnetization measurements for various spacer geometries.

[1] L. Wysocki et al., Appl. Phys. Lett. **113**, 192402 (2018)

MA 5.12 Mon 12:30 H53

Charge-transfer driven ferromagnetism in a disordered three-dimensional 3*d*-5*d* spin system — •Philipp Komissinskiy[1], Supratik Dasgupta[1], Ilya Radulov[1], Andrei Rogalev[2], Fabrice Wilhelm[2], Marton Major[1], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany — [2]European Synchrotron Radiation Facility, 71 Avenue des Martyrs, 38000 Grenoble, France

A three-dimensional disordered spin system consisting of the 3d transitional metal ion Mn^{4+} with strong electronic correlations and the heavy 5d transition metal ion Ir^{4+} with large spin-orbit coupling has been investigated in form of a perovskite thin film. The studied compound of the composition $SrMn_{0.5}Ir_{0.5}O_3$ does not exist as bulk or single crystal, but can be stabilized by epitaxy as fully disordered double perovskite thin film onto $SrTiO_3$ single-crystal substrate using pulsed laser deposition. As measured by X-ray circular dichroism, the ground state of this material is ferromagnetic with both, Mn and Ir, spins aligned in parallel. This unusual ground state can be qualitatively explained by charge-transfer driven magnetic exchange involving the effective $J = 1/2$ state of Ir. Due to the coexistence of competing magnetic interactions and randomness in the system, spin-glass features are observed at low temperatures.

MA 5.13 Mon 12:45 H53

Thickness independent magnetism of the magnetic MAX phase films $(Cr_0.5Mn_0.5)_2GaC$ — •Iuliia P. Novoselova[1], Andrejs Petruhins[2], Ulf Wiedwald[1], Johanna Rosen[2], Michael Farle[1], and Ruslan Salikhov[1] — [1]Faculty of Physics and Center for Nanointegration (CENIDE), University of Duisburg-Essen, Duisburg, Germany — [2]Department of Physics, Linköping University, Linköping, Sweden

Atomically laminated magnetic MAX phases $M_{n+1}AX_n$ (n = 1, 2, 3) have attracted interest as novel materials exhibiting both ceramic and metallic properties. Here 12.5 to 156 nm thick films $(Cr_0.5Mn_0.5)_2GaC$ were investigated by ferromagnetic resonance, electron scanning microscopy and magnetometry. The X-ray diffraction reveals a high crystalline quality and phase purity. Magnetocrystalline anisotropy energy density of 140 mT as well as magnetization of 240 kA/m are found to not depend on thickness. All films are environmentally stable without a change of magnetic properties for more than one year at ambient conditions and without any protection layer. Such independence on thickness combined with the chemical stability makes the $(Cr_0.5Mn_0.5)_2GaC$ films attractive for various applications such as spintronic devices or corrosion resistant magnetic sensors. This work is supported by DFG, Grant SA 3095/2-1 and DAAD Doctoral Programmes in Germany,57214224. [1] M. W. Barsoum, Prog. Solid State Chem. 28, 201 (2000).[2] A. Petruhins, et al. Journal of Mat. Sci. 50-13, 4495 (2015).[3] R. Salikhov, et al. Mat. Res, Lett. 3-3, 156-160 (2015).[4] I. P. Novoselova, Sci. Reports 8, 2637 (2018).

MA 5.14 Mon 13:00 H53

The polar distortion and its relation to magnetic order in multiferroic HoMnO3 — •Nazaret Ortiz[1], Yoav William Windsor[2], Jose Renato Linares Mardegan[1], Christof Schneider[1], Gareth Nisbet[3], and Urs Staub[1] — [1]Paul Scherrer Institute, Swiss Light Source, Switzerland — [2]Fritz Haber Institut der Max Planck Gesellschaft, Germany, — [3]Diamond Light Source, United Kingdom

The orthorhombic (Pbnm) HoMnO3 is of particular interest due to its high magnetically-induced polarization values (P) and magnetoelectric coupling strength. The mechanism behind this involves high magnetic frustration, which results in a magnetic order that creates a distortion in the crystal lattice. This distortion breaks inversion symmetry and creates a macroscopic electric polarization P along the a-axis.

We investigated the atomic distortion to identify the broken symmetry of Pbnm in thin films of HoMnO3 at low temperature and the relation between the magnetic order of Ho and the structural distortion. Forbidden reflections for Pbnm has been observed, showing that the distortion does not exclusively affect to the atomic position along the polar axis, it also moves atoms along other directions. Moreover, studying reflections with component along the polar axis we observe the polar distortion directly, visualized by the difference diffraction intensity from opposite domains.

MA 6: Frustrated Magnets - Spin Liquids (joint session TT/MA)

Time: Monday 15:00–18:45 Location: Theater

MA 6.1 Mon 15:00 Theater

Designer spin liquids — •Nic Shannon[1,2], Han Yan[2], Owen Benton[3], and Ludovic Jaubert[4] — [1]TUM, Garching, Germany — [2]OIST, Okianwa, Japan — [3]RIKEN, Wakoshi, Japan — [4]Universite Bordeaux, Bordeaux, France

The pyrochlore lattice has proved a rich source of spin liquids, both in theory, and in the experiment. The best known examples are "spin ices" such as $Dy_2Ti_2O_7$, which offer a concrete realisation of a U(1) lattice gauge theory, complete with magnetic monopole excitations. However many other spin liquid-materials are known, with many different types of phenomenology, motivating the question "what else is out there ?"

In this talk we show how a variety of different spin liquids on the pyrochlore lattice can be generated systematically, by exploiting the degeneracies which arise where different forms of order meet. As examples we present the tensor spin liquid found in models of pyrochlores with anisotropic exchange interactions [1]; the nematic spin liquid found in frustrated quantum spin ice [2,3]; and a rank-2 U(1) spin liquid found by perturbing a simple Heisenberg antiferromagnet [4]. In all cases, the predictions of the relevant gauge theory are compared with the results of Monte Carlo simulation. The relevance of these results to experiments on pyrochlore magnets, including $Tb_2Ti_2O_7$, is also discussed.

[1] O. Benton *et al.*, Nat. Commun. **7**, 11572 (2016)
[2] M. Taillefumier *et al.*, Phys. Rev. X **7**, 041057 (2017)
[3] O. Benton *et al.*, Phys. Rev. Lett. **121**, 067201 (2018)
[4] H. Yan *et al.*, preprint.

MA 6.2 Mon 15:15 Theater

MIEZE spectroscopy of spin dynamics and crystal field excitations in $Tb_2Ti_2O_7$ — •Andreas Wendl[1], Steffen Säubert[1,2], Christian Franz[2], Olaf Soltwedel[1,4], Johanna Jochum[2,5], Prabhakaran Dharmalingam[3], Andrew Boothroyd[3], and Christian Pfleiderer[1] — [1]Technische Universität München, Garching, Germany — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany — [3]Clarendon Laboratory, University of Oxford, United Kingdom — [4]Technische Universität Darmstadt, Darmstadt, Germany — [5]Bayerisches Geoinstitut, Bayreuth, Germany

The nature of the spin liquid ground state in the cubic rare earth pyrochlore oxide $Tb_2Ti_2O_7$ has been attracting great interest for many years, where recent studies suggest a prominent role of magneto-elastic crystal field - phonon interactions [1,2]. We present measurements of the spin dynamics of $Tb_2Ti_2O_7$ by means of the Modulation of IntEnsity by Zero Effort technique (MIEZE) [3], representing an implementation of high-resolution neutron spin echo suitable for depolarizing sample conditions. Our data of the intermediate scattering function cover time-scales of over seven orders of magnitude between 1 fs and 1 ns, corresponding to an energy spectrum from the meV to neV regime. We find strong paramagnetic fluctuations as well as crystal field transitions at elevated temperatures, shedding new light on the low-lying spin dynamics.

[1] Constable et al., Phys. Rev. B, 95, 020415(R) (2017)
[2] Fennell et al. Phys. Rev. Lett., 112, 017203 (2014)
[3] Franz and Schröder, J. Large-Scale Res. Facil. JLSRF 1, 14 (2015)

MA 6.3 Mon 15:30 Theater

Magnetisation Avalanches in Classical Spin Ice $Dy_2Ti_2O_7$ — •M. Kleinhans[1], C. Duvinage[1], D. Prabhakaran[2], A. T. Boothroyd[2], and C. Pfleiderer[1] — [1]Physik-Department, Technische Universität München, D-85748 Garching, Germany — [2]Department of Physics, University of Oxford, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, United Kingdom

Spin ice attracts great interest as a state in which emergent fractionalized excitations and magnetic-field induced topological forms of order may occur [1]. We report vibrating coil magnetometry down to mK temperatures [2,3] of $Dy_2Ti_2O_7$, addressing the evidence of putative magnetisation avalanches in the spin-frozen state which depend sensitively in number and size on the magnetic field ramp rate, sample shape and quality. These avalanches have been interpreted in terms of magnetic monopole dynamics [4].

[1] Castelnovo *et al.*, Nature **451**, 7174 (2008)
[2] Krey *et al.*, PRL **108**, 257204 (2012)
[3] Legl *et al.*, PRL **109**, 047201 (2012)
[4] Slobinsky *et al.*, PRL **105**, 267205 (2010)

MA 6.4 Mon 15:45 Theater

Magnetization beyond the Ising limit of $Ho_2Ti_2O_7$ — •L. Opherden[1], T. Herrmannsdörfer[1], M. Uhlarz[1], D. I. Gorbunov[1], A. Miyata[2], O. Portugall[2], I. Ishii[3], T. Suzuki[3], and J. Wosnitza[1,4] — [1]Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — [2]Laboratoire National des Champs Magnetiques Intenses (LNCMI-EMFL), Toulouse, France — [3]Department of Quantum Matter, AdSM, Hiroshima University, Japan — [4]Institut für Festkörper- und Materialphysik, TU Dresden, Germany

We report that the local Ising anisotropy in pyrochlore oxides – the crucial requirement for realizing the spin-ice state – can be broken by means of high magnetic fields. For the case of the well-established classical spin-ice compound $Ho_2Ti_2O_7$ the magnetization exceeds the angle-dependent saturation value of the Ising limit using ultra-high fields up to 120 T. However, even under such extreme magnetic fields full saturation cannot be achieved. Crystal-electric-field calculations can account for the measured magnetization dependence and reveal that a level crossing for two of the four ion positions leads to magnetization steps at 55 and 100 T. In addition, we show that by using a field-sweep rate in the range of the spin-relaxation time, the dynamics of the spin system can be probed. Exclusively at 25 ns/T a novel peak of the susceptibility appears around 2 T. We argue, this signals the cross-over between spin-ice and polarized correlations.

MA 6.5 Mon 16:00 Theater

The Quantum Life of Worms: Quantum Spin Ice in a [100] Magnetic Field — •Olga Sikora[1], Karlo Penc[2], Frank Pollmann[3], Ying-Jer Kao[4], and Nic Shannon[5] — [1]Institute of Nuclear Physics, Polish Academy of Sciences, ul. Radzikowskiego 152, PL-31342 Kraków, Poland — [2]Wigner Research Centre for Physics, H-1525 Budapest, POB 49, Hungary — [3]Physics Department, Technical University Munich, 85748 Garching, Germany — [4]Department of Physics, National Taiwan University, Taipei 10617, Taiwan — [5]Okinawa Institute for Science and Technology Graduate University, Onna, Okinawa, 904-0495 Japan

Quantum spin ice in a magnetic field exhibits rich physics, with many open questions about possible ordered and spin–liquid states. Here we consider the case of strong [100] magnetic field, and study excitations about the maximally–polarized spin–ice state, within a model with short–range interactions. In this approach a single string of flipped spins — a "worm" — can be mapped onto an S = 1/2 XXZ chain. This mapping provides a complete understanding of a single string, exhibiting different properties in the gapped (confined) and gapless (extended) phase of the XXZ model. We further investigate the interaction between strings, using both an effective model, and large–scale variational and Green's function Monte Carlo methods previously applied to quantum spin ice in zero field [1].

[1] N. Shannon, O. Sikora, F. Pollmann, K. Penc and P. Fulde, Phys. Rev. Lett. **108**, 067204 (2012).

MA 6.6 Mon 16:15 Theater

Investigation of the Thermodynamic Properties of Insulating Pr-based Pyrochlores — •J. Gronemann[1,2], T. Gottschall[1], E.L. Green[1], H.D. Zhou[3], A. Islam[4], B. Lake[4,5], and J. Wosnitza[1,2] — [1]Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, Dresden, Germany — [2]Institut für Festkörper- und Materialphysik, TU Dresden, Germany — [3]Univ. of Tennessee, Knoxville, USA — [4]Helmholtz-Zentrum Berlin, Germany — [5]Institut für Festkörperphysik, TU Berlin, Germany

Geometrically frustrated pyrochlores exhibit novel properties at low temperatures and are well-known spin-liquid candidates. In the insulating compounds $Pr_2Sn_2O_7$ and $Pr_2Hf_2O_7$ the orientation of the spins of the Pr^{3+} ions on corner-sharing tetrahedrons show dynamics beyond the spin-ice state [1]. Due to the small magnetic moment of the Pr^{3+} ion, generating only a small dipolar interaction, transverse fluctuations may have a significant influence. The spin dynamics in these materials remains unfrozen to lowest temperatures and the possibility of quantum fluctuations makes them quantum spin-liquid candidates

[2], which are expected to host a variety of emergent electrodynamic phenomena in analogy to magnetic monopoles in spin-ice. To probe the nature of the low-temperature ground state and the changes in the entropy, specific heat was measured down to 450 mK and up to 13 T.
[1] H. D. Zhou. et al., Phys. Rev. Lett. **101**, 227204 (2008)
[2] R. Sibille et al., Phys. Rev. B **94**, 024436 (2016)

MA 6.7 Mon 16:30 Theater

Giant magneto-elastic effect in d^2 pyrochlores and the formation of a spin-lattice liquid — •Andrew Smerald[1] and George Jackeli[1,2] — [1]Max Planck Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart — [2]Insitute for Functional Matter and Quantum Technologies, University of Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart

We discuss the idea of a giant magneto-elastic effect in frustrated magnets, and suggest that this may provide a good way to understand d^2 pyrochlore systems such as $Y_2Mo_2O_7$. We define magneto-elastic coupling as "giant" when it selects low-temperature spin configurations that are completely unexpected from the point of view of a pure spin model. This can be contrasted with the more usual case in which magneto-elastic coupling selects one or more of the otherwise extensively degenerate ground states of a frustrated magnet. In the case of $Y_2Mo_2O_7$ we propose that this mechanism results in a classical spin-lattice liquid at intermediate temperatures, in which spin and lattice degrees of freedom are intimately coupled together.

15 min. break.

MA 6.8 Mon 17:00 Theater

Intermultiplet transitions and long-range order in Sm-based pyrochlores — •Viviane Peçanha-Antonio[1], Erxi Feng[1], Devashibhai Adroja[2], Fabio Orlandi[2], Xiao Sun[3], Yixi Su[1], and Thomas Brückel[3] — [1]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany — [2]ISIS Facility, Rutherford Appleton Laboratory, Chilton, Didcot, United Kingdom — [3]Jülich Centre for Neutron Science (JCNS) and Peter Grünberg Institut (PGI), Forschungszentrum Jülich GmbH, Jülich, Germany

We present bulk and neutron scattering measurements performed on the isotopically enriched $^{154}Sm_2Ti_2O_7$ and $^{154}Sm_2Sn_2O_7$ samples. Both compounds display sharp heat capacity anomalies, at 350 mK and 440 mK, respectively. Inelastic neutron scattering measurements are employed to solve the crystalline electric field (CEF) excitations scheme, which includes transitions between the ground and first excited J multiplets of the Sm^{3+} ion. To further validate those results, the single-ion magnetic susceptibility of the compounds is calculated and compared with the experimental dc-susceptibility measured in low applied magnetic fields. It is demonstrated that the inclusion of intermultiplet transitions in the CEF analysis is fundamental to the understanding of the intermediate and, more importantly, low temperature magnetic behaviour of the Sm-based pyrochlores. Finally, the heat capacity anomaly is shown to correspond to the onset of an all-in-all-out long-range order in the stannate sample, while in the titanate a dipolar long-range order can be only indirectly inferred.

MA 6.9 Mon 17:15 Theater

Field-induced magnetic transitions in the Yb- based $J_{\rm eff} = \frac{1}{2}$ triangular lattice antiferromagnet $NaYbO_2$ — •Kizhake Malayil Ranjith Kumar[1], Daryna Dmytriieva[2], Seunghyun Khim[1], Jörg Sichelschmidt[1], Hiroshi Yasuoka[1], Hannes Kühne[2], and Michael Baenitz[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, D-01314 Dresden, Germany

Spin-$\frac{1}{2}$ triangular lattice antiferromagnets (TLAF) are one of the active fields of research in condensed matter physics. The Yb^{3+}- based delafossite $NaYbO_2$ provides an ideal $J_{\rm eff} = \frac{1}{2}$ triangular lattice motif with spin-orbit entanglement. We have synthesized the phase pure polycrystalline $NaYbO_2$ material and investigated the ground state properties. At zero field, $NaYbO_2$ exhibits no sign of magnetic long-range order down to 0.35 K, which proposes a spin liquid like ground state with strong persisting quantum fluctuations. In external magnetic fields above 2 T, it yields field-induced ordered phases. We investigated the magnetic properties in detail by magnetization, specific heat, nuclear magnetic resonance (NMR), and electron spin resonance (ESR) experiments down to 0.35 K. The results are discussed within the extended XXZ model for bond-dependent exchange interactions on planar triangles.

MA 6.10 Mon 17:30 Theater

Spin orbit entangled planar $J = 1/2$ triangular lattice magnet $NaYbS_2$: from a putative spin liquid to field induced magnetic order — •M. Baenitz[1], K.M. Ranjith[1], Ph. Schlender[2], J. Sichelschmidt[1], B. Schmidt[1], H. Yasuoka[1], A.P. Mackenzie[1], and Th. Doert[2] — [1]MPI for Chemical Physics of Solids, D-01187 Dresden, Germany — [2]TU Dresden, Department of Chemistry and Food Chemistry, D-01062 Dresden, Germany

Spin orbit coupling (SOC) brought significant progress to the field of quantum spin liquids (QSLs). Having strong spin orbit entanglement promote Yb-based magnets to ideal prime candidates for QSLs and as such $NaYbS_2$ is a unique model system for planar spin 1/2 triangular lattice magnetism (TLM). In contrast to $YbMgGaO_4$ [1], which shares the same space group (R-3m) and highlighted as first SOC-TLM-QSL, $NaYbS_2$lacks inherent lattice distortions and Yb resides on a unique centrosymmetric position in the YbS_6 octahedron. Our comprehensive single crystal study combines bulk- and local- probes and identifies $NaYbS_2$ as a new spin orbit entangled TLM and putative QSL hosted on a perfect triangular lattice [2]. The application of fields along the (a,b)-plane introduces magnetic order, whereas for fields in the c-direction the system remains unaffected. We present magnetization, specific heat and NMR data down to 300 mK for both directions.
[1] J.A.M. Paddison et al., Nat. Phys. 13, 112 (2017)
[2] M. Baenitz et al.c arXiv:1809.01947 (2018)

MA 6.11 Mon 17:45 Theater

Frustrated Ising magnetism of $TmMgGaO_4$ — Yuesheng Li, •Alexander A. Tsirlin, and Philipp Gegenwart — EP VI, EKM, University of Augsburg, Germany

Motivated by the interesting spin-liquid physics of the triangular antiferromagnet $YbMgGaO_4$, we studied its Tm-based analog. Unlike Yb^{3+}, Tm^{3+} is a non-Kramers ion that would normally feature nonmagnetic singlet as the crystal-field ground state. However, random crystal electric field (CEF) caused by the random distribution of Mg and Ga in the structure mixes two lowest-lying CEF singlets into a quasidoublet that gives rise to Ising-like pseudospins with $g_\parallel \simeq 13.2$ and $g_\perp \simeq 0$. Low-temperature thermodynamic measurements indicate three field-induced phase transitions that can be broadly understood within the $J_1^{zz} - J_2^{zz}$ Ising model on the triangular lattice, albeit with a distribution of the critical fields and underlying exchange couplings. Interestingly, only one ordered state, the $\frac{1}{3}$-plateau below 2.5 T, shows long-range order confirmed by neutron diffraction, whereas other ordered states expected in the $J_1^{zz} - J_2^{zz}$ triangular Ising antiferromagnet seem to be only short-range in nature. Moreover, no zero-point entropy is observed.

MA 6.12 Mon 18:00 Theater

Low-energy spin excitations in the triangular-lattice quantum spin liquid candidate $YbMgGaO_4$ — •Yuesheng Li, Alexander Tsirlin, and Philipp Gegenwart — Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86159 Augsburg, Germany

$YbMgGaO_4$ was first proposed as a perfect triangular-lattice rare-earth quantum spin liquid (QSL) candidate in 2015. After that, several scenarios, such as the spin-liquid mimicry, valence bond (VB) glass, and spin-glass, were reported in the presence of the site-mixing disorder between nonmagnetic Mg^{2+} and Ga^{3+}. Here, we critically test these scenarios by probing the low-energy spin excitations of $YbMgGaO_4$ based on the low-T magnetization and triple-axis inelastic neutron scattering (INS) experiments. Our magnetization data measured down to 40 mK speak against any conventional freezing and reinstate YbMgGaO4 as a QSL candidate. The low-energy ($E \leq J_0 \sim 0.2$ meV) part of the INS continuum presents at low temperatures, but *completely* disappears upon warming the system above $T \gg J_0/k_B$. In contrast to the high-energy part at $E > J_0$ that is rooted in the breaking of nearest-neighbor VBs and persists to temperatures well above J_0/k_B, the low-energy one originates from the rearrangement of the valence bonds and thus from the propagation of unpaired spins. We further extend this picture to herbertsmithite, the QSL candidate on the kagome lattice, and argue that such a hierarchy of magnetic excitations may be a universal feature of QSLs.

MA 6.13 Mon 18:15 Theater

Randomness in the quantum spin liquid candidate κ-(BEDT-TTF)$_2$Cu$_2$(CN)$_3$ investigated by artificial distortion of the triangular lattice — •Yohei Saito[1], Andrej Pustogow[1], Roland Rösslhuber[1], Miriam Alonso[1], Maxim Wenzel[1], Anja Löhle[1], Martin Dressel[1], Takaaki Minamidate[2], Noriaki Matsunaga[2], Kazushige Nomura[2], and Atsushi Kawamoto[2] — [1]1. Physikalisches Inst., Universität Stuttgart, Germany — [2]Department of Physics, Hokkaido University, Sappro, Japan

The organic-molecular solid κ-(BEDT-TTF)$_2$Cu$_2$(CN)$_3$ is recognized as a quantum spin liquid candidate as it does not show magnetic ordering regardless of the large magnetic interactions. There is a debate about the importance of spin frustration on the triangular lattice and inherent randomness in the crystals. Does a suppression of geometrical frustration change the magnetic properties? To clarify that, we artificially distorted triangular lattices of κ-(BEDT-TTF)$_2$Cu$_2$(CN)$_3$ by donor molecular substitution that modifies exchange interactions. As a result, geometrical frustration is suppressed locally. We performed electric conductivity, dielectric spectroscopy, infrared spectroscopy, and 13C NMR measurements. Comparing results of non-substituted and substituted samples, we found that their magnetic fluctuation was the same as opposed to the remarkable impurity substitution effect of the conductivity. Thus, the electronic state of the (CN)$_3$ salt is already disordered even in the non-substituted sample, and that not only the ideal geometrical frustration but also the disorder effect should be considered.

MA 6.14 Mon 18:30 Theater

Thermal expansion studies on the spin-liquid candidate system κ-(BEDT-TTF)$_2$Ag$_2$(CN)$_3$ — •S. Hartmann[1], E. Gati[2], Y. Yoshida[3], G. Saito[4], and M. Lang[1] — [1]Physikalisches Institut, SFB/TR 49, Goethe-Uni Frankfurt, Germany — [2]Ames Laboratory, Iowa State University, USA — [3]Division of Chemistry, Kyoto University, Japan — [4]Toyota Physical and Chemical Research Institute, Nagakute, Japan

The search for the realization of a quantum spin-liquid (QSL) is a major concern for condensed matter physicists since its proposal in 1973. The entangled QSL state lacks magnetic ordering down to lowest temperatures where spins continue to fluctuate even at $T = 0$ K [1]. One way to experimentally realize a QSL is magnetic frustration of geometric origin, inherent to the quasi-2D triangular lattice of the organic charge-transfer salts κ-(BEDT-TTF)$_2X$, known as weak Mott insulators. We present results of ultra-high-resolution thermal expansion measurements on the newly-synthesized QSL-candidate system X = Ag$_2$(CN)$_3$. Our main finding includes pronounced broad extrema in the thermal expansion coefficient at $T \sim 18$ K along all three crystallographic directions which we assign to the effect of strong electronic correlations. The observed anomalies are qualitatively consistent with theoretical results based on the Hubbard model on a triangular lattice [2]. The directional anisotropy of the anomalies implies a ratio of the hopping integrals $t'/t < 1$.

[1] Balents, Nature 2010
[2] Kokalj, McKenzie, PRB 2015

MA 7: Magnetic Textures: Statics and Imaging I

Time: Monday 15:00–19:15 Location: H37

Invited Talk MA 7.1 Mon 15:00 H37

The Surface Spin Flop in Synthetic Antiferromagnets with Perpendicular Magnetic Anisotropy — •Benny Böhm[1], Nikolai Kiselev[2], Darius Pohl[3], Lorenzo Fallarino[4], Leopold Koch[1], Bernd Rellinghaus[3], Kornelius Nielsch[5], and Olav Hellwig[1,4] — [1]Chemnitz University of Technology — [2]Forschungszentrum Jülich and JARA — [3]TU Dresden — [4]Helmholtz-Zentrum Dresden-Rossendorf — [5]IFW Dresden

The talk will provide an introduction to the basic mechanism of the surface spin flop, a transition predicted theoretically for layered antiferromagnets 50 years ago by Mills et. al.[1]. We will present the experimental confirmation that this transition exists also in the case of out-of-plane magnetic anisotropy in addition to the in-plane case studied already earlier [2]. While the in-plane case requires single crystal substrates to create a uniaxial in-plane anisotropy, our out-of-plane easy axis system based on a magnetic multilayer system provides such a uniaxial anisotropy naturally and can thus be easily prepared on amorphous surfaces. Furthermore, we reveal a pathway to stabilize the surface spin flop state, usually only obtained for high external fields of about 0.5 T, also at remanence. Overall, our results make the out-of-plane surface spin flop state accessible for further studies without the requirement of single crystal substrates or external fields, thus opening up the possibility of dynamic studies as well as an easy integration into more complex structures.

[1] D. L. Mills, Phys. Rev. Lett. 20, 1968, p. 18-21
[2] R. W. Wang et al., Phys. Rev. Lett. 72, 1994, p. 920-923

MA 7.2 Mon 15:30 H37

Magnetic exchange interaction at the Fe/Ir(111) interface — •Sergey Tsurkan and Khalil Zakeri Lori — Heisenberg Spin-dynamics Group, Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, D-76131 Karlsruhe, Germany

The magnetic ground state of the Fe monolayer on Ir(111) has been observed to be a spontaneous skyrmion lattice. The formation of such an exotic ground state is attributed to the interplay between the Heisenberg exchange, four spin and Dzyaloshinskii-Moriya interaction [1]. However, these fundamental magnetic interactions in this system have not been measured quantitatively. In order to quantify these interactions we performed spin-polarized high resolution electron energy-loss spectroscopy experiments on a trilayer structure consisting of Co/Co/Fe epitaxially grown on Ir(111). By probing the magnon dispersion relation across the surface Brillouin zone we quantified the interfacial exchange interaction at the Fe/Ir(111) interface. Our results indicate that the Heisenberg exchange interaction in the interface Fe layer is very weak and exhibits a rather complex pattern. Such a weak exchange interaction in the presence of the Dzyaloshinskii-Moriya interaction would allow for the formation of the skyrmionic ground state.

[1] S. Heinze, *et al.*, Nature Physics **7**, 713 (2011).

The work has been supported by the Deutsche Forschungsgemeinschaft (DFG) through the Heisenberg Programme ZA 902/3-1 and the DFG grant ZA 902/4-1.

MA 7.3 Mon 15:45 H37

Diversity of magnetic phases occuring in perpendicular synthetic antiferromagnets — •Leopold Koch[1], Fabian Samad[1], Benny Böhm[1], Sven Stienen[2], Pierre Pudwell[1], and Olav Hellwig[1,2] — [1]Technische Universität Chemnitz, Reichenhainer Straße 70, 09126 Chemnitz — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden

Magnetic domain formation in synthetic antiferromagnets (SAF) consisting of layered thin films with perpendicular magnetic anisotropy and thin non-magnetic interlayers is determined by magnetic energies like interlayer exchange, interfacial anisotropy and demagnetization. The competitive character of the energies leads to a variety of stable magnetic configurations with characteristic domain patterns. We show that the energies depend on specific system parameters like films thicknesses or number of repeats and can therefore be easily controlled via the design of the multilayer. Furthermore, we show that also ex-situ manipulation like (focused) ion beam irradiation leads to a transition of the magnetic phases which provides a possibility to create lateral heterogeneous magnetic nanostructures.

Since the domain structures are highly reproducible and even compatible with amorphous substrates, the presented SAFs are suitable for a wide variety of applications.

MA 7.4 Mon 16:00 H37

Boundary-Driven Twist States in Systems with Broken Spatial Inversion Symmetry — •Karin Everschor-Sitte — Institute of Physics, Johannes Gutenberg-University Mainz

In the quest for miniaturising magnetic devices, the effects of boundaries and surfaces become increasingly important. Bulk properties are modified or even dominated by the properties of the surface of the sample. We derive the general micromagnetic boundary condition for ferromagnetic systems with broken inversion symmetry. Based on these we predict novel boundary-induced twist states in ferromagnetic systems with Dzyaloshinskii-Moriya interaction.[1] We show that these new spin structures can even be purely boundary-induced. Furthermore, they can significantly influence the ferromagnetic bulk state as well as magnetic textures such as domain walls and skyrmions in thin films[2] which might lead to observable effects in transport measurements.

[1] Hals, Everschor-Sitte, PRL **119**, 127203 (2017)
[2] Mulkers et al., PRB **98**, 064429 (2018)

MA 7.5 Mon 16:15 H37

Metamagnetic texture in a polar antiferromagnet — •Dmitry A. Sokolov[1], Ulrich Rössler[2], Naoki Kikugawa[3], Robert Cubitt[4], Andrew P. Mackenzie[1], Toni Helm[1], and Kurt Kummer[5] — [1]MPI CPfS, Dresden, Germany — [2]IFW, Dresden, Germany — [3]National Institute for Materials Science, Tsukuba, Japan — [4]Institut Laue-Langevin, Grenoble, France — [5]ESRF, Grenoble, France

We report a new type of mixed state between antiferromagnetism and ferromagnetism, which can be created in certain acentric materials. In the Small-Angle Neutron Scattering (SANS) experiments we observe a field-driven spin-state in the layered antiferromagnet Ca3Ru2O7, which is modulated on a scale between 8 and 20 nm and has both antiferromagnetic and ferromagnetic parts [1]. We call this state a metamagnetic texture and explain its appearance by the chiral twisting effects of the asymmetric Dzyaloshinskii-Moriya (DM) exchange. The observation can be understood as an extraordinary coexistence, in one thermodynamic state, of spin-orders belonging to different symmetries.

[1] Metamagnetic texture in a polar antiferromagnet, D. A. Sokolov et al., arXiv:1810.06247.

MA 7.6 Mon 16:30 H37

Investigation of focused ion beam irradiation induced magnetic spin textures in synthetic antiferromagnets — •Fabian Samad[1,2], Leopold Koch[1], Sri Sai Phani Kanth Arekapudi[1], and Olav Hellwig[1,2] — [1]Institute of Physics, Chemnitz University of Technology, Germany — [2]Institute for Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany

We study synthetic antiferromagnets (AF) consisting of ferromagnetic (FM) multilayers that are antiferromagnetically-coupled via nonmagnetic interlayers [1]. They possess various remarkable properties, such as very high domain wall velocities [2] and an absence of stray fields, making them interesting for possible future data storage applications. It was shown previously that the energy balance of those systems can be tuned by increasing the FM layer thickness, yielding a dipolar energy driven phase transition to a FM ground state [1].

In contrast, in our current work we use focused ion beam irradiation to locally change the energy balance between AF interlayer exchange and dipolar energy, using different ion beam energies and fluences. Therefore, we are able to create a rich variety of laterally coexisting magnetic phases and spin textures in different confinements. Detailed investigations of their interactions as well as their field reversal behavior are performed via in-field high-resolution magnetic force microscopy.

[1] Hellwig et al., J. Magn. Magn. Mater. 319, 13-55 (2007).
[2] Yang et al., Nat. Nanotechnol. 10, 221-226 (2015).

MA 7.7 Mon 16:45 H37

Magnetic bimerons as skyrmion analogues in in-plane magnets — •Börge Göbel[1], Alexander Mook[2], Jürgen Henk[2], Ingrid Mertig[1,2], and Oleg A. Tretiakov[3,4] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle (Saale), Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany — [3]Institute for Materials Research and Center for Science and Innovation in Spintronics, Tohoku University, Sendai 980-8577, Japan — [4]School of Physics, The University of New South Wales, Sydney 2052, Australia

A magnetic bimeron [1] is a pair of two merons and can be understood as the in-plane magnetized version of a skyrmion. Here [2] we theoretically predict the existence of single magnetic bimerons as well as bimeron crystals, and compare the emergent electrodynamics of bimerons with their skyrmion analogues. We show that bimeron crystals can be stabilized in frustrated magnets and analyze what crystal structure can stabilize bimerons or bimeron crystals via the Dzyaloshinskii-Moriya interaction. We point out that bimeron crystals, in contrast to skyrmion crystals, allow for the detection of a pure topological Hall effect. By means of micromagnetic simulations, we show that bimerons can be used as bits of information in in-plane magnetized racetrack devices, where they allow for current-driven motion for torque orientations that leave skyrmions in out-of-plane magnets stationary.

[1] Y. Kharkov, et al., Phys. Rev. Lett. 119, 207201 (2017)
[2] B. Göbel, et al., arXiv: 1811.07068 (2018)

15 min. break

MA 7.8 Mon 17:15 H37

THz and SANS study of magnons in BiFeO3 — •Dániel Gergely Farkas[1], Dávid Szaller[1,2], István Kézsmárki[1,3], Laur Peedu[4], Johan Viirok[4], Urmas Nagel[4], Toomas Rõõm[4], and Sándor Bordács[1] — [1]Department of Physics, BUTE, Hungary — [2]Institute of Solid State Physics, TU Wien, Austria — [3]Experimental Physics V., UA, Augsburg, Germany — [4]NICPB, Tallinn, Estonia

Multiferroic materials with coexisting and strongly coupled magnetic and ferroelectric orders have attracted much interest due to the novel phenomena they possess, such as magnetoelectric effect [1] and directional dichroism [2]. Among these compounds BiFeO3 has received special attention as it is one of the few known room-temperature multiferroics [3]. Previously we showed by using THz spectroscopy that in contrast to the theoretical models the (111) plane of BiFeO3 is almost isotropic and the magnetic field dependence of the excitation frequencies have hysteresis. With small angle neutron scattering (SANS) measurements we determined the low temperature behavior of the magnetic domains in external magnetic fields [4], which helped in the interpretation of the THz data. The improved picture of the magnetic domains supports all THz results including the isotropic (111) plane, selection rules and hysteresis of the mode frequencies. References: [1] M. Tokunaga, et al., Nat. Commun. 6, 5878 (2015). [2] I. Kézsmárki, et al., Phys. Rev. Lett. 106, 057403 (2011). [3] J. Moreau, et al., J. Phys. Chem. Solids 32, 1315 (1971). [4] S. Bordács, et al., Phys. Rev. Lett. 120, 147203 (2018).

MA 7.9 Mon 17:30 H37

LTEM and DPC measurements on room temperature magnetic skyrmions in Pt/Co/W multilayers — •S. Pöllath[3], T. Lin[1], H. Liu[2], Y. Zhang[4], B. Ji[1], N. Lei[1], J. J. Yun[5], L. Xi[5], D. Z. Yang[5], Z. Xing[1], Z. L. Wang[1], L. Sun[2], Y. Z. Wu[2], L. F. Yin[2], W. B. Wang[2], J. Shen[2], J. Zweck[3], C. H. Back[6], Y. G. Zhang[1], and Q. S. Zhao[1] — [1]Beihang University, Beijing 100191, China — [2]Fudan University, Shanghai 200433, China — [3]Universität Regensburg, Regensburg 93040, Germany — [4]Chinese Academy of Sciences, Beijing 100190, China — [5]School of Physical Science and Technology, Lanzhou University, Lanzhou 730000, China — [6]Technische Universität München, Garching 85748, Germany

In this work, measurements on Pt/Co/W multilayer systems using Transmission Electron Microscopy (TEM) in Lorentz (LTEM) and Differential Phase Contrast (DPC) mode are reported. In LTEM, the contrast mechanism of the Neel-type skyrmions is analyzed and used to estimate the skyrmion size with LTEM image contrast simulations. Phase diagrams are recorded showing the wide range of the skyrmion phase pocket in temperature. History dependent phase diagrams reveal that the thermodynamical existence of the observed skyrmions is rather allowed by the topological remnants of the stripe domains, than by a real thermodynamic phase. Further it is shown how DPC can be used to measure the skyrmion size in-focus.

MA 7.10 Mon 17:45 H37

Multi-k spin textures in the complex magnetic phase diagram of rare-earth copper compounds — •Wolfgang Simeth[1], Marein Rahn[2], Andreas Bauer[1], Robert Georgii[3], Matthias Gutmann[7], Vladimir Hutanu[3], Pascal Manuel[7], Martin Meven[3], Sebastian Mühlbauer[3], Kirill Nemkovski[4], Bachir Ouladdiaf[6], Karel Prokes[5], Tobias Schrader[3,4], and Christian Pfleiderer[1] — [1]Technische Universität München — [2]Los Alamos National Laboratory — [3]Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II) — [4]Forschungszentrum Jülich — [5]Helmholtz-Zentrum Berlin — [6]Institut Laue-Langevin — [7]ISIS neutron and muon source

The rare-earth intermetallics RCu (R = Ho, Tm, Er) condense in the centrosymmetric CsCl-structure. As a consequence of several competing interactions (itinerant, indirect exchange, quadrupolar interactions as well as crystal electric fields), a rich magnetic phase diagram with a multitude of phase pockets unfolds. In these phases, the localized 4f magnetic moments exhibit complex arrangements as magnetic ground states. For a proper determination of these structures, several neutron techniques were combined. Both as a function of temperature and field the compounds undergo phase transitions between several antiferromagnetic multi-k states. The textures we identified are highly non-collinear and exhibit modulations with a large wavelength in the range of nanometres.

MA 7.11 Mon 18:00 H37

Chiral Magnetic Skyrmions with Arbitrary Topological Charge — Filipp N. Rybakov[1] and •Nikolai N. Kiselev[2] — [1]Department of Physics, KTH-Royal Institute of Technology, SE-10691 Stockholm, Sweden — [2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

In many work related to study of magnetic skyrmions one can find the statement that in a conventional model of a chiral magnet the coexistence of stable skyrmion solutions with Q=*1 and Q= 1 is impossible. In this presentation we show that in fact a conventional model of chiral ferro- and antiferromagnets possesses an infinite number of skyrmion solutions with different value and sign of topological charge [1]. We provide a detailed description of the diverse morphology of new skyrmions and the corresponding energy dependencies of skyrmions with respect to their topological charge. Because the considered model is general it is expected that predicted phenomenon may occur in various compaunds including atomic layers, e.g., PdFe/Ir(111), rhombohedral GaV_4S_8 semiconductor, B20-type alloys as $Mn_{1-x}Fe_xGe$, $Mn_{1-x}Fe_xSi$, $Fe_{1-x}Co_xSi$, Cu_2OSeO_3, acentric tetragonal Heusler compounds.

[1] F. N. Rybakov, N. S. Kiselev, Chiral Magnetic Skyrmions with Arbitrary Topological Charge, arXiv:1806.00782

MA 7.12 Mon 18:15 H37

Entropic stabilization of magnetic skyrmions in ultrathin films — •Stephan von Malottki[1], Pavel F. Bessarab[2], Soumyajyoti Haldar[1], Anna Delin[3], and Stefan Heinze[1] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel — [2]School of Engineering and Natural Sciences - Science Institute, University of Iceland — [3]Department of Applied Physics, School of Engineering Sciences, KTH, Kista

We show that thermal stability of magnetic skyrmions can be strongly affected by entropic effects [1]. The lifetimes of isolated skyrmions in atomic Pd/Fe bilayers on Ir(111) and on Rh(111) are calculated in the framework of harmonic transition state theory based on an atomistic spin model parametrized from density functional theory. Depending on the system the attempt frequency for skyrmion collapse can change by up to nine orders of magnitude with the strength of the applied magnetic field. We demonstrate that this effect is due to a drastic change of entropy with skyrmion radius which opens a novel route towards stabilizing sub-10 nm skyrmions at room temperature.

[1] von Malottki *et al.*, arXiv:1811.12067

MA 7.13 Mon 18:30 H37

Electrically controllable magnetic switching and soliton motion in insulating magnetic garnets with perpendicular magnetic anisotropy — •Andrew Ross[1,2], Shilei Ding[1,2,3], Sven Becker[1], Yuichiro Kurokawa[1,4], Shruti Gupta[2], Jinbo Yang[3], Romain Lebrun[1], Gerhard Jakob[1,2], and Mathias Kläui[1,2,5] — [1]Johannes Gutenberg University, Mainz, Germany — [2]Staudinger Weg 7 — [3]Peking University, China — [4]Kyushu University, Japan — [5]QuSpin, Center for Quantum Spintronics, Norwegian University of Science and Technology, Norway

Insulating rare earth iron garnets (RIG), with low Gilbert damping, low pinning, and magnetic and angular momentum compensation points, show great promise for the field of spintronics[1]. Here we grow high quality TmIG ($Tm_3Fe_5O_{12}$)films by pulsed laser deposition. Over a range of thicknesses, perpendicular magnetic anisotropy is observed, tailored by lattice strain between film and substrate. Utilizing the (inverse) spin Hall effect in a neighboring heavy metal layer, electrical detection and control of the magnetic state is successfully achieved for low current densities. We investigate the switching of TmIG films as a function of in-plane and out of plane magnetic fields, highlighting a thickness dependence to the efficiency of the interfacial spin orbit torques in such an insulating system. [1] C. O. Avci et al, Nature Materials, 16 (2017)

MA 7.14 Mon 18:45 H37

Robust modulated magnetic phases in lacunar spinel $GaMo_4S_8$ — •Ádám Butykai[1], Dávid Szaller[2], László Balogh[1], László Ferenc Kiss[3], Lisa DeBeer-Schmitt[4], Hiroyuki Nakamura[5], Sándor Bordács[1], and István Kézsmárki[1,6] — [1]Department of Physics, Budapest University of Technology and Economics — [2]Institute of Solid State Physics, Vienna University of Technology — [3]Department of Experimental Solid State Physics, Wigner-MTA Research Centre for Physics — [4]Oak Ridge National Laboratory — [5]Department of Materials Science and Engineering, Kyoto University — [6]Center for Electronic Correlations and Magnetism, University of Augsburg

Two members of the lacunar spinel crystal family, GaV_4S_8 and GaV_4Se_8, featuring a polar symmetry, have been reported to host Néel-type skyrmions [1,2]. Here, we present a provisional magnetic phase diagram for the 4d cluster magnet $GaMo_4S_8$, based on the combination of magnetization and small-angle neutron scattering experiments. $GaMo_4S_8$ is isostructural with the two other lacunar spinels, but exhibits a markedly stronger spin-orbit interaction. As a result, the periodicity of the magnetic modulations is found to be two times smaller, ~ 10 nm, whereas the modulated magnetic phases extend from the Curie-temperature down to the lowest temperatures and show an extreme robustness against external fields up to 1.5-2 T.

[1] I. Kézsmárki *et al.*, Nat. Mat., **14**, 1116, (2015). [2] S. Bordács *et al.*, Sci. Rep., **7**, 7584, (2017).

MA 7.15 Mon 19:00 H37

Magnetic force microscopy investigation of spin textures in the ferromagnetic semimetal Fe_3Sn_2 — •Markus Altthaler[1], Dennis Meier[2], Mohammed Kassem[3], Vladimir Tsurkan[1], Stephan Krohns[1], and István Kézsmárki[1] — [1]Experimentalphysik V, EKM, Universität Augsburg, 86135 Augsburg — [2]Department of Materials Science and Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway — [3]Department of Physics, Assiut University, Assiut 71516, Egypt

Recently, Fe_3Sn_2 has been reported to exhibit a giant anomalous Hall effect [1] as well as a topological electronic structure [2] and to host magnetic skyrmions [3]. Z. Hou et al. [3] suggested that both uniaxial magnetic anisotropy and frustration due to the Kagome lattice play a significant role in the formation of skyrmions at room temperature in this compound. Our goal was to specify in more details the driving force of skyrmion formation, namely whether exchange frustration or uniaxial anisotropy competing with long-range dipolar interactions stabilize the skyrmions. In contrast to former observations of magnetic spirals and skyrmions in sub-micron thin lamellas, on the surface of bulk crystals we did not find such modulated structures, instead a dendrite pattern with fascinating magnetic field evolution was observed. The fact that the stability of skyrmions is restricted to thin lamellas implies that the uniaxial anisotropy competing with dipolar interactions is the main drive of skyrmion formation in Fe_3Sn_2.

[1] L. Ye et al., Nature **555** (2018), 638; [2] J.-X. Yin et al., Nature **562** (2018), 91; [3] Z. Hou et al., Adv. Mater. (2017), 1701144

MA 8: Magnonics

Time: Monday 15:00–18:45 Location: H52

MA 8.1 Mon 15:00 H52

Integrated magnonic half-adder — •Qi Wang[1], Roman Verba[2], Thomas Brächer[1], Philipp Pirro[1], and Andrii Chumak[1] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Institute of Magnetism, Kyiv 03680, Ukraine

Spin waves and their quanta, magnons, open up a promising branch of high-speed and low-power information processing. Several important milestones were achieved recently in the realization of separate magnonic data processing units. Nevertheless, the realization of an integrated magnonic circuit consisting of at least two logic gates and suitable for further integration is still an unresolved challenge. Here we demonstrate such an integrated circuit. We show a magnonic half-adder using micromagnetic simulations. The magnonic half-adder has a strikingly simple design, consisting of two components only. The first one is a linear directional coupler that combines two inputs in a planar fashion. The second one is a nonlinear directional coupler in which the coupling strength is strongly dependent on the input power and which perform simultaneously a XOR and an AND logic operation. All information is carried and controlled exclusively by magnons in the circuit.

MA 8.2 Mon 15:15 H52

Efficient Magnonic Spin Transport in Insulating Antiferromagnetic Thin Films — •Andrew Ross[1,2], Romain Lebrun[1], Scott Bender[3], Joel Cramer[1,2], Asaf Kay[4], David Ellis[4], Daniel Grave[4], Lorenzo Baldrati[1], Alireza Qaiumzedah[5], Arne Brataas[5], Anvar Rothschild[4], Rembert Duine[3,5,6], and Mathias Kläui[1,2,5] — [1]Johannes Gutenberg University Mainz, Germany — [2]Graduate School of Excellence MAINZ, Germany — [3]Utrecht University, The Netherlands — [4]Technion-Israel Institute of Technology, Israel — [5]QuSpin, Norwegian University of Science and Technology, Norway — [6]Eindhoven University of Technology, The Netherlands

Antiferromagnet (AF) insulators benefit from unparalleled stability in external fields, magnetisation dynamics at THz frequencies, a lack of stray fields and have been shown to exhibit low Gilbert damping, which enables efficient long-range propagation of magnons[1] as recently demonstrated[2]. Here we investigate the underlying mechanisms behind magnon transport in AF thin films. We find that efficient spin transport is possible across μm distances in nm thick thin films, contrary to previous studies reporting only nm spin-diffusion lengths in AF thin films[3]. By XMLD imaging of the AF domains we demonstrate the role of magnetic correlation in the propagation of magnons. We achieve efficient control over the AF system and establish the possibility to propagate long-distance spin-waves in AF thin films. [1] Chumak et al., Nature Phys. 11, 6 (2015), [2] Lebrun et al., Nature 561 (2018), [3] Cramer et al., J. Phys. D: Appl. Phys. 51, 14 (2018)

MA 8.3 Mon 15:30 H52

Phase-resolved imaging of non-linear spin-wave excitation at low magnetic bias field — •Rouven Dreyer, Lea Apel, Niklas Liebing, and Georg Woltersdorf — Martin Luther University Halle-Wittenberg, Institute of Physics, Von-Danckelmann-Platz 3, 06120 Halle (Saale), Germany

Recently it was shown that the prediction of the non-linear spin-wave excitation in the framework of Suhl instability processes is not adequate at low magnetic bias fields. In particular, it was shown by spatially averaged and time-resolved x-ray ferromagnetic resonance spectroscopy that in the low field regime non-linear spin waves are excited parametrically at 3/2 of the excitation frequency [1].

Here we demonstrate the 3/2 ω non-linear spin-wave (NLSW) excitation in $Ni_{80}Fe_{20}$ microstructures using time-resolved table-top magneto-optical microscopy. We have developed a novel variant of scanning magneto-optical microscopy which we term super-Nyquist sampling microscopy (SNS-MOKE) [2]. This technique allows for phase-resolved imaging of the sample at arbitrary frequencies. In this way we detect the parametrically excited NLSWs at 3/2 ω of the excitation frequency in space and time directly. The corresponding wave vectors obtained from the two dimensional Fourier transformation of the observed spin-wave pattern at 3/2 ω and higher harmonics are in agreement with the theoretical predictions from Bauer et al. [1].

[1] H. G. Bauer et al., Nat. Commun. 6:8274 (2015)
[2] R. Dreyer et al., arXiv:1803.04943 [cond-mat.mes-hall] (2018)

MA 8.4 Mon 15:45 H52

Magnon Bose-Einstein condensation in a wide temperature range — •Laura Mihalceanu, Dmytro A. Bozhko, Vitaliy I. Vasyuchka, Alexander A. Serga, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Today, magnon Bose-Einstein condensates (BEC) and supercurrents are experimentally confirmed phenomena, which exist on a macroscopic scale in parametrically driven spin systems at room-temperature. Allowing for a charge-free information transport and being, thus, free from ohmic heating these macroscopic quantum phenomena pave the path towards more efficient computing technologies. Specifically, they possess the potential for low power consumption information transfer and processing of phase-encoded data by nanometer-sized devices at GHz and THz frequencies. Temperature-dependent experiments provide valuable information about the magnon BEC as its lifetime, threshold, and coherency. Prior, we studied the relaxation behavior of parametrically injected magnons with wavenumbers ranging up to 6×10^5 rad cm^{-1} from 20K to 340K by means of the conventional microwave technique. Here, we incorporate the Brillouin Light Scattering (BLS) spectroscopy via the direct detection of condensed magnons at the bottom of the spin-wave spectrum. This allows us to investigate the magnon BEC formation, as well as magnon supercurrents in a wide range of temperatures. By comparing the microwave results with those of the BLS measurements, we reveal a correlation between the damping of the parametric magnons and the BEC formation.

MA 8.5 Mon 16:00 H52

Second sound in magnon Bose-Einstein condensate — •Halyna Yu. Musiienko-Shmarova[1], Dmytro A. Bozhko[1], Alexander J.E. Kreil[1], Alexander A. Serga[1], Anna Pomyalov[2], Victor S. L'vov[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot 76100, Israel

A macroscopic collective motion of a quantum condensate is commonly associated with phenomena such as superconductivity and superfluidity, often generalized by the term supercurrent. A quantum condensate supports also another type of motion – second sound. Second sound can be considered as a flow of elementary excitations of various types, which can propagate in a continuous medium with an almost linear dispersion law in the long-wavelength limit. Here, this refers to Bogoliubov waves with oscillations of both the amplitude and the phase of the Bose-Einstein Condensate's (BEC) wave function. We discovered a Bogoliubov wave, magnon second sound, in a magnon BEC prepared by microwave parametric pumping in a room-temperature yttrium iron garnet film. Furthermore, we demonstrate a transition from the supercurrent-type to the second-sound-type motion of the magnon BEC. Financial support from the ERC Advanced Grant "SuperMagnonics" is acknowledged.

MA 8.6 Mon 16:15 H52

Free standing 3D yttrium iron garnet nanobridges with very low Gilbert damping fabricated by room temperature laser deposition. — •Philip Trempler[1], Christoph Hauser[1], Philipp Geyer[1], Rouven Dreyer[1], Frank Heyroth[2], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, MLU Halle-Wittenberg, Germany

We have fabricated YIG nanobridges by electron beam lithography and room temperature laser deposition with subsequent recrystallization [1]. The structures are monocrystalline except for a single defect in the center of the span. In ferromagnetic resonance the linewidth is 140 *T at 8 GHz and the Gilbert damping can be as low as 2x10-4. Investigations with spatially and time resolved magneto-optic Kerr effect (TR-MOKE) show various resonant magnon modes in the 3D nanobridges. Additionally inductively detected FMR was performed on single YIG bridges confirming the low damping which is in the range typically known for high quality PLD grown YIG thin films. This makes these YIG bridges perfect candidates for more complex spintronic devices where coupling of magnons and mechanical oscillations is utilized [2]. By coupling these excitations to Qubits the structures may ultimately be used in transmons for quantum information processing [3].

[1] Heyroth, F., et al., arXiv:1802.03176 (2018)
[2] Tabuchi, Yutaka, et al, Phys. Rev. Lett. 113.8 (2014)
[3] Zhang, Xufeng, et al., Phys. Rev. Lett. 113.15 (2014)

MA 8.7 Mon 16:30 H52

Construction and investigation of spin wave lenses — •Philipp Geyer[1], Rouven Dreyer[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle (Saale), Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, Nanotechnikum Weinberg, 06120 Halle (Saale), Germany

Magnonics is a promising field to realize low energy information transmission and processing, just by excitation of the spin lattice and not by moving electrons. It has been shown experimentally, that spin waves passing through a lateral thickness variation in a magnetic thin film obey snell's law [1]. So, a controlled change of the dispersion parameters like film thickness or magnetic field can be used to focus a plane spin wave [2]. We present two different types of spin wave lenses that are realized by lateral patterning of thin film Yttrium-Iron-Garnet (YIG) fabricated by room temperature pulsed laser deposition and subsequent annealing [3]. Both types of lenses are designed for spin waves in Damon-Eshbach geometry. We investigate their functionality by micromagnetic simulations with mumax3 [4] and experimentally with spatially and time resolved magneto-optical Kerr effect (TR-MOKE) and ferromagnetic resonance (FMR) measurements.

[1] J. Stigloher et al., Phys. Rev. Lett. 117, 037204 (2016) [2] J. Toedt et al., Scientific Reports 6, 33169 (2016) [3] C. Hauser et al., Scientific Reports 6, 20827 (2016) [4] A. Vansteenkiste et al., AIP Advances 4, 107133 (2014)

MA 8.8 Mon 16:45 H52

Unidirectional spin wave propagation in a magnetic bilayer system — •Moritz Geilen[1], Matías Grassi[2], Morteza Mohseni[1], Yves Henry[2], Thomas Brächer[1], Damien Louis[2], Michel Hehn[3], Matthieu Bailleul[2], Burkard Hillebrands[1], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Germany — [2]Institut de Physique et Chimie des Matériaux de Strasbourg, CNRS and Université de Strasbourg, Strasbourg, France — [3]Institut Jean Lamour, Université de Lorraine, UMR 7198 CNRS, 54506 Vandoeuvre-lés-Nancy, France

We present the realization of a magnonic diode based on a magnetic bilayer system, which allows spin wave propagation effectively only in one direction. Spin waves traveling perpendicular to the static magnetization intrinsically show a non-reciprocal propagation. But as long as both surfaces of the film are equal and the film itself has homogenous material parameters across its thickness, the frequencies of counter-propagating spin waves are degenerate. This symmetry is broken in a magnetic bilayer system leading to a frequency shift between counter-propagating spin waves with the same wavelength, while leaving the good propagation characteristics of the materials unharmed. This non-reciprocal behaviour is studied in a CoFeB/Py bilayer film using wave-vector resolved Brillouin light scattering spectroscopy (BLS) and micromagnetic simulations. The spin wave propagation in the microstructured device is measured using BLS microscopy. It reveals unidirectional spin-wave propagation in a wide frequency range.

15 min. break

MA 8.9 Mon 17:15 H52

Magnonic crystals on atomic length scales — Huajun Qin[1,2], Sergey Tsurkan[1], Arthur Ernst[3,4], and •Khalil Zakeri Lori[1] — [1]Heisenberg Spin-dynamics Group, Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, D-76131 Karlsruhe, Germany — [2]NanoSpin, Department of Applied Physics, Aalto University School of Science, FI-00076 Aalto, Finland — [3]Institute for Theroretical Physics, Johannes Kepler University,Altenberger Str. 69, 4040 Linz, Austria — [4]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We discuss the possibility of designing atomic-scale magnonic crystals for operation in terahertz regime. Utilizing spin-polarized high-resolution electron energy-loss spectroscopy we investigate ferromagnetic multilayers composed of alternating layers of Fe and Co grown on different substrates. We show that in such atomically designed multilayers one can efficiently excite different magnon modes associated with the quantum confinement in the third dimension i.e., the direction perpendicular to the layers. We demonstrate experimentally that the magnonic band structure in these materials exhibits bands of allowed magnon states as well as forbidden gaps. The band structure can be tuned by changing the materials combination and the number of atomic layers. The work has been supported by the Deutsche Forschungsgemeinschaft (DFG) through the Heisenberg Programme ZA 902/3-1 and the DFG grant ZA 902/4-1.

MA 8.10 Mon 17:30 H52

Spin waves in disordered film and bulk samples — Pawel Buczek[1], •Martin Hoffmann[2], Wulf Wulfhekel[3], Khalil Zakeri[4], and Arthur Ernst[2,5] — [1]Fakultät Technik und Informatik, Hochschule für Angewandte Wissenschaften Hamburg, Germany — [2]Institute for Theoretical Physics, Johannes Kepler University Linz, Austria — [3]Physikalisches Institut, Karlsruhe Institute of Technology, Germany — [4]Heisenberg Spin-dynamics Group, Physikalisches Institut, Karlsruhe Institute of Technology, Germany — [5]Max Planck Institute of Microstructure Physics, Halle, Germany

In many studied materials and mixed compounds, the magnetic response and in particular the energy spectrum of magnons will be strongly influenced by different kinds of disorder. Thin films might consist of islands or alloys might form solid solutions. Hence, we need to take into account disorder as well, in order to describe magnons theoretically. We will present briefly the underlying theory of our two complementary approaches based on a Heisenberg model. The included effective interaction between magnetic moments entering the Heisenberg model can be obtained from first-principles using a self-consistent Green function method within the density functional theory. We demonstrate the application of both methods on experimentally relevant material systems: 3ML Co/Cu(001), 1ML Fe/Pd(001), and Fe-Co alloys. Taking into account the disorder improves a lot the agreement between the spin-polarized electron energy loss spectroscopy measurements and the theoretical results.

MA 8.11 Mon 17:45 H52

Frequency multiplication in ferromagnetic layers detected by diamond nitrogen-vacancy centers — •Chris Körner, Niklas Liebing, Rouven Dreyer, and Georg Woltersdorf — Martin Luther University Halle-Wittenberg

We demonstrate that inhomogenous magnetic properties can lead to frequency multiplication effects. Close to ferromagnetic resonance, this effect locally generates high harmonics of the magnetic driving field. In the experiment, we detect multiple harmonics as well as parametric excitations in thin ferromagnetic layers via scanning time-resolved Kerr microscopy (MOKE) [1]. The spatial frequencies of the response of the magnetic system increases at higher harmonics up to the diffraction-limited resolution of the microscope. Nitrogen-vacancy defect centers (NV-centers) in diamond can be used as local probe of magnetic fields. Here we employ a double-resonant optical detection of magnetic resonance (ODMR) in NV-centers in the vicinity of the ferromagnetic layer [2]. The NV-centers represent a highly localized probe for the dynamic magnetic fields produced by the precessing magnetization in the adjacent ferromagnet. By this means, it is possible to locally detect rf-magnetic fields with spatial frequencies beyond the optical diffraction limit of MOKE. We use this method to detect up to the 20th harmonic of the magnetic excitation frequency in Permalloy at low bias fields and frequencies (as low as 100 MHz) as well as parametric excitations at large driving amplitudes.

[1] R. Dreyer et al. arXiv:1803.04943 [cond-mat.mes-hall] (2018)
[2] C. S. Wolfe et al. ArXiv 1512.05418v2 (2016)

MA 8.12 Mon 18:00 H52

Propagating magnetic droplet solitons as moveable nano-scale spin-wave sources — •Morteza Mohseni[1], Thomas Brächer[1], Qi Wang[1], Majid Mohseni[2], Burkard Hillebrands[1], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany. — [2]Faculty of Physics, Shahid Beheshti University, Evin, Tehran 19839, Iran

Magnetic droplet solitons are strongly nonlinear magnetic nano-objects which can be formed in spin torque nano-oscillators with large perpendicular magnetic anisotropies. The droplet is a localized magnetodynamical soliton which can only be stabilized in the presence of the applied spin transfer torque. However, a propagating droplet can be an attractive information carrier since it can transport energy and momentum at the same time. Here, we propose a simple way to launch droplets in an inhomogeneous waveguide. We use the drift motion of a droplet and we show that in a system with broken translational symmetry, the droplet acquires momentum and starts to propagate. By using numerical simulations, we find that the droplet velocity is tunable via the strength of the broken symmetry and the size of the nano-contact. In addition, we demonstrate that the launched droplet can propagate up to several micrometers in a realistic system with reasonable damping. Finally, we demonstrate how a blowing droplet delivers its momentum to a highly non-reciprocal spin-wave burst. Such a propagating droplet can be used as a moveable spin-wave source in nano-scale magnonic networks.

MA 8.13 Mon 18:15 H52

Control and stimulation of three-magnon scattering in a magnetic vortex — •Lukas Körber[1,2], Katrin Schultheiss[1], Tobias Hula[1,3], Roman Verba[4], Toni Hache[1], and Helmut Schultheiss[1,2] — [1]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany — [3]Technische Universität Chemnitz, 09111 Chemnitz, Germany — [4]Institute of Magnetism, National Academy of Sciences of Ukraine, Kyiv 03680, Ukraine

When applying a large enough RF field amplitude, spin waves in a magnetic vortex disk can be forced to decay into two other spin waves via three-magnon scattering. These scattering processes obey certain selection rules. Here, we show that three-magnon scattering in such a system can be stimulated below the usual instability threshold. We further present how this may be integrated into magnonic conduits by coupling the vortex to a adjacent magnon waveguide. The authors acknowledge financial support from the Deutsche Forschungsgemeinschaft within programme SCHU 2922/1-1.

MA 8.14 Mon 18:30 H52

Temporal evolution of magnon-magnonen interactions in a magnetic vortex — •Tobias Hula[1], Katrin Schultheiss[1], Lukas Körber[1,2], Franziska Wehrmann[1], Kai Wagner[1], and Helmut Schultheiss[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany

Brillouin light scattering microscopy measurements on a Permalloy disk magnetized in the vortex state are presented. By applying a homogenous out-of-plane AC field with sufficiently large amplitudes it is possible to drive the spin waves in the nonlinear regime and initiate three- and four-magnon scattering processes.

Time resolved BLS microscopy is used to show that these pumping conditions cause cascades of different types of magnon-magnon interactions. It is shown, that the temporal transition of different scattering mechanisms can be tuned by the excitation frequency and amplitude.

Further, an experimental approach to determine the coupling between directly excited magnons and magnons excited via nonlinear scattering is presented. To rule out unknown parameters like lifetime and thermal population, tr-BLS measurements with two RF sources where performed.

MA 9: Cooperative phenomena: Spin structures and magnetic phase transitions

Time: Monday 15:00–17:00 Location: H53

MA 9.1 Mon 15:00 H53

Linearly coordinated Ni in the two-dimensional quantum magnet K_2NiO_2 — •Tanita J. Ballé, Laurin Brunner, Alexander A. Tsirlin, and Anton Jesche — EP VI, Center for Electronic Correlations and Magnetism, Augsburg University, 86135 Augsburg, Germany

A huge magnetic anisotropy and the highest known coercivity field of more than 11 T are observed in $Li_2[Li_{1-x}Fe_x]N$, one of the scarce rare-earth free hard magnets. In this compound an unquenched orbital moment is manifested, enabled by the perfect linear, twofold coordination of iron between nitrogen, that gives rise to these properties [1]. In order to investigate the limits in exploiting this geometrical motive to achieve stable magnetic moments, we investigated similar compounds [2]. We will discuss the magnetic properties of a new member of this series: K_2NiO_2 that contains nickel in linear, twofold coordination between oxygen.

Field- and temperature dependent measurements of the Magnetization were performed, complemented by heat capacity data. Density functional theory revealed moderately enhanced orbital contributions to the magnetic moment of nickel. The magnetic susceptibility was calculated in a Heisenberg model and is in reasonable agreement with experiment.

[1] A. Jesche *et al.* Nat. Commun. **5**:3333. doi: 10.1038/ncomms4333 (2014)

[2] P. Höhn, TJB *et al.* Inorganics 4, **42** (2016)

MA 9.2 Mon 15:15 H53

Structural and magnetic properties of the compounds of the series $Mn_{5-x}Fe_xSi_3$ (x=1,2,3) — •Mohammed Ait haddouch, Jörg Voigt, Nicolo Violini, Karen Friese, Jörg Persson, and Thomas Brückel — Jülich Centre for Neutron Science-2/Peter Grünberg Institut-4, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

The magnetic and the structural properties of the members of the $Mn_{5-x}Fe_xSi_3$ series with x=1,2,3 are investigated macroscopically and with diffraction methods to reexamine their structural and magnetic phase diagram using single crystalline specimen. Similar to the parent compound Mn_5Si_3, the compounds with x=1, 2, exhibit two antiferromagnetic phase transitions AF1 and AF2. In Mn_5Si_3 an inverse magneto-caloric effect is related to the transition from AF1→ AF2. The inverse magnetocaloric effect has been assigned to a transition from a spin wave excitation spectrum to a fluctuation dominated excitation spectrum when the magnetic structure is changed by application of an external magnetic field [1]. We are now interested in the changes of the magnetic structure if Mn is replaced by Fe. We present the similarities and differences when compared to the undoped parent compound and try to explain the transition from the AF structure found for low Fe content to an FM structure found at large Fe($x > 3$) content.

[1] N. Biniskos et al, PHYS REV LET 120,257205 (2018)

MA 9.3 Mon 15:30 H53

Weak ferromagnetism in Mn_3X (X=Sn, Ge, Ga) compounds — •Bendegúz Nyári[1], András Deák[1,2], Jerome Jackson[3], and László Szunyogh[1,2] — [1]Budapest University of Technology and Economics, Budapest, Hungary — [2]MTA-BME Condensed Matter Research Group, Budapest, Hungary — [3]STFC Scientific Computing Department, Warrington, UK

The intermetallic compounds Mn_3X (X=Sn, Ge, Ga) in hexagonal crystal structure show complex magnetic behavior. Neutron diffraction [1] and theoretical [2,3] studies reveal that these compounds have a triangular spin configuration displaying weak ferromagnetic deformation. In this work, we investigate theoretically the noncollinear magnetic structures of these compounds. Spin model parameters are obtained by using a spin-cluster expansion (SCE) technique. A model based on three magnetic sublattices allows both a group theoretical analysis and also a quantitative description of weak ferromagnetism. We also perform unconstrained and constrained LSDA calculations, where we focused on exploring the effect of spin-orbit coupling and induced moments. In case of Mn_3Sn, neutron diffraction experiments also reveal a helical modulation of the weak-ferromagnetic state along the z-axis not yet explained theoretically. We present detailed investigations on how these helical states appear in the isotropic Heisenberg model.

[1] S. Tomiyoshi *et al.*, J. Magn. Mater. 54–57, 1001 (1986)

[2] L. M. Sandratskii and J. Kübler, Phys. Rev. Lett. 76, 4963 (1996)

[3] D. Zhang *et al.* J. Phys.: Condens. Matter **25** (2013)

MA 9.4 Mon 15:45 H53

Electronic properties and spin waves of Mn5Si3 from first principles — •Flaviano José dos Santos[1], Nikolaos Biniskos[2,3], Manuel dos Santos Dias[1], Karin Schmalzl[2], Stefan Blügel[1], Stéphane Raymond[3], and Samir Lounis[1] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, Jülich, Germany — [2]Jülich Centre for Neutron Science, Forschungszentrum Jülich, Outstation at ILL, Grenoble, France — [3]Université Grenoble Alpes, CEA, INAC, MEM, Grenoble, France

Mn5Si3 is an antiferromagnet hosting rich physics, such as the inverse magnetocaloric effect [1] and a large anomalous Hall effect [2]. However, many questions remain unanswered [3-4], such as why some Mn magnetic moments vanish in its collinear phase, what is the role of spin fluctuations and what is the minimal magnetic model hamiltonian. We tackle some of these problems with DFT calculations using the full-potential Korringa-Kohn-Rostoker method including spin-orbit coupling. We investigated the electronic and magnetic properties of the system in different magnetic phases, also determining the magnetic exchange interactions and the magnetocrystalline anisotropy. We used a scheme for spin waves in noncollinear magnets [5] to compute the spin-wave energies as a function of the external magnetic field. Our theoretical results, with a single free parameter, are in good agreement with experimental data from neutron scattering. – [1] Biniskos et al., PRL 120, 257205(2018). [2] Sürgers et al., Sci. Rep. 7, 42982(2017). [3] Silva et al., JPCM 14, 8707(2002). [4] Gottschilch et al., J. Mater. Chem. 22, 15275(2012). [5] Dos Santos et al., PRB 97, 024431(2018).

MA 9.5 Mon 16:00 H53

Photo-induced excitation and its relaxation in the magnetic and polaronic microstructure of a manganite studied by Ehrenfest dynamics — •Sangeeta Rajpurohit[1], Michael ten Brink[1,2], and Peter Blöchl[1,2] — [1]Institute for Theoretical Physics, Technical University Clausthal, Germany — [2]Institute for Theoretical Physics, Universität Göttingen, Germany

With several recent experimental observations of the long-lived excited states, manganites are seen as promising candidates for the future energy devices. The theoretical understanding of relaxation process in the strongly correlated manganites by investigating the interplay of the charge, spin and lattice degrees is of great interest. A microscopic model, extracted from the first-principles calculations, is proposed to analyse the electronic, atomic and magnetic microstructure of the manganites. The model is used within the framework of the Ehrenfest-like dynamics to study the evolution of the photo-excited system. The time-dependent Schrodinger equation is adopted for the evolution of the electron wave functions and spin degree of freedom while the atoms are treated classically. The relaxation timescale and pathway in the photo-excited $Pr_{0.5}Ca_{0.5}MnO_3$, notably, depend on the light-pulse intensity. In the weak intensity case, the electronic sub-system relaxes through an ultrafast lattice-assisted conical intersection process. The spin dynamics on the sub-picosecond timescale plays a crucial role, besides lattice dynamics, if the system is subjected to a high-intensity light pulse. Interestingly, a new long-lived excited-state, exhibiting phase-separation, emerges at an intermediate light-pulse intensity.

MA 9.6 Mon 16:15 H53

Magnetic properties of novel Rare-Earth Molybdenum oxides — •Kseniia Denisova[1,2,3], Anna Shlyakhtina[4], Mahmoud Abdel-Hafiez[5], Maxim Avdeev[6], Peter Lemmens[2,3], Olga Volkova[1], and Alexander Vasiliev[1] — [1]Dept. of Phys., MSU, Moscow, Russia — [2]IPKM, TU-BS, Braunschweig, Germany — [3]LENA, TU-BS, Braunschweig, Germany — [4]SICP, Moscow, Russia — [5]CHPSTAR, Beijing, China — [6]ANSTO, Bragg Inst., NSW, Australia

Compounds with the general formula $Ln_6MoO_{12-\delta}$ attract attention as they contain both transition and rare-earth elements. Heavy rare-earth molybdenum oxides may crystallize in two different defect fluorite structures, i.e., cubic and rhombohedral ones [1,2]. The systematic experimental study of these series reveals that $Ln_6MoO_{12-\delta}$ in both structural modifications exhibit magnetism largely influenced by deviation from stoichiometry [3]. Supported by DFG-LE967/16-1, NUST "MISiS" Grant No. K2-2017-084 and RFBR project 16-03-00463a. [1] Schildhammer, et al., Chem. Mater. 28, 7487 (2016). [2] Shlyakhtina, et al., J. Mater. Chem. A 5, 7618 (2017). [3] Denisova, et al., J. Alloys and Comp. 778, 756 (2019).

MA 9.7 Mon 16:30 H53

Competition between Kondo and Kitaev Physics in a frustrated impurity coupled to a fermionic bath — •Tathagata Chowdhury, Ralf Bulla, and Achim Rosch — University of Cologne, Germany

Geometrically frustrated quantum impurities coupled to metallic leads have been shown to exhibit rich behavior with a quantum phase transition separating Kondo screened and local moment phases. Frustration in the quantum impurity can alternatively be introduced via Kitaev-couplings between different spins of the impurity cluster. We use the Numerical Renormalization Group (NRG) to study a range of systems where the quantum impurity comprising of a Kitaev cluster is coupled to a bath of non-interacting fermions. We characterize the ground state and intermediate unstable fixed points of the system in terms of the plaquette fluxes and determine the temperature dependence of the various crossover scales of the model. We also show that the model can be mapped at low temperatures to an effective two-impurity Kondo model.

MA 9.8 Mon 16:45 H53

Magnetism and magneto-elastic coupling in $LiFePO_4$ — Johannes Werner[1], Sven Sauerland[1], Changhyun Koo[1], Mahmoud Abdel-Hafiez[1,2], Christoph Neef[1], Sergei Zvyagin[3], and •Rüdiger Klingeler[1] — [1]Kirchhoff Institute of Physics, Heidelberg University, Heidelberg, Germany — [2]Physikalisches Institut, Goethe Universität, Frankfurt a.M., Germany — [3]High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

We report thermal expansion, magnetostriction, specific heat, static and pulsed-field magnetisation, and antiferromagnetic resonance studies on single-crystalline $LiFePO_4$ [1]. The evolution of long-range antiferromagnetic order at $T_N = 50.1(5)$ K which is associated with a significant magnetoelectric effect [2] features pronounced anomalies in the thermal expansion coefficients. Uniaxial pressure effects are positive for pressure along the *a*- and *b*-axes and only very small for p_c. This behaviour as well as anomalies in α appearing upon further cooling are discussed considering coupling of spin, structure, and dielectric properties. The magnetic phase diagram is mapped out. It features a spin-flop transition at $B \| b = 32$ T. Pulsed-field ESR experiments show closing of the AFM gap at B_{SF}. The AFM resonance modes are well described by a mean-field model employing orthorhombic anisotropy, DM interaction, and the excitation gap inferred from recent neutron data [3].

[1] C. Neef et al., J. Cryst. Growth 462, 50 (2017)
[2] R. Toft-Petersen et al., Phys. Rev. B 92, 024404 (2015)
[3] Y. Yiu et al., Phys. Rev. B 95, 104409 (2017)

MA 10: Poster Session: Topological Topics (joint session TT/MA)

Time: Monday 15:00–18:30 Location: Poster D

MA 10.1 Mon 15:00 Poster D

Helical edge state interferometry in a quantum spin Hall insulator — •Raul Stühler, André Kowalewski, Felix Reis, Johannes Weis, Jörg Schäfer, and Ralph Claessen — Physikalisches Institut (EP4) der Universität Würzburg, 97074 Würzburg, Germany

Since the discovery of the quantum spin Hall (QSH) effect, two-dimensional topological insulators (2D-TI) have constituted a promising system for spintronics and ballistic electronic transport. The latter property of 2D-TIs is based on exceptional quantum coherence of helical edge state electrons in the absence of time-reversal symmetry breaking. Notwithstanding, quantum interference between helical edge state electrons becomes relevant when a multitude of helical edge state pairs are being brought into direct proximity in a nano-constriction. Here we present the realization of a helical edge state nano-constriction embedded in the high-temperature 2D-TI bismuthene [1], formed by an anti-phase domain boundary of limited extent. Via STS, we prove quantum interference between counter propagating helical electrons and make use of an analogy to a Fabry-Pérot electronic resonator. Such interplay between quantum coherence and interference might be further exploited, e.g., as a controllable charge and spin current switch operated with gate voltages instead of magnetic fields [2].

[1] F. Reis et al., Science 357, 287-290, (2017)
[2] P. Sternativo, F. Dolcini, Phys. Rev. B 89, 035415 (2014).

MA 10.2 Mon 15:00 Poster D

Potassium-Induced n-Doping of the High-Temperature Quantum Spin Hall System Bismuthene on SiC(0001) — •Johannes Weis, André Kowalewski, Felix Reis, Raul Stühler, Felix Spriestersbach, Lenart Dudy, Victor Rogalev, Jörg Schäfer, and Ralph Claessen — Physikalisches Institut und Röntgen Center for Complex Material Systems, Universität Würzburg, D-97074 Würzburg, Germany

Bismuthene, a monolayer of Bi-atoms bonded onto a SiC(0001) substrate in a honeycomb lattice, has recently been experimentally realized [1]. This 2D system has a large band gap of approx. 0.8 eV and is a most promising candidate for the realization of the quantum spin Hall effect at room-temperature. Theoretical tight-binding and DFT calculations consistently predict the existance of helical edge states forming Dirac branches. While Reis et al. [1] showed proof for 1D metallic edge states spanning the 2D bulk band gap by means of STM and STS, up to date a direct experimental observation of the linear electron dispersion has not been reported and ARPES would be highly desirable.

One major obstacle here is the Fermi level being too close to the 2D bulk valence band maximum. Here we present the adsorption of potassium as a tool to shift the Fermi level above the predicted Dirac point in a controlled way. The effect of the dopant has been investigated both on an atomic level by STM and STS and spacially integraged by ARPES.

[1] F. Reis *et al.*, Science 357,287-290 (2017)

MA 10.3 Mon 15:00 Poster D

Electronic correlation effects on double Dirac semimetals — •Niklas Wagner[1], Domenico Di Sante[1], Sergio Ciuchi[2], and Giorgio Sangiovanni[1] — [1]Institut fuer Theoretische Physik und Astrophysik, Universitaet Wuerzburg, Germany — [2]Department of Physical and Chemical Sciences, University of L'Aquila, Italy

Particles without a high-energy analog, namely special multiple-degeneracy points in the electronic bandstructure of solids protected by fundamental symmetries of the underlying lattice, have been recently postulated in condensed matter physics [1]. A particularly interesting example is that of space groups Nr. 130 and 135, whose Brillouin zones host double Dirac points at high-symmetry points [2]. We study tight-binding models for these two space groups and look at the influence of electronic correlation on the eightfold degeneracies at the touching points of their valence and conduction bands. To this aim, we use methods ranging from simple approaches like the Hubbard-I and Hubbard-III approximations, to more sophisticated ones including DMFT and cluster extensions thereof [3].

[1] B. Bradlyn, et al., Science 353, aaf5037 (2016)
[2] B. Wieder, et al., PRL 116, 186402 (2016)
[3] D. Di Sante, et al., PRB 96, 121106(R) (2017)

MA 10.4 Mon 15:00 Poster D

Bychkov-Rashba Spin-Orbit Coupling Effects in a Multi-Band Tight-Binding Model of Graphene — •Thorben Schmirander, Marta Prada, and Daniela Pfannkuche — I. Institut für theoretische Physik - Universität Hamburg, Hamburg, Deutschland

The description of Dirac electrons in the band structure of graphene is commonly performed using effective tight binding models [1]. These effective models use single-orbital Hamiltonians with modified hopping parameters in order to account for the influence of the higher energy orbitals in graphene. We go beyond such effective models by including d-orbitals in an atomistic tight-binding model. The inclusion of the Bychkov-Rashba spin-orbit coupling splits each of the two Dirac cones into four distinct ones [2]. When considering a finite graphene sample, edge states occur, which cross the band gap and connect the Dirac cones at the K and K' point. These edge states are the key to the topological properties of graphene. The crossing of the edge states under the influence of Bychkov-Rashba spin-orbit coupling is examined by computing the winding number around each of the cones.

[1] van Miert, G., Juricic, V. and Morais Smith, C. Phys. Rev. B 90, 195414 (2014)
[2] van Gelderen, R. and Morais Smith, C., Phys. Rev. B 81, 125435 (2010)

MA 10.5 Mon 15:00 Poster D

Surface currents in Weyl semimetal nanowires — •Patrick Grössing, Daniel Hernangómez-Pérez, and Ferdinand Evers — Institute of Theoretical Physics, Regensburg University, D-93053 Regensburg (Germany)

We investigate the transport properties of thin wires made of a Weyl semimetal within the framework of a tight-binding model. Our focus is on bias induced surface currents in materials where time-reversal symmetry is broken because of magnetisation [1, 2]. Depending on the crystallographic growth direction, the current flow exhibits different patterns; in particular, large transverse (wrapping) currents can be observed. We perform a careful finite size analysis that reveals,. e. g., the interplay between quantum size effects and the Fermi arcs, which are a hallmark of the topological nature of the material [3, 4].

[1] P. Baireuther et al., New J. Phys. 18, 045009 (2016)
[2] A. Igarashi et al., Phys. Rev. B 95, 195306 (2017)
[3] F. D. M. Haldane, arXiv:1401.0529 (2014)
[4] Y. Chen et al., Phys. Rev. B 88, 125110 (2013)

MA 10.6 Mon 15:00 Poster D

Anomaly transport ingraphene and Weyl semimetals — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN,Campus Universitário Lagoa nova,59078-970 Natal, Brazil

Based on the quantum kinetic equations for systems with SU(2) structure, regularization-free density and pseudospin currents are calculated in Graphene and Weyl-systems realized as the infinite-mass limit of electrons with quadratic dispersion and a proper spin-orbit coupling. Correspondingly the currents possess no quasiparticle part but only anomalous parts. The intraband and interband conductivities are discussed. The optical conductivity agrees well with the experimental values using screened impurity scattering and an effective Zeeman field. The universal value of Hall conductivity is shown to be modified due to the Zeeman field. The chiral anomalous terms are shown to be derivable from a conserving transport theory and their usually believed origin is questioned.

[1] arXiv:1809.01547, arXiv:1806.06214, Phys. Rev. B 94 (2016) 165415, Phys. Rev. B 92 (2015) 245425, errata: Phys. Rev. B 93 (2016) 239904(E), Phys. Rev. B 92 (2015) 245426

MA 10.7 Mon 15:00 Poster D

Edge currents as a probe of the strongly spin-polarized topological noncentrosymmetric superconductors — •M. Biderang[1,2], M.H. Zare[3], H. Yavari[2], P. Thalmeier[4], and A. Akbari[1,5] — [1]Asia Pacific Center for Theoretical Physics, POSTECH, Pohang, Korea — [2]Department of Physics, University of

Isfahan, Isfahan, Iran — [3]Department of Physics, Faculty of Science, Qom University of Technology, Qom, Iran — [4]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [5]Department of Physics, POSTECH, Pohang, Korea

Recently the influence of antisymmetric spin-orbit coupling has been studied in novel topological superconductors such as half-Heusler compounds and artificial heterostructures. We investigate the effect of Rashba and/or Dresselhaus spin-orbit couplings on the band structure and topological properties of a two-dimensional noncentrosymmetric superconductor. For this goal, the topological helical edge modes are analyzed for different spin-orbit couplings as well as for several superconducting pairing symmetries. To explore the transport properties, we examine the response of the spin-polarized edge states to an exchange field in a superconductor-ferromagnet heterostructure. The broken chiral symmetry causes the unidirectional currents at opposite edges[1].

[1] M. Biderang et al., Phys. Rev. B 98, 014524 (2018)

MA 10.8 Mon 15:00 Poster D

Decoherence of Majorana edge modes under adiabatic drives — •Zihao Gao, Yuval Vinkler-Aviv, and Achim Rosch — Institute for Theoretical Physics, University of Cologne, D-50937 Cologne, Germany

We study how Majorana edge modes behave under adiabatic movement in the presence of disorder, interactions and thermal fluctuations. In a 1D Kitaev chain, zero-energy Majorana bound states are formed at the edges of the topological region. Such Majorana edge modes are robust due to protection by an energy gap and their spatial separation. Therefore they can effectively encode a qubit, and are believed to be useful for quantum computation. By controlling the chemical potential we have the ability to adiabatically move these Majorana edge modes. However, during this process, disorder, interactions and thermal fluctuations can be harmful to the fidelity of the Majorana qubit. We numerically calculate the time-evolution of a Majorana qubit in such a setup in order to measure the decoherence from different sources, applying approximations based on exploiting the adiabatic nature of the movement and the protection by the gap.

MA 10.9 Mon 15:00 Poster D

Anyonic statistics of quantum impurities in two dimensions — •Enderalp Yakaboylu and Mikhail Lemeshko — IST Austria (Institute of Science and Technology Austria)

We demonstrate that identical impurities immersed in a two-dimensional many-particle bath can be viewed as flux-tube-charged-particle composites described by fractional statistics. In particular, we find that the bath manifests itself as an external magnetic flux tube with respect to the impurities, and hence the time-reversal symmetry is broken for the effective Hamiltonian describing the impurities. The emerging flux tube acts as a statistical gauge field after a certain critical coupling. This critical coupling corresponds to the intersection point between the quasiparticle state and the phonon wing, where the angular momentum is transferred from the impurity to the bath. This amounts to a novel configuration with emerging anyons. The proposed setup paves the way to realizing anyons using electrons interacting with superfluid helium or lattice phonons, as well as using atomic impurities in ultracold gases [1].

[1] E. Yakaboylu and M. Lemeshko, Phys. Rev. B 98, 045402 (2018)

MA 10.10 Mon 15:00 Poster D

Truncation of lattice fractional quantum Hall Hamiltonians derived from CFT — •Srivatsa N. S[1], Dillip Nandy[2], and Anne E. B. Nielsen[3] — [1]MPIPKS, Dresden, Germany — [2]Aarhus University, Aarhus, Denmark — [3]MPIPKS, Dresden, Germany

Conformal field theory has recently been applied to derive few-body Hamiltonians whose ground states are lattice versions of fractional quantum Hall states. The exact lattice models involve interactions over long distances, which is difficult to realize in experiments. It seems, however, that such long-range interactions should not be necessary, as the correlations decay exponentially in the bulk. This poses the question, whether the Hamiltonians can be truncated to contain only local interactions without changing the physics of the ground state. Previous studies have in a couple of cases with particularly much symmetry obtained such local Hamiltonians by a combination of guesswork and numerical optimization. Here, we propose a different strategy to construct truncated Hamiltonians, which does not rely on optimization, and which can be applied independent of the choice of lattice. We test the approach on models with bosonic Laughlin-like ground states and find that the overlaps per site between the states constructed from conformal field theory and the ground states of the truncated models are higher than 0.98 for all the studied lattices.

MA 10.11 Mon 15:00 Poster D

Effects of topological line defects on two-dimensional electronic transport — •Nico Bassler and Kai Schmidt — Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany

We investigate the effect of topological line defects on the transport properties of two-dimensional electronic systems. Experimentally, this is mostly motivated by bilayer graphene which is known to host a superstructure of line defects separating AB- and BA-stacking domains. More concretely, we study microscopically specific arrangements of such line defects by calculating the conductance, local densities, and topological invariants using an effective one-particle description for bilayer graphene in a magnetic field. In addition, we compare our findings to the well-known Haldane model on the honeycomb lattice, which is exactly solvable in the absence of line defects and displays a topologically non-trivial band structure.

MA 10.12 Mon 15:00 Poster D

Robustness of Haah's code in a magnetic field — •Matthias Walther and Kai Phillip Schmidt — Institut für Theoretische Physik I FAU Erlangen-Nürnberg, Erlangen, Deutschland

Haah's cubic code is an exactly solvable three-dimensional quantum spin model realizing topological fracton order. It is a promising candidate for self correcting quantum memory due to its macroscopic energy barrier between different ground states. Here we analyse the quantum robustness of this topological fracton order in a homogeneous magnetic field at zero temperature. Technically, this is achieved by applying the method of perturbative continuous unitary transformations and a mean-field approach. In all cases studied, we find strong first-order phase transitions separating the topological fracton phase and the polarized phase.

MA 10.13 Mon 15:00 Poster D

Quantum phase transitions to topological Haldane phases in spin-one chains studied by linked-cluster expansions — •Patrick Adelhardt[1], Julian Gritsch[1], Marvin Hille[2], David Anselm Reiss[1], and Kai Phillip Schmidt[1] — [1]Institute for Theoretical Physics, FAU Erlangen-Nürnberg, Germany — [2]Lehrstuhl für Theoretische Physik 1, TU Dortmund, Germany

We use linked-cluster expansions to analyze the quantum phase transitions between symmetry-unbroken trivial and topological Haldane phases in two different spin-one chains. The first model is the spin-one Heisenberg chain in the presence of a single-ion anisotropy, while the second one is the dimerized spin-one Heisenberg chain. For both models, we determine the ground-state energy and the one-particle gap inside the nontopological phase as a high-order series using perturbative continuous unitary transformations. Extrapolations of the gap series are applied to locate the quantum critical point and to extract the associated critical exponent. We find that this approach works unsatisfactorily for the anisotropic chain, since the quality of the extrapolation appears insufficient due to the large correlation length exponent. In contrast, extrapolation schemes display very good convergence for the gap closing in the case of the dimerized spin-one Heisenberg chain.

MA 11: Focus Session: Magnetic materials for energy efficient applications

Time: Monday 15:45–18:45 Location: H38

Invited Talk MA 11.1 Mon 15:45 H38

Microstructure optimization for rare-earth efficient permanent magnets — •Thomas Schrefl[1], Johann Fischbacher[1], Alexander Kovacs[1], Lukas Exl[2], Kazuya Yokota[1,3], and Tetsuya Shoji[3] — [1]Danube University Krems, Austria — [2]Wolfgang Pauli Institute, c/o University of Vienna, Austria — [3]Toyota Motor Corporation, Japan

Permanent magnets are widely used in modern society including consumer electronics, transport, and power generation. The key figures of merit, coercive field and energy density product, depend on the interplay between the intrinsic magnetic properties and the microstructure. We use synthetically generated grain structures to model the influence of grain morphology and grain boundary phases on coercivity. By computing the lowest saddle point for magnetization switching we find the weakest point in the structure, where magnetization reversal starts. We apply machine learning to quantify the reduction of coercivity caused by different microstructural features. Again, regions where the local coercive field is much lower than the average can be identified. Our results suggest that adding heavy rare-earth elements through grain boundary diffusion to these specific regions only will be sufficient to increase coercivity. Thus, the magnet's performance and temperature stability may be improved with a minimum amount of heavy rare-earth elements. Examples will be given for $Nd_2Fe_{14}B$ and $SmFe_{11}Ti$ based magnets.

Work supported by Toyota Motor Corporation and the Austrian Science Fund (grant no F41, P31140).

Invited Talk MA 11.2 Mon 16:15 H38

Advanced methods for the development of high performance hard and soft magnetic materials — •Dagmar Goll and Gerhard Schneider — Aalen University, Materials Research Institute, Beethovenstr. 1, 73430 Aalen, Germany

Higher efficiency in electro mobility requires high performance and economic motor concepts. Recent progresses in the development of hard and soft magnetic materials and their production processes offer new possibilities to further improve electric energy converters. For permanent magnets remaining challenges are the dependence on critical rare earth elements and the limited possibility to optimize the microstructure to approach theoretical predictions of micromagnetism. Equally important is the minimization of magnetic losses in soft magnetic cores. Innovative synthesis processes like high-throughput experiments and additive manufacturing by laser powder bed fusion offer new degrees of flexibility. These allow optimized alloy compositions and microstructures as well as novel topological structures and multilayer composites. Selected examples for different hard and soft magnetic prototypes and their performance will be presented.

MA 11.3 Mon 16:45 H38

Microscopic insights into the disorder induced phase transition in FeRh thin films — •Benedikt Eggert[1], Alexander Schmeink[2,3], Kay Potzger[2], Jürgen Lindner[2], Jürgen Fassbender[2,3], Katharina Ollefs[1], Werner Keune[1], Rantej Bali[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [3]Dresden University of Technology, Germany

By employing ^{57}Fe conversion electron Mössbauer spectroscopy, we qualitatively determined the changes of the microscopic Fe moment of chemical disordered epitaxial B2-FeRh(001) thin films, where the chemical disorder has been induced by ion irradiation with Ne^{+}. Apart from the initial magnetic splitting at 25.4 T an additional sextet contribution arises with an hyperfine field of 27.4 T. A comparison between the structural disorder and the temperature induced phase transition shows a similar change of the ^{57}Fe hyperfine field as a function of the macroscopic magnetisation. This gives an indirect indication, that the metamagnetic phase transition proceeds via a defect-driven domain nucleation of ferromagnetic domains in the antiferromagnetic matrix, as it was suggested based on XPEEM and nano-XRD measurements along the phase transition [1]. We would like to thank the Ion Beam Center at Helmholtz-Zentrum Dresden-Rossendorf for providing the necessary facilities and acknowledge the financial support by DFG (WE2623/17-1).

[1] D. Keavney et al. Scientific Reports 8 1778 (2018)

15 min. break

Invited Talk MA 11.4 Mon 17:15 H38

Compositionally graded films as model systems to study magnetic materials for energy applications — •Nora Dempsey — Univ. Grenoble Alpes, CNRS/UGA, Grenoble INP, Institut Néel, Grenoble, France

Combinatorial thin film studies are being used for the screening and optimization of a range of functional materials [1]. The basic idea is to produce compositionally graded films, to allow high throughput screening of materials properties as a function of composition, as well as other processing parameters such as deposition temperature and post-deposition annealing. In this talk I will present studies of compositionally graded films of two types of magnetic materials of interest for energy applications, namely hard magnetic materials and magnetocaloric materials. Films were produced by sputtering asymmetric targets. Composition variations were characterised using EDX mapping while structural and magnetic characterisation was performed with SEM, XRD and magnetometry. A scanning polar MOKE set-up incorporating a bipolar pulsed magnetic field system capable of applying fields of up to 10 T was specifically developed for high throughput magnetic characterisation of these compositionally graded films [2]. The relationship between processing parameters and structural and magnetic properties will be presented.

[1] M. L. Green, I. Takeuchi, and J. Hattrick-Simpers, J. Appl. Phys. 113 (2013) 231101 [2] A. Dias, Gabriel Gomez, Dominique Givord, et al., AIP ADVANCES 7 (2017) 056227

Invited Talk MA 11.5 Mon 17:45 H38

Dissecting the magneto-structural transformation in materials with first-order field-induced transitions — •Konstantin Skokov — Technische Universität Darmstadt, 64287 Darmstadt, Germany

We report on a detailed study of the evolution occurring in the magnetic, electronic and structural subsystems of FeRh, La(FeSi)13, MnAs and Heuslers alloys, when the materials pass through a first-order field-induced transition. We have built a unique experimental setup which allows us to investigate the correlation between changes occurring in magnetization, magnetostriction, resistivity and the resulting magnetocaloric effect (MCE). The field-induced transitions from antiferromagnetic/paramagnetic to ferromagnetic states do not complete in one single step, as is commonly assumed. In fact, there are some well-distinguished and system dependent stages of the transition. In some stages the increase of magnetization and resulting MCE is the consequence of transformations taking place mainly in electronic subsystems containing carrying magnetic moment itinerant 3d electrons. In other stages the transformation in the electronic and magnetic subsystems is the result of lattice expansion/contraction. We demonstrate that it is possible to lock the sample in the intermediate state when the lattice parameters relate to the antiferromagnetic/paramagnetic state and the electronic structure and magnetization relate to the ferromagnetic state.

The work was supported by funding from the European Research Council (ERC), grant no. 743116 - project Cool Innov

MA 11.6 Mon 18:15 H38

Design of control field pulses to efficiently induce magnetic transitions — •Pavel F. Bessarab[1,2] and Grzegorz Kwiatkowski[1,3] — [1]University of Iceland, Reykjavík, Iceland — [2]ITMO University, St. Petersburg, Russia — [3]Immanuel Kant Baltic Federal Uni- versity, Kaliningrad, Russia

Control of magnetization switching is of critical importance for the development of novel, energy efficient magnetic memory devices. Transitions between stable magnetic states can follow various pathways which are not equivalent in terms of efficiency and required time. In this study, we propose a general theoretical approach to design external field pulses for efficient switching between magnetic states. The approach involves calculation of a minimum energy path (MEP) for desired magnetic transition and systematic identification of the temporal and spatial shape of the pulse needed to drive the system along the MEP.

The approach is applied to the magnetization switching in the atomically-thin Fe nanowires on Cu_2N surface, a system that has previously been studied extensively in the laboratory [1]. Short nanowires reverse their magnetization via coherent rotation which is induced by applying a uniform magnetic field. Transitions in longer chains involve nucleation and propagation of transient domain walls, for which a localized, time-dependent pulse needs to be applied. Our results demonstrate that efficient switching pulses can be predicted from first principles, contributing to the development of low-power technologies.

[1] A. Spinelli et al., Nature Mater. **13**, 782 (2014).

MA 11.7 Mon 18:30 H38

Computational Design of Heusler Alloys for Energy Applications — •Nuno M. Fortunato, Qiang Gao, Ingo Opahle, Oliver Gutfleisch, and Hongbin Zhang — Institute of Materials, TU Darmstadt, Darmstadt, Germany

Heusler alloys are multi-functional materials with a wide range of potential applications, among them permanent magnets and magnetic refrigeration, which are relevant for energy efficient industrial and commercial processes.

A great deal of experimental effort has been put into exploiting the Heusler family's large number of possible compositions and substitutional disorder. To accelerate this search we perform a high-throughput Density Functional Theory screening of material properties of stochiometric all-d-metal based Heuslers and MM'X (M=metal, X= main group) hexagonal/orthorhombic compounds [2], looking at the stability of the martensite and austenite phases.

Further, permanent magnet relevant properties like tetragonality, magnetic anisotropy energy, saturation magnetization and Curie temperature are calculated. We found 192 stable all-d-metal Heusler alloys where the martensite is the lower energy phase, of which 44 are also stable in the austenite. To elucidate the feasibility of these compounds as magnetocaloric materials we look at the Bain path, magneto-volume coupling [2], mechanical stability and interplay of magnetic and structural transition temperatures estimates.

[1] . A. Taubel et al., J. Phys. D: Appl. Phys **51**, 464005 (2017);
[2] . J.D. Bocarsly, et al., Chem. Mater. **29**, 1613 (2017);

MA 12: Spincaloric transport

Time: Monday 17:15–18:30 Location: H53

MA 12.1 Mon 17:15 H53

Magneto-thermoelectronic properties of Weyl semimetal Co2MnGa thin films — •H. Reichlova[1], R. Schlitz[1], S. Beckert[1], P. Swekis[1,2], A. Markou[2], Y. C. Cheng[2], D. Kriegner[2], S. Fabretti[1], G. H. Park[3,4], A. Niemann[3], S. Sudheendra[3], A. Thomas[3], K. Nielsch[3,4], C. Felser[2], and S. Goennenwein[1] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, Germany — [2]MPI CPfS, Dresden, Germany — [3]IFW Dresden, Institute for Metallic Materials, Germany — [4]Technische Universität Dresden, Institute of Materials Science, Germany

The non-trivial topology of the band structure of Weyl semimetals leads to unexpected magneto-thermoelectronic transport phenomena. A promising Weyl semimetal is the ferromagnetic Heusler compound Co_2MnGa with the Fermi energy in the vicinity of the Weyl nodes. Here we report the observation of a record large anomalous Nernst coefficent -2μV/K in Co_2MnGa thin films [1]. We will discuss the procedure for the quantitative determination of the thermal gradient and address potential artifacts potentially impacting the anomalous Nernst coefficient. Comparing the magnitude of the anomalous Nernst coefficient in Co_2MnGa films of different thickness, we conclude that the microscopic origin of the anomalous Nernst effect in Co_2MnGa is complex and contains contributions from the intrinsic Berry phase and surface states. [1] Reichlova *et al.*, APL 113, 212405 (2018)

MA 12.2 Mon 17:30 H53

Spin Seebeck Effect in Noncollinear Antiferromagnets — •Robin R. Neumann[1], Alexander Mook[1], Jürgen Henk[1], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität, D-06120 Halle — [2]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle

Applying a temperature gradient to a magnetic insulator results in a magnonic spin current response, a phenomenon that goes under the name "spin Seebeck effect" (SSE). To date the SSE has been measured in ferromagnets/ferrimagnets [1] or in collinear antiferromagnets in an external magnetic field [2]. However *in zero field* the SSE vanishes in collinear antiferromagnets [2] whereas *noncollinear* antiferromagnets exhibit a SSE, which we demonstrate theoretically by reference to the kagome antiferromagnet potassium iron jarosite. Our findings suggest to replace ferromagnets by antiferromagnets as the spin-active parts of next-generation spincaloritronic devices.

[1] Uchida *et al.*, Nat. Materials **9**, 894–897 (2010).
[2] Wu *et al.*, PRL **116**, 097204 (2016).

MA 12.3 Mon 17:45 H53

Anomalous Nernst effect in magnetic tunnel junctions: A concept for direction dependent temperature sensing — Ulrike Martens[1], Torsten Huebner[2], Henning Ulrichs[3], Oliver Reimer[2], Timo Kuschel[2], Ronnie Tamming[4], Chia-Lin Chang[4], Raanan Tobey[4], Andy Thomas[5], Markus Münzenberg[1], and •Jakob Walowski[1] — [1]Universität Greifswald, Greifswald, Germany — [2]Bielefeld University, Bielefeld, Germany — [3]Universität Göttingen, Göttingen, Germany — [4]University of Groningen, Groningen, The Netherlands — [5]IFW Dresden, Institute for Metallic Materials, Dresden, Germany

CoFeB/MgO based magnetic tunnel junctions (MTJs) exhibit a large tunnel magnetoresistence effect due to a high spin polarization given by the material combination. This enables information storage based on the magnetization state. Replacing the voltage as a driving force for the spin polarized currents by temperature gradients opens up new functionalities for these devices. By applying a homogeneous temperature gradient across the tunnel barrier, the tunneling magneto-Seebeck effect (TMS) can be used as a readout method, because the generated voltage is magnetization dependent. Inhomogeneous temperature gradients generate additional thermomagnetic effects, which have an impact on the TMS. Those effects, e.g. the anomalous Nernst effect (ANE), can be extracted by systematically changing the temperature gradient direction and measuring the TMS. We demonstrate, that analyzing the ANE with respect to the temperature gradient directions, allows for direction dependent temperature sensing.

MA 12.4 Mon 18:00 H53

Thermal Hall Effect in Noncollinear Coplanar Insulating Antiferromagnets — •Alexander Mook[1], Jürgen Henk[1], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität, D-06120 Halle — [2]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle

Recently, it was predicted and demonstrated that antiferromagnets can exhibit an anomalous Hall effect [1], which was traditionally ascribed to ferromagnets. Here, we show that insulating antiferromagnets can exhibit a thermal Hall effect due to their collective magnetic excitations, magnons. The two necessary requirements for the existence of this Hall effect are: (i) the breaking of an effective time-reversal symmetry and (ii) a magnetic point group compatible with ferromagnetism. Since the latter does not imply the actual presence of ferromagnetism, antiferromagnets with sufficiently low symmetry may meet both requirements. Such antiferromagnets are realized, for example, on the kagome lattice in the inverse vector chiral magnetic phase, as it occurs approximately in cadmium kapellasite [2].

[1] Chen *et al.*, PRL **112**, 017205 (2014); Kübler, Felser, EPL, **108**, 67001 (2014); Ajaya *et al.*, Science Advances **2**, e1501870 (2016).
[2] Okuma *et al.*, PRB **95**, 094427 (2017).

MA 12.5 Mon 18:15 H53

Impact of magnetic moment and anisotropy of $Co_{1-x}Fe_x$ thin films on the magnetic proximity effect of Pt — Panagiota Bougiatioti[1], Orestis Manos[1], Olga Kuschel[2], Joachim Wollschläger[2], Martin Tolkiehn[3], Sonia Francoual[3], and •Timo Kuschel[1] — [1]Center for Spinelectronic Materials and Devices, Bielefeld University, Germany — [2]Center of Physics and Chemistry of New Materials, Osnabrück University, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

We have investigated the magnetic proximity effect in Pt depending on the magnetic moment and anisotropy of adjacent metallic ferromagnetic films by x-ray resonant magnetic reflectivity at the Pt absorption edge (11565 eV) [1]. For Pt on different ferromagnetic metals such as $Ni_{1-x}Fe_x$ [2] and $Co_{1-x}Fe_x$ [3], we observe a linear dependence between the Pt magnetic moment and the moment of the adjacent ferromagnet. The largest Pt magnetic moment of $(0.72\pm0.03)\ \mu_B$ per spin polarized Pt atom has been detected in $Pt/Co_{0.33}Fe_{0.67}$ [3]. In addition, the Pt magnetic moment clearly follows the magnetic anisotropy of the ferromagnet below. This has been studied for Pt on Fe(001) and on $Co_{0.5}Fe_{0.5}$(001) with 45° rotated fourfold magnetocrystalline anisotropy as checked by magnetooptic Kerr effect [3]. In future work, the interplay of spin caloritronic and thermoelectric effects in these all-metallic bilayers will be explored.

[1] T. Kuschel et al., Phys. Rev. Lett. 115, 097401 (2015)
[2] C. Klewe et al., Phys. Rev. B 93, 214440 (2016)
[3] P. Bougiatioti et al., arXiv:1807.09032

MA 13: Frustrated Magnets - General 1 (joint session TT/MA)

Time: Tuesday 9:30–13:00 Location: Theater

MA 13.1 Tue 9:30 Theater

Ground state properties of the sawtooth chain — •Alexandros Metavitsiadis and Wolfram Brenig — Institute for Theoretical Physics, TU Braunschweig, 38106 Braunschweig, Germany

Recent experimental and theoretical studies on the natural mineral Atacamite [$Cu_2Cl(OH)_3$] have revealed that it might be one of the few true cases where a sawtooth chain, a minimal one-dimensional frustrated system, is materialized. Prompted by these recent results, we revisit the low energy properties of the sawtooth chain presenting a comprehensive theoretical study of its ground state properties using numerical techniques (full diagonalization, Lanczos, and matrix product states), as well as analytical field theory calculations.

MA 13.2 Tue 9:45 Theater

Magnetization plateau in the frustrated quantum sawtooth chain atacamite, $Cu_2Cl(OH)_3$ — •Leonie Heinze[1], Xiaxin Ding[2], Vivien Zapf[2], Franziska Weickert[2], Marcelo Jaime[2], Gaël Bastien[3], Anja U.B. Wolter[3], Manfred Reehuis[4], Jens-Uwe Hoffmann[4], Ralf Feyerherm[4], Dirk Menzel[1], Kirrily C. Rule[5], and Stefan Süllow[1] — [1]IPKM, TU Braunschweig, Braunschweig, Germany — [2]NHMFL, Los Alamos, USA — [3]IFW Dresden, Dresden, Germany — [4]HZB, Berlin, Germany — [5]ANSTO, Kirrawee, Australia

The frustrated nature of the quantum magnet atacamite, $Cu_2Cl(OH)_3$, is displayed by its magnetic properties [1]. Band structure calculations [2] suggest that the magnetic coupling scheme can essentially be understood in terms of a quantum sawtooth chain with a dominant coupling along the chain of about $J_1 \sim 100$ K, and a secondary coupling about $J_2 \sim 30$ K.

Here, we present new insights into the magnetic phase diagram of atacamite. We discuss the long-range ordered magnetic ground state below $T_N = 8.6$ K and present high field magnetization data revealing a 1/2-magnetization plateau. Magnetic saturation is estimated to be attained in fields between 75 to 80 T.

[1] L. Heinze, *et al.*, Physica B **536**, 377 (2018)
[2] H. O. Jeschke and R. Valentí, private communication.

MA 13.3 Tue 10:00 Theater

Phase diagram of the pseudo-Kagome francisite $Cu_3Bi(SeO_3)_2O_2Cl$ studied by high-resolution dilatometry — •Sven Spachmann[1], Liran Wang[1], Alexander Vasiliev[2], and Rüdiger Klingeler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Lomonosov Moscow State University, Moscow, Russia

Single crystals of the layered Kagome-like francisite $Cu_3Bi(SeO_3)_2O_2Cl$ have been studied by high-resolution thermal expansion and magnetostriction as well as by bulk magnetization measurements. At $B = 0$ T, in addition to a well-known structural phase transition at $T_s = 120$ K, long range antiferromagnetic order of the ferromagnetically coupled layers develops around $T_N = 26.4$ K. The ordering is associated with pronounced anomalies in the uniaxial thermal expansion coefficients. Magnetic fields yield a suppression of T_N. In plane, a sign change of the uniaxial pressure dependencies (at $B > 2$ T for $B \| a$) signals a change in the nature of the phase transition. At $T = 2$ K, metamagnetic transitions are observed for B parallel to the (in-plane) a-, b-, and (out-of-plane) c-axes at $B_C = 5.4$ T, 1.6 T, and 0.9 T, respectively. The transitions are associated with sharp magnetization jumps. The magnetic phase diagram for all three crystal axes is constructed and discussed.

MA 13.4 Tue 10:15 Theater

Magnetic excitations in the correlated paramagnetic state of the frustrated quantum antiferromagnet Cs_2CuCl_4 — •Bernd Wolf, Paul Eibisch, Lars Postulka, Franz Ritter, Cornelius Krellner, and Michael Lang — Physikalisches Institut, Goethe Universität, SFB/TR49, D-60438 Frankfurt (M)

We present a magnetoelastic investigation of the frustrated triangular-lattice S = 1/2 antiferromagnet Cs_2CuCl_4 by studying the longitudinal modes c_{11}, c_{22} and c_{33}. The measurements were performed in magnetic fields up to 10 T and down to 0.032 K to cover the the long range order and the spin-liquid regime. At the lowest temperatures of our experiment the field dependence of the c_{33} mode can be well described using a Landau free energy model which combines the elastic constant with the magnetic susceptibility data, measured independently. From fits to the experimental c_{33} data we obtain a very small magnetoelastic coupling constant $G/k_B = 2.8$ K for Cs_2CuCl_4 consistent with the results of susceptibility measurements under hydrostatic pressure. Remarkably, we find that the classical approach provides an excellent description of the data at lowest temperatures, i.e., close to the putative quantum critical point at B = 8.5 T of this material. However, at somewhat higher temperatures, there are deviations between the experimental data and the theoretical curves. At these temperatures we also observe anomalies in the ultrasonic attenuation α and χ'', the imaginary part of the magnetic susceptibility. We discuss these losses with respect to the peculiarities of the magnetic excitation spectrum for this low dimensional spin system.

MA 13.5 Tue 10:30 Theater

Thermodynamics of the 2D $S = 1/2$ Shastry-Sutherland Model and $SrCu_2(BO_3)_2$ — Alexander Wietek[1], Philippe Corboz[2], Frédéric Mila[3], Bruce Normand[4], Stefan Wessel[5], and •Andreas Honecker[6] — [1]Center for Computational Quantum Physics, Flatiron Institute, New York, USA — [2]Institute for Theoretical Physics and Delta Institute for Theoretical Physics, University of Amsterdam, The Netherlands — [3]Institute of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland — [4]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institute, Switzerland — [5]Institut für Theoretische Festkörperphysik, RWTH Aachen University, Germany — [6]Laboratoire de Physique Théorique et Modélisation, Université de Cergy-Pontoise, France

Reliable computation of the low-temperature thermodynamic properties of highly frustrated quantum magnets such as the 2D $S = 1/2$ Shastry-Sutherland model is a considerable challenge. Notwithstanding recent progress with QMC simulations in the dimer basis, the parameter regime relevant to $SrCu_2(BO_3)_2$ has remained inaccessible [1]. Here we present accurate results obtained from two other methods, namely Thermal Pure Quantum (TPQ) states and infinite Projected Entangled Pair States (iPEPS). We observe the emergence of a low-temperature peak in the specific heat C and relate it to the large number of bound states that emerge close to the first-order transition from the dimer to the plaquette phase.

[1] S. Wessel, I. Niesen, J. Stapmanns, B. Normand, F. Mila, P. Corboz, A. Honecker, Phys. Rev. B **98**, 174432 (2018)

MA 13.6 Tue 10:45 Theater

Theory of the intermediate phase of $SrCu_2(BO_3)_2$ under pressure — •Carolin Boos[1,2], Schelto Crone[3], Ido Niesen[3], Philippe Corboz[3], Frédéric Mila[2], and Kai Phillip Schmidt[1] — [1]FAU Erlangen-Nürnberg, Germany — [2]EPF Lausanne, Switzerland — [3]University of Amsterdam, Netherlands

Building on the NMR evidence that two different Cu sites are present in the intermediate phase of $SrCu_2(BO_3)_2$ under pressure, we investigate the nature of the intermediate phase in an orthorhombically distorted Shastry-Sutherland model. We show that a few percent difference between nearest-neighbor couplings is sufficient to destabilize the plaquette phase in favor of a one-dimensional phase in which bonds around half the full plaquettes become stronger. This phase is adiabatically connected to the Haldane phase that is stabilized when next-nearest neighbor couplings take different values, and the excitations in this one-dimensional phase are shown to agree qualitatively with neutron scattering results.

MA 13.7 Tue 11:00 Theater

Electron spin resonance studies on the frustrated tripod-Kagome compound $Mg_2Gd_3Sb_3O_{14}$ — •Christoph Wellm[1,2], Julian Zeisner[1,2], Mihai Sturza[1], Gaël Bastien[1,2], Sebastian Gass[1], Anja U.B. Wolter[1], Bernd Büchner[1,2], and Vladislav Kataev[1] — [1]Leibniz Institute for Solid State and Materials Research IFW Dresden, D-01171 — [2]Institut für Festkörper-und Materialphysik, TU Dresden, D-01062

As an example of a class of geometrically frustrated magnetic systems, the so-called tripod Kagome materials have been suggested as an interesting target of experimental investigation due to the frustrated nature and the question of dimensionality of the magnetic interactions. In our work we performed high-field electron spin resonance measurements on a powder sample of $Mg_2Gd_3Sb_3O_{14}$, a representative of a quasiclassical Heisenberg magnet, where the effect of spin-orbit coupling of Gd^{3+} ions vanishes to first order. Measurements were conducted over a frequency range of 70-420 GHz and temperatures ranging from 3-50 K. The Gaussian lineshape is consistent with a model of dominant dipolar spin-spin interactions, while the growing asymmetry of the lineshape upon decrease of temperature signifies an increase of an effective internal field, an indication of increasing short-range spin-spin-correlations. Such a behavior is typical for frustrated systems, making our studies one of the first to reveal such significant features in this family of materials. Furthermore, temperature dependent critical broadening of the linewidth and increase of the internal field strength provide insights into the dimensionality of the spin-spin correlations.

15 min. break.

MA 13.8 Tue 11:30 Theater

Frustrated magnetism of S=5/2 moments on a coupled triangular lattice in $Cs_3Fe_2Br_9$ — •Daniel Brüning[1], Tobias Fröhlich[1], Markus Braden[1], Ladislav Bohatý[2], Petra Becker[2], and Thomas Lorenz[1] — [1]II. Physikalisches Institut, Universität zu Köln, Deutschland — [2]Abteilung Kristallographie, Institut für Geologie und Mineralogie, Universität zu Köln, Deutschland

$Cs_3Fe_2Br_9$ is a hexagonal material consisting of Fe^{3+} ions with S=5/2 in face-sharing Fe_2Br_9 bi-octahedra, which form hexagonal double layers of the Fe ions. The triangular arrangement of the magnetic ions in the individual layers causes magnetic frustration. The type of magnetic ground state depends on the ratio between the magnetic exchange couplings: the intradimer coupling J, the intralayer (or in-plane) coupling J_p, and the interlayer coupling J_c. The magnetic ground state of $Cs_3Fe_2Br_9$ is not a singlet-dimer state as in isostructural $Cs_3Cr_2Br_9$ and $Cs_3Cr_2Cl_9$, but there is evidence for antiferromagnetic order with $T_N = 13.5$ K. However, our measurements up to 17 T on large single crystals reveal a very unusual magnetic field vs. temperature phase diagram. For an in-plane field, we find linear M(H) curves, whereas a field H$\|$c causes multiple phase transitions including a magnetization plateau of 1/3 $M_{sat} = 10\mu_B$. Neutron diffraction resolved the magnetic structure of two phases which indicate an increasing intralayer coupling. Additionally, we present pulsed-field magnetization measurements revealing further transitions, before reaching saturation around 40 T for H$\|$c.

This work was supported by the DFG through CRC 1238.

MA 13.9 Tue 11:45 Theater

Importance of biquadratic exchange for a new Ni-based quantum magnet of frustrated $S = 1$ isolated spin-triangles — •B Lenz[1], S Chattopadhyay[2], S Kanungo[3], NA Sushila[4], S K Panda[1], S Biermann[1,5], W Schnelle[6], K Manna[2], R Kataria[4], M Uhlarz[2], Y Skourski[2], S A Zvyagin[2], A Ponomaryov[2], T Herrmannsdörfer[2], R Patra[4], and J Wosnitza[2,7] — [1]CPHT, Ecole Polytechnique, Palaiseau, France — [2]Dresden High Magnetic Field Laboratory (HLD-EMFL), HZDR, Germany — [3]School of Physical Sciences, IIT Goa, India — [4]Department of Chemistry and Centre for Advanced Studies in Chemistry, Panjab University, India — [5]Collège de France, Paris, France — [6]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [7]Institut für Festkörper- und Materialphysik, TU Dresden, Germany

The new metal-organic framework BHAP-Ni_3 is comprised of essentially isolated spin-1 triangle centers, which renders this quantum magnet an ideal system to study the magnetism of a frustrated spin-triangle unit. Pulsed-field magnetometry and AC-susceptibility measurements of single-crystalline samples allow to identify a disordered magnetic ground state and a peculiar pronounced 2/3 magnetization plateau between 7T and 20T. Here, we show how theoretical modeling guided by ab initio calculations identifies the interplay of Heisenberg and biquadratic spin-spin interactions to be responsible for the stabilization of an exotic state that manifests itself in form of the 2/3 magnetization plateau.

MA 13.10 Tue 12:00 Theater

Estimating the density of states of frustrated spin systems — •Martin Weigel[1], Lev Barash[2], Jeffrey Marshall[3], and Itay Hen[3] — [1]Applied Mathematics Research Centre, Coventry University, Priory Street, Coventry, CV1 5FB, UK — [2]Landau Institute for Theoretical Physics, 142432 Chernogolovka, Russia — [3]Department of Physics and Astronomy, and Center for Quantum Information Science & Technology, University of Southern California, Los Angeles, California 90089, USA

Estimating the density of states of systems with rugged free energy landscapes is a notoriously difficult task of the utmost importance in many areas of physics ranging from spin glasses to biopolymers. Density of states estimation has also recently become an indispensable tool for the benchmarking of quantum annealers when these function as samplers. Some of the standard approaches suffer from a spurious convergence of the estimates to metastable minima, and these cases are particularly hard to detect. Here, we introduce a sampling technique based on population annealing enhanced with a multi-histogram analysis and report on its performance for spin glasses. We demonstrate its ability to overcome the pitfalls of other entropic samplers, resulting in some cases in orders of magnitude scaling advantages that can result in the uncovering of new physics. To do that we devise several schemes that allow us to achieve exact counts of the degeneracies of the tested instances.

MA 13.11 Tue 12:15 Theater

Ground states of the transverse-field long-range Ising model on infinite-cylinder triangular lattices — •Jan Koziol, Sebastian Fey, and Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, Staudtstraße 7, Universität Erlangen-Nürnberg, D-91058 Erlangen, Germany

To gain a better understanding of the interplay between frustrated long-range interactions and zero-temperature quantum fluctuations, we investigate the ground-state phase diagram of the transverse-field Ising model with algebraically-decaying long-range Ising interactions on quasi one-dimensional infinite-cylinder triangular lattices. Technically, we apply various approaches including low-field and high-field series expansions. For the classical long-range Ising model, we investigate cylindric triangular lattice configurations, i.e. a triangular lattice with an even finite length periodic boundary condition ($4 - 40$ lattice sites) in one direction and infinite extension in the other direction. We show the occurrence of new columnar-ordered phases differing from the infinitely degenerate nearest-neighbour Ising ground-state manifold on the two-dimensional triangular lattice. The existence of these columnar phases is connected to the long-range nature of the Ising interaction. For the full quantum model, we concentrate on cylinders with extensions four and six. The ground-state phase diagram consists of several quantum phases in both cases including a polarised phase, columnar-ordered phases, and ordered phases which emerge from an order by disorder scenario already present in the nearest-neighbour model.

MA 13.12 Tue 12:30 Theater

Quantum-criticality in two-dimensional transverse-field Ising models with frustrated long-range interactions — •Sebastian Fey, Sebastian C. Kapfer, and Kai P. Schmidt — FAU Erlangen-Nürnberg, Germany

Quantum-critical behavior is found in many quantum systems displaying universal properties such as critical exponents. In the past, most investigations of strongly correlated quantum many-body systems have tackled short-range interactions because long-range interacting systems are notoriously difficult to treat. Nevertheless, important examples of long-range interactions exist in nature, e.g. dipolar interactions in spin ice or long-range forces between cold atoms in optical lattices. Here, we present results for the frustrated long-range transverse-field Ising model (lrTFIM) with antiferromagnetic interactions on two-dimensional lattices obtained via linked-cluster expansions extended by classical Monte-Carlo integrations. It is found that the nature of the phase transition crucially depends on the lattice geometry: On the square lattice, the lrTFIM remains in the nearest-neighbor universality class for all algebraically-decaying interactions studied. In contrast, on the triangular lattice, the nature of the quantum phase transition changes from 3D XY universality to a first-order transition due to the presence of a stripe-ordered phase for very slowly-decaying Ising interactions.

MA 13.13 Tue 12:45 Theater

Magnetism of the N = 42 kagome lattice antiferromagnet — •Jürgen Schnack[1], Jörg Schulenburg[2], and Johannes Richter[3] — [1]Fakultät für Physik, Universität Bielefeld, Postfach 100131, D-33501 Bielefeld, Germany — [2]Universitätsrechenzentrum, Universität Magdeburg, D-39016 Magdeburg, Germany — [3]Institut für Physik, Universität Magdeburg, P.O. Box 4120, D-39016 Magdeburg, Germany and Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

For the paradigmatic frustrated spin-half Heisenberg antiferromagnet on the kagome lattice we performed large-scale numerical investigations of thermodynamic functions by means of the finite-temperature Lanczos method for system sizes of up to N = 42 [1]. We present the dependence of magnetization as well as specific heat on temperature and external field and show in particular that a finite-size scaling of specific heat supports the appearance of a low-temperature shoulder below the major maximum. This seems to be the result of a counterintuitive motion of the density of singlet states towards higher energies. Other interesting features that we discuss are the asymmetric melting of the 1/3 magnetization plateau as well the field dependence of the specific heat that exhibits characteristic features caused by the existence of a flat one-magnon band. By comparison with the unfrustrated square-lattice antiferromagnet the tremendous role of frustration in a wide temperature range is illustrated.

[1] Phys. Rev. B 98, 094423 (2018)

MA 14: INNOMAG e.V. Dissertationspreis 2019 / Ph.D. Thesis Prize

Die Arbeitsgemeinschaft Magnetismus der DPG hat einen Dissertationspreis ausgeschrieben, welcher auf der Frühjahrstagung der DPG 2019 in Regensburg vergeben wird. Ziel des Preises ist die Anerkennung herausragender Forschung im Rahmen einer Promotion und deren exzellente Vermittlung in Wort und Schrift. Im Rahmen dieser Sitzung tragen die besten der für ihre an einer deutschen Hochschule durchgeführten Dissertation Nominierten vor. Im direkten Anschluss entscheidet das Preiskommittee über den Gewinner des INNOMAG e.V. Dissertationspreises 2019. Talks will be given in English!

Time: Tuesday 9:30–11:30 Location: H48

MA 14.1 Tue 9:30 H48

Spin-charge coupled transport in two- and three-dimensional Rashba systems — •Sebastian Tölle — Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

Recent progress in the theoretical description of two- and three-dimensional systems with Rashba spin-orbit coupling is described. Based on a Boltzmann-like quasiclassical approach, the transport equations are derived and applied to the following three - experimentally relevant - setups. First, a generalization of the spin-motive force due to a proximity induced magnetization in a quasi two-dimensional electron gas is derived, highlighting, in particular, a novel 'inverse-spin-filter' contribution as the result of a consistent treatment of spin-orbit contributions to the Elliott-Yafet collision operator [1]. Second, a two-dimensional Rashba system laterally attached to a ferromagnet is considered. In this setup, current-induced spin-polarizations significantly affect the boundary conditions at the interface, leading to a non-trivial asymmetric magnetization-dependence of the magnetoresistance [2]. In the third setup, the Rashba system is extended to the third dimension and placed on top of a ferromagnetic insulator. Several qualitative features of related experiments are reproduced. In particular, it is shown that the anisotropy of the spin relaxation, enhanced due to the mass anisotropy, plays a major role for the interpretation of the observed signals [3].

[1] S. Tölle et al., Phys. Rev. B 95, 115404 (2016).
[2] S. Tölle et al., Ann. Phys. (Berlin) 530, 1700303 (2018).
[3] S. Tölle et al., New J. Phys. 20, 103024 (2018).

MA 14.2 Tue 10:00 H48

Spin-Orbit-Induced Dynamics of Chiral Magnetic Structures - Skyrmion Dynamics in Thin Film Devices at Varying Temperatures — •Kai Litzius — Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany — Max Planck Institute for Intelligent Systems, 70569 Stuttgart, Germany

Magnetic skyrmions are nanoscale magnetic quasi-particles with spherical topology. They are promising candidates for future spintronic devices such as the skyrmion racetrack memory. Interfacial systems, as studied here, cannot only provide a Dzyaloshinskii-Moriya interaction that stabilizes skyrmions, but also efficient spin dynamics, making them extremely promising for applications. This talk will provide an overview over the progress within the field of skyrmionics during the past four years. Special focus will be placed on the discovery of a sizable and drive dependent skyrmion Hall angle (SkHA) and the different theoretical models that have been put forward for the creep [1,2] and viscous flow [3] regime to explain this behavior. By X-ray microscopy with temperature control, we find that the underlying mechanism of the SkHA is independent of the temperature and identify the different mechanisms that lead to distinctly different angles in the creep and the flow regimes. Furthermore, we find highly temperature dependent skyrmion speeds and that higher temperatures are beneficial for efficient skyrmion motion. References: [1] Jiang et al., Nat. Phys. 13, 162-169 (2017). [2] Reichhardt & Reichhardt, New J. Phys. 18, 095005 (2016). [3] Litzius et al., Nat. Phys. 13, 170-175 (2017).

MA 14.3 Tue 10:30 H48

Topological properties of complex magnets from an advanced ab-initio Wannier description — •Jan-Philipp Hanke — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

Our understanding of many fundamental effects in solids has been revolutionized by the advent of Berry phases [1]. In particular, the recent discovery that Berry phases in momentum space relate to orbital electronic properties allows us to predict from theoretical arguments pronounced orbital magnetism in various situations, ranging from Rashba systems to Chern insulators [2-4]. We demonstrate that the combined complex geometry of real and momentum space manifests in topological orbital magnetism in non-collinear magnets, which offers new avenues for magnetization manipulation and large current-induced orbital responses in antiferromagnets [2,3]. By developing and applying advanced ab-initio methods [5,6], we finally predict that in insulators with non-trivial topologies the magnitude of magneto-electric effects in terms of spin-orbit torques can significantly exceed that of conventional metallic magnets, which lays out highly attractive perspectives for energy-efficient magnetization control of nanomagnets [7].

[1] M. Berry, Proc. R. Soc. Lond. A **392**, 45 (1984). [2] J.-P. Hanke et al, Phys. Rev. B **94**, 121114(R) (2016). [3] J.-P. Hanke et al, Sci. Rep. **7**, 41078 (2017). [4] D. Go, J.-P. Hanke et al, Sci. Rep. **7**, 46742 (2017). [5] J.-P. Hanke et al, Phys. Rev. B **91**, 184413 (2015). [6] J.-P. Hanke et al, J. Phys. Soc. Jpn. **87**, 041010 (2018). [7] J.-P. Hanke et al, Nature Comm. **8**, 1479 (2017).

MA 14.4 Tue 11:00 H48

Making Magnonic Spin Currents useful - propagation, manipulation and detection — •Joel Cramer — Institut für Physik, Johannes Gutenberg-Universität Mainz, Mainz, Germany — Graduate School of Excellence Materials Science in Mainz, Mainz, Germany

Magnon-based spintronic applications enable a promising alternative to charge-driven devices for information transport and processing [1]. I discuss different key aspects of magnon spintronics necessary to functionalize such spin currents. First, the efficient interconversion of spin and charge information by the (inverse) spin Hall effect in the binary alloy $Cu_{1-x}Ir_x$ [2] is demonstrated. In this material, the spin Hall effect exhibits a complex composition dependence with a maximum spin Hall angle near 40% Ir content. I will further compare and show that DC and THz spin currents exhibit similar behavior, revealing the functionality of spin-charge conversion up to THz speeds. Regarding magnon logic as a key feature of magnon spintronics, the spin-dependent (inverse) spin Hall effect in metallic ferromagnets like Co or $Co_{60}Fe_{20}B_{20}$ is demonstrated. In ferromagnetic resonance spin pumping [3] and non-local spin transport [4] measurements, it is shown that the spin detection efficiency strongly depends on the angle between that ferromagnet's magnetization and the spin current polarization. The distinct properties of spin-up and spin-down electrons in the ferromagnet allow one to implement a spin valve like effect using magnon detection with an amplitude of up to 120%. [1] Chumak *et al.*, Nat. Phys. 11, 453 (2015) [2] Cramer *et al.*, Nano Lett. 18, 1064-1069 (2018) [3] Cramer *et al.*, Nat. Commun. 9, 1089 (2018) [4] Cramer *et al.*, arXiv:1810.01227 (2018)

MA 15: Magnetism Poster A

Time: Tuesday 10:00–13:00 Location: Poster E

MA 15.1 Tue 10:00 Poster E

Asymmetric Skyrmion Hall Effect in Systems with Hybrid Dzyaloshinskii-Moriya Interaction — Kyoung-Whan Kim[1,2], Kyoung-Woong Moon[3], Nico Kerber[1,4], •Jonas Nothhelfer[1], and Karin Everschor-Sitte[1] — [1]Institute of Physics, JGU Mainz, Germany — [2]Center for Spintronics Korea Institute of science and Technology, Korea — [3]Spin Convergence Research Team, KRISS Daejeon, Korea — [4]Graduate School MAINZ, Staudinger Weg 9, Mainz, Germany

We demonstrate that magnetic skyrmions can move along the direction of a current without showing a skyrmion Hall effect in ferromagnetic thin films that are subject to both structural and bulk inversion asymmetry.[1] In such systems, a hybrid type of the Dzyaloshinskii-Moriya interaction (DMI) arises as a mixture of interfacial and bulk DMIs. We discuss the current-induced skyrmion dynamics and find that the spin-orbit-torque-induced skyrmion Hall angle is asymmetric for the two different skyrmion polarities, even allowing one of them to be tuned to zero. Our results can be understood within a simple picture by using a global spin rotation which maps the hybrid DMI model to an effective model containing purely interfacial DMI. In this sense, the formalism directly reveals the effective spin torque and effective current acting on systems with a hybrid DMI. We propose several experimental ways to achieve the necessary straight skyrmion motion for racetrack memories, even without any interaction with another magnet or an antiferromagnet. [1] K-W. Kim, K-W. Moon, N. Kerber, J. Nothhelfer, K. Everschor-Sitte, Phys. Rev. B **97**, 224427 (2018)

MA 15.2 Tue 10:00 Poster E

Hall effect and magnetoelectric effect in systems with toroidal order — •Oliver Busch[1], Börge Göbel[2], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther-Universität, D-06120 Halle — [2]Max-Planck-Institut für Materialforschung, D-06120 Halle

In systems that exhibit a toroidal moment the magnetoelectric effect arises due to antisymmetric time or space inversion symmetry [1]. The Hall effect and the magnetoelectric effect have already been predicted in metals without local inversion symmetry, described by a effective tight-binding model [2].

We examine a square-octagon lattice with regard to Hall effect and magnetoelectric effect based on a full *sp*-tight-binding model. Our model includes the description of coupling to the magnetic texture that causes toroidal order, spin-orbit coupling and *sp*-hybridization. We confirmed an asymmetric shift of the band structure in the direction of the toroidal moment that changes to a symmetric shift, if there is just *sp*-hybridization and spin-orbit coupling, but no toroidal order.

Breaking the combined TI-symmetry yields the topological Hall effect without spin-orbit coupling resp. the anomalous Hall effect in combination with spin-orbit coupling. Furthermore we show that the system gives rise to a transverse magnetoelectric Hall effect that vanishes for non toroidal order e.g. flux order. Last but not least we analyse the connection of the asymmetric shift and the magnetoelectric effect.

[1] N. Spaldin *et al.*, J. Phys.: Condens. Matter **20**, 434203 (2008).
[2] S. Hayami *et al.*, Phys. Rev. B **90**, 024432 (2014).

MA 15.3 Tue 10:00 Poster E

Electrical writing, deleting, reading, and moving of magnetic skyrmioniums in a racetrack device — Börge Göbel[1], •Alexander F. Schäffer[2], Jamal Berakdar[2], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle (Saale), Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany

A magnetic skyrmionium (also called 2π-skyrmion) can be understood as a skyrmion — a topologically non-trivial magnetic whirl — which is situated in the center of a second skyrmion with reversed magnetization.

In this contribution, we propose a new optoelectrical writing and deleting mechanism for skyrmioniums in thin films, as well as a reading mechanism based on the topological Hall voltage. Furthermore, we point out advantages for utilizing skyrmioniums as carriers of information in comparison to skyrmions with respect to the current-driven motion.

We simulate all four constituents of an operating skyrmionium-based racetrack storage device: creation, motion, detection and deletion of bits. The existence of a skyrmionium is thereby interpreted as '1' and its absence as '0' bit.

MA 15.4 Tue 10:00 Poster E

Atomistic simulation of electric field assisted writing and deleting of magnetic skyrmions — •Moritz A. Goerzen[1], Stephan v. Malottki[1], Pavel F. Bessarab[2], and Stefan Heinze[1] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel — [2]School of Engineering and Natural Sciences - Science Institute, University of Iceland

Future magnetic skyrmion technologies require a high degree of control of writing and deleting processes. While first experimental results demonstrate, that skyrmions can be nucleated and annihilated at will by varying electric field of a scanning-tunneling microscope tip [1], a theoretical understanding of the underlying effects is still missing. We attempt to clarify the role of the electric field in skyrmion creation and annihilation processes by means of atomistic spin dynamics simulations, minimum energy path calculations, transition state theory and density functional theory [2]. The influence of the electric field is modeled within linear response approximation to the surface magneto-electric effect and Rashba effect. We systematically study how the ground state and skyrmion stabilities are influenced by this parameter change caused by the electric field in Pd/Fe/Ir(111) system.
[1] Hsu *et al.*, Nat. Nano. **12**, 123 (2017)
[2] Haldar *et al.*, Phys. Rev. B **98**, 060413 (2018)

MA 15.5 Tue 10:00 Poster E

Anomalous Hall effect and magneto-optical Kerr effect of SrRuO3 based epitaxial multilayers — •LIN YANG, JÖRG SCHÖPF, LENA WYSOCKI, ROLF VERSTEEG, PAUL VAN LOOSDRECHT, and IONELA LINDFORS-VREJOIU — Universität zu Köln, II. Physikalisches Institut, 50933 Köln, Germany

Ferromagnetic heterostructures with strong interfacial Dzyaloshinskii-Moriya interaction (DMI) have been extensively studied, because they can host topologically non-trivial spin textures, such as skyrmions. The topological magnetic structures stabilized by interfacial DMI can be probed by the occurrence of the topological Hall effect (THE) in an experimental setup in which the anomalous Hall effect (AHE) can be simultaneously measured with the magneto-optic Kerr effect (MOKE). Here, we focus on the study of the AHE and MOKE of epitaxial heterostructures composed of ferromagnetic SrRuO3 and large spin-orbit coupling perovskite oxides, such as SrIrO3. We aim to elucidate the origins of the anomalies of the Hall resistivity exhibited by these heterostructures, as they have been previously assigned to the formation of skyrmions.

MA 15.6 Tue 10:00 Poster E

Floquet dynamics of a chiral magnet — •Nina del Ser and Achim Rosch — University of Cologne

We investigate how the magnon spectrum of a chiral magnet is affected by the application of a time-dependent magnetic field. Our model is a 3D spin lattice Hamiltonian with Heisenberg and Dzyaloshinskii-Moriya interactions driven by a spatially uniform, sinusoidally time-varying magnetic field. We expand analytically around the ground state conical spin arrangement using the Holstein-Primakoff formalism for bosonic excitations. Floquet theory is used to make progress with the time-dependent problem. We investigate the resulting Floquet band structure and study the role of possible instabilities which may occur when the external driving frequency resonantly couples different branches of the magnon spectrum.

MA 15.7 Tue 10:00 Poster E

Production of Inplane Skyrmion — •Venkata Krishna Bharadwaj[1], Kyoung-Whan Kim[2], and Karin Everschor-Sitte[1] — [1]Johannes Gutenberg-University, Mainz — [2]Center for Spintronics, Korea Institute of Science and Technology, South Korea

Magnetic skyrmions are topological magnetic whirls with a trivial magnetization configuration at their boundary. In thin films, most studies consider skyrmions with an out-of-plane easy axis anisotropy, where the magnetization at both the skyrmion centre and boundary is pointing perpendicular to the plane. In this work we analyze skyrmions in inplane magnets, [1] which have recently been observed [2,3]. We do a comparative study of their existence, stability and their properties to those of out-of-plane skyrmions. While in the absence of stray fields a global spin rotation maps an inplane skyrmion to its out-of-plane counterpart exactly, the presence of magnetostatic interactions changes the size and profile of the skyrmion. Furthermore, as the rotational symmetry around the axis perpendicular to the plane is broken, we study the skyrmion dynamics as a function of the relative angle between current and inplane magnetization direction. We also show by means of micromagnetic simulations that the 'blowing bubbles' technique, i.e. the creation of skyrmions due to current flow through constricted geometries, works for inplane skyrmions similar to their out-of-plane analogues [4]. [1] G. Chen et al., Nat. Commun. 8, 15302 (2017), [2] S. A. Meynell, et al., Physical Review B 96, 054402 (2017), [3] T. Yokouchi, et al., Journal of the Physical Society of Japan 84, 104708 (2015) [4] W.Jiang et al., Science 349, 283 (2015)

MA 15.8 Tue 10:00 Poster E

Optimizing spin-orbit torques and DMI in multilayer heterostructures — •Franziska Martin[1], Joel Cramer[1,2], Kyujoon Lee[1], Tom Seifert[3], Alexander Kronenberg[1], Felix Fuhrmann[1], Gerhard Jakob[1,2], Martin Jourdan[1,2], Tobias Kampfrath[3,4], and Mathias Kläui[1,2] — [1]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [2]Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany — [3]Department of Physical Chemistry, Fritz Haber Institute of the Max Planck Society, 14195 Berlin, Germany — [4]Department of Physics, Freie Universität Berlin, 14195 Berlin, Germany

The use of thin films in magnetic storage devices requires suitable materials that enable for instance ultra-fast and low power domain wall motion. The research of recent years has shown that tri-layers consisting of a heavy metal (HM), a ferromagnetic (FM) and an oxide layer are a promising system for spintronic applications [1]. In these, the combination of large spin-orbit torques [2] and chiral Néel domain walls due to the Dzyaloshinskii-Moriya interaction (DMI) [1] allow for fast domain wall motion. We have recently identified CuIr alloys with strong spin-orbit coupling leading to a large spin hall angle in the HM layer [2][3]. Making use of the large spin-orbit torques in Cu60Ir40, we quantify the DMI in a tri-layer system by current induced domain wall motion [4]. References: [1] A. Brataas et al., Nature Nano 9, 86 (2014), [2] J. Cramer et al., Nano Lett. 18, 1064 (2018), [3] T. Seifert et al., Nature Photon. 10, 483 (2016), [4] F. Martin et al., (in preparation)

MA 15.9 Tue 10:00 Poster E

Dipolar stabilized bubble-like skyrmions in Fe/Gd multilayers — •Michael Heigl[1], Zahra Inanloo Maranloo[1], Henrik Gabold[2], Peter Böni[2], and Manfred Albrecht[2] — [1]Experimental Physics IV, Institute of Physics, University of Augsburg, 86159 Augsburg, Germany — [2]Physics Department E13, Technical University of Munich, 85748 Garching, Germany

Magnetic skyrmions are topologically nontrivial chiral spin textures. Most skyrmionic structures studied in today's research are stabilized by the Dzyaloshinskii-Moriya interaction. In this work, we present a topologically similar spin structure stabilized by the competition of long-range dipolar energy in a thin film and domain wall energy. These chiral bubbles can be also described as dipolar stabilized skyrmions. [1]

We studied highly tunable ferrimagnetic multilayers consisting of Fe, Co and Gd. The layer structures with up to 80 bilayer repetitions are known for forming dipolar stabilized skyrmions [2]. They were magnetron sputtered at room temperature with each layer being thinner than 0.5 nm. We investigated dependent on composition, strain, field and temperature the formation of skyrmions and skyrmion lattices by SQUID magnetometry, magnetic force and lorentz transmission electron microscopy.

References:

[1] N. Nagaosa and Y. Tokura, Nat. Nanotech. 8, 899 (2013).

[2] S. A. Montoya et. al., Phys. Rev. B 95, 024415 (2017).

MA 15.10 Tue 10:00 Poster E

Spin structures in Fe/Rh bilayers on Re(0001) — •Souvik Paul, Stephan von Malottki, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel, Germany

Transition-metal-superconductor hybrid systems are promising candidates for realizing Majorana bound states, useful for topological quantum computation [1,2]. The prerequisite is a complex spin structure within the transition-metal layer. Here, we study Fe/Rh and Rh/Fe bilayers on Re(0001), a 5*d* transition-metal substrate with large spin-orbit coupling (SOC) strength which becomes superconducting at $T = 2.4$ K. Previously, it has been shown that Rh/Fe bilayers on Ir(111) can exhibit intriguing spin structures due to the competition of Dzyaloshinskii-Moriya interaction and higher-order exchange interactions [3]. Using density functional theory (DFT), we explore the magnetic phase space by calculating the energy dispersion of homogeneous flat spin spirals with and without SOC and by computing multi-Q states. From our DFT calculations, we parametrize an atomistic spin model which we study using spin dynamics simulations. This allows us to explore complex magnetic structures beyond those studied explicitly by DFT.

[1] H. Kim *et al.*, Sci Adv. **4**, eaar5251 (2018).

[2] A. Palacio-Morales *et al.*, arXiv:1809.04503.

[3] N. Romming*et al.* , Phys. Rev. Lett. **120**, 207201 (2018).

MA 15.11 Tue 10:00 Poster E

Magnetization hysteresis extraction from MFM images of ultra-thin SrRuO3-films — •Gerald Malsch[1], Dmytro Ivaneiko[1], Peter Milde[1], Lena Wysocki[2], Ionela Lindors-Vrejoiu[2], and Lukas Eng[1] — [1]TU Dresden, Institute for Applied Physics, TU Dresden, 01062 Dresden, Germany — [2]I. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany

Magnetic force microscopy (MFM) allows the imaging of the domain nucleation and growth during the magnetic switching of a ferromagnetic material. However, as the MFM signal strength cannot be directly translated to a local magnetization and the magnetization of the MFM tip itself is affected by the external field, the extraction of a full hysteresis loop from the analysis of MFM images is difficult. We present an algorithm using Otsu's thresholding method and two fixed thresholds that allows the extraction of a full approximate hysteresis loop from MFM images alone.

We exemplify our method with SrRuO3 (SRO) thin films grown on a stepped (100)-SrTiO3 substrate. SRO shows a strong dependency of the magnetic properties on the layer thickness [1], which we demonstrate by correlating the hysteresis data with atomic force measurements, and separately obtaining a hysteresis for each thickness.

[1] K. Ishigami et al, *Phys. Rev. B* 92, 064402 (2015)

MA 15.12 Tue 10:00 Poster E

Dzyaloshinskii-Moriya Interaction using Spin-Spirals in First

Principle Calculations — •Marius Weber[1,2], Ashok Pokhrel[1], Hans Christian Schneider[2], Tim Mewes[1], and Claudia Mewes[1] — [1]The University of Alabama, Tuscaloosa, USA — [2]University of Kaiserslautern, Kaiserslautern, Germany

The Dzyaloshinskii-Moriya Interaction (DMI) is an anti-symmetric exchange interaction and plays a crucial role in the generation of magnetic skyrmions. In order to utilize the DMI one needs a system with broken inversion symmetry, which can be realized in bulk with inherent broken inversion symmetry or in asymmetric multilayer structures, where a ferromagnetic metal is sandwiched between two different nonmagnetic metals with high spin orbit coupling. This work focuses on the analysis of the DMI vector in multilayer structures, such as Platinum/Cobalt/Iridium. The simulations employ first principles calculations based on Density Functional Theory (DFT) using the Vienna Ab initio Package (VASP). To determine the DMI vector we use a constrained simulation method and different spin spiral configurations [1,2]. Due to the anti-symmetric character of the DMI interaction one can extract the DMI contribution by comparing clockwise and anticlockwise spin spiral configurations.

Part of this project was sponsored by NSF CAREER #1452670 and DARPA #D18AP00011. M. Weber would like to thank the MINT center for financial support.

[1] Yang et al., Phys. Rev. Lett. 115, 267210 (2015)
[2] Xiang et al., Phys, Rev. B 84, 224429 (2011)

MA 15.13 Tue 10:00 Poster E

Temperature dependent investigation of stripe morphology and DMI determination from stripe width measurements in multilayer stacks — Nico Kerber[1,2], Kai Litzius[1,2,3], Jakub Zazvorka[1], Niklas Keil[1], Jonas Nothhelfer[1], Pedram Bassirian[1], •Boris Seng[1,2], Marco Asa[4], Ivan Lemesh[5], Markus Weigand[3], Simone Finizio[6], Jörg Raabe[6], Geoffrey D. Beach[5], and Mathias Kläui[1,2] — [1]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany. — [2]Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany. — [3]Max Planck Institute for Intelligent Systems, 70569 Stuttgart, Germany. — [4]Department of Physics, Politecnico di Milano, 20133 Milano, Italy. — [5]Department of Materials Science and ENgineering, Massassuchsetts Institute of Technology, Cambridge, Massassuchets 02139, USA. — [6]Swiss Light Source, Paul Scherrer Institut, Villigen PSI CH-5232, Switzerland.

The Dzyaloshinskii-Moriya Interaction (DMI) is recently in the focus of spintronics, due to its fundamental role in the stabilization of chiral magnetic textures in thin films, such as magnetic skyrmions and chiral domain walls. Since for applications good spin structure stability is required across a certain temperature range, the temperature dependence of the DMI is of great interest.

In this work, we investigate the temperature dependence of the DMI, using high-resolution transmission x-ray microscopy to image the evolution of spin textures with temperature and magnetic field in Pt/CoFeB/MgO systems.

MA 15.14 Tue 10:00 Poster E

Semi-analytical approaches for the radius of skyrmions in thin magnetic films — •Fabian R. Lux, Bernd Zimmermann, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich

The skyrmion radius is an important quantity for any skyrmion characterisation, motion and device concept. A closed analytic expression mapping micromagnetic parameters (A, D, K, H, M_s) to the skyrmion radius is unknown. Minimizing the micro-magnetic energy functional for the case of skyrmions in thin magnetic films is equivalent to the solution of the associated Euler-Lagrange equations – a set of highly nonlinear differential equations with no hope for an exact global solution in terms of closed form expressions [1]. However, as we demonstrate, the local analytic properties put strong constraints on possible trial functions which allow us to derive approximate results for the skyrmion radius, valid for a wide range of experimental parameters. Magnetostatic interactions can be included by renormalizing the material parameters for magnetocrystalline anisotropy energy and Dzyaloshinskii-Moriya interaction. Extending previous attempts to this problem [2-4], our approach gives a deep insight into the physical mechanisms by which a competition between local degrees of freedom condenses into an expression for the skyrmion radius.

[1] Leonov, A. O., *et al.* New J. Phys. **18**, 065003 (2016)
[2] Bernand-Mantel, A., *et al.* SciPost Phys. **4**, 027 (2018)
[3] Büttner, F., *et al.*, Sci. Rep. **8**, 4464 (2018)
[4] Wang, X. S., *et al.* Commun. Phys. **1**, 31 (2018)

MA 15.15 Tue 10:00 Poster E

Novel Topological Spin Textures in Helimagnetic FeGe — •Erik Lysne[1,2], Mariia Stepanova[1,2], Peggy Schoenherr[3], Jan Müller[4], Laura Köhler[5], Achim Rosch[4], Naoya Kanazawa[6], Yoshinori Tokura[6,7], Markus Garst[4,5], and Dennis Meier[1,2] — [1]NTNU, Trondheim, Norway — [2]Center for Quantum Spintronics, NTNU, Trondheim, Norway — [3]ETH Zurich, Zürich, Switzerland — [4]Universität zu Köln, Köln, Germany — [5]Technische Universität Dresden, Dresden, Germany — [6]University of Tokyo, Tokyo, Japan. — [7]RIKEN , Wako, Japan

In chiral magnets, the Dzyaloshinskii-Moriya interaction twists the magnetization and leads to a helimagnetic ground state. We use magnetic force microscopy (MFM) to investigate the magnetic long-range order in the near room-temperature helimagnet FeGe with nanoscale spatial resolution. Completely new types of magnetic domain walls are observed, connecting regions with different orientation of the helical structure. Analogous to the much-studied skyrmions, the walls can exhibit a nonzero topological winding number and, hence, possibly give rise to emergent electrodynamics. Our goal is to control the domain wall formation, demonstrating new opportunities for future applications in spintronics.

MA 15.16 Tue 10:00 Poster E

Switching dependence of single skyrmions on in-plane magnetic field — Florian Muckel, •Christian Holl, Marco Pratzer, and Markus Morgenstern — II. Physikalisches Institut B, RWTH Aachen University and JARA-FIT, Germany

We study single skyrmions of about 5 nm in diameter, which are created by applying an out-of-plane magnetic field to the PdFe atomic bilayer on Ir(111) [1]. Using spin-polarized scanning tunneling microscopy at 7 K, we observe a current dependent switching of these skyrmions between different defect positions. The skyrmions are pinned eccentrically at its rim and flip, e.g., in angle around this pinning position exploiting additional defects. The switching rate can be tuned by about 2 orders of magnitude via an in-plane magnetic field of up to 3 T. We also employed high frequency excitation voltages up to 15 GHz to the pinned skyrmions without compelling results yet. The results are compared with micromagnetic simulations based on density functional theory calculations of the interaction potential between different adsorbates and the skyrmions [2].

MA 15.17 Tue 10:00 Poster E

Large magnetocaloric effect in $Ni_2Cr_xMn_{(1.4-x)}In_{0.6}$ Heusler alloys — •C. Salazar-Mejia[1], P. Devi[2], S. Singh[3], C. Felser[2], and J. Wosnitza[1] — [1]High Magnetic Field Laboratory (HLD-EMFL), Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [3]School of Materials Science and Technology, Indian Institute of Technology (BHU), Varanasi, India

In the search for promising magnetocaloric materials for solid-state refrigeration, we have successfully prepared a new family of Heusler alloys, $Ni_2Cr_xMn_{(1.4-x)}In_{0.6}$. Based on the widely studied $Ni_2Mn_{1.4}In_{0.6}$, we have substituted Cr for Mn tuning the structural and the ferromagnetic transition towards lower temperatures. All samples show a structural transition at a temperature located between 200 and 300 K. Here, we present our results on the adiabatic temperature change, ΔT_{ad}, in these compounds under applied magnetic-field pulses of 2 and 6 T. The samples exhibit a large inverse magnetocaloric effect (temperature decrease under field application) due to the martensitic transition and a conventional effect (temperature increase under field application) due the ferromagnetic transition. For instance, the $Ni_2Cr_{0.1}Mn_{1.3}In_{0.6}$ alloy exhibits $\Delta T_{ad} = 5$ K at $T_0 = 315$ K and a large adiabatic temperature change of $\Delta T_{ad} = -7$ K at $T_0 = 270$ K under first field application and −5.7 K after second field application, for a field change of 6 T.

[1]M. Ghorbani Zavareh et al., Appl. Phys. Lett. **106**, 071904 (2015).

MA 15.18 Tue 10:00 Poster E

Effects of decomposition on the magnetocaloric effect in Ni-Co-Mn-In Heusler-based compounds — •Merivan Sasmaz[1], Felix Dreist[2], Michael Farle[2], and Mehmet Acet[2] — [1]Physics Department, Adiyaman University, Adiyaman, Turkey — [2]Experimentalphysik AG Farle Universität Duisburg-Essen, Duisburg

Off-stoichiometric Ni-based Heusler compounds in the form

$Ni_{50}Mn_{25+x}Z_{25-x}$ decompose into full Heusler, $Ni_{50}Mn_{25}Z_{25}$, and $Ni_{50}Mn_{50}$ components when annealed in the temperature range $650 \leq T \leq 750$ K. Compounds that are considered in relation to magnetocaloric effects also fall in this composition range, so that any decomposition resulting from heat treatments can influence the magnetocaloric properties. Here we study systematically the effect of decomposition on the magnetocaloric properties of $Ni_{46}Co_7Mn_{35}Z_{12}$, which is known to be a prototype inverse magnetocaloric material. We follow the decomposition process from time-dependent magnetization measurements at 750 K and determine entropy-changes from field-dependent magnetization measurements. Although a broadening of the hysteresis increases in the decomposed state, the entropy-change is found to increase, while the martensitic transition temperatures and the Curie temperature shifts, indicating both a change in the composition and the degree of $L2_1$ ordering.

MA 15.19 Tue 10:00 Poster E

Adiabatic T-change and thermal relaxation of magnetocaloric core-shell wires — •Alexander Funk[1], Tino Gottschall[2], Lukas Beyer[1], Anja Waske[3], and Maria Krautz[1] — [1]IFW Dresden, Germany — [2]HZDR Dresden, Germany — [3]BAM Berlin, Germany

Conventional magnetocaloric materials (MCMs) generate or release heat when magnetized or demagnetized. This effect can be utilized in a cooling device. Although materials and prototypes have been investigated deeply for the last two decades [1], the shaping of the MCMs into complex heat exchanger geometries (HEG) is still challenging.

One possibility to overcome shaping difficulties is to combine MCMs to composites with a 2nd binder phase, e.g. polymers or ductile metals [2]. The composite's shape is commonly limited to plates, however recently magnetocaloric core-shell wires, based on a $La(Fe,Co,Si)_{13}$-core and a steel-shell, were presented [3]. Such wires are versatile semi-finished products, which can be assembled to different HEG [4].

In this work, the adiabatic T-change of the core and the shell were assessed by pulse-field measurements in 2T, 5T and 10T. By monitoring the temperature change on both components simultaneously, the thermal transfer between core and shell is investigated. The thermal relaxation of the wire was also investigated via optical infrared microscopy and FEM-simulation.

[1] Franco et al., Progress in Materials Science 93, 2018. [2] Radulov et al., Acta Materialia, 2017. [3] Funk et al., Materials Today Energy 9, 2018. [4] Trevizoli et al., Applied Energy 187, 2017.

MA 15.20 Tue 10:00 Poster E

Magnetic properties of centered spin-rings — •Jonas Heinze and Jürgen Schnack — Fakultät für Physik, Universität Bielefeld, D-33501 Bielefeld

The magnetic properties of centered spin-rings with J_1-J_2-Heisenberg-interaction are determined by exact diagonalization. We characterize the ground state as well as excited states by their respective quantum numbers and investigate the dependence of the latter on the ratio J_1/J_2. General rules are suggested if possible.

MA 15.21 Tue 10:00 Poster E

High-field ESR study of giant single ion magnetic anisotropy in $Li_2(Li_{1-x}Co_x)N$ — •Y. Krupskaya[1], T. Ballé[2], L. Puntigam[2], A. Jesche[2], Z. Zangeneh[1], L. Xu[1], L. Hozoi[1], B. Büchner[1], and V. Kataev[1] — [1]IFW Dresden, Germany — [2]Augsburg University, Germany

Recently an extreme, uniaxial magnetic anisotropy and large magnetic hysteresis were observed in the $Li_2(Li_{1-x}Fe_x)N$ compound [1]. Static magnetization measurements revealed a coercivity field of over 11 T at T = 2 K and allowed to estimate a magnetic anisotropy field of 220 T. Substitution of Fe with other transition metal ions allows to alternate the sign of the magnetic anisotropy, resulting in easy plane - easy axis - easy plane - easy axis configurations when progressing along the Mn - Fe - Co - Ni series [2]. We have studied a $Li_2(Li_{1-x}Co_x)N$ single crystal with x = 0.01 by means of high-field multi-frequency electron spin resonance spectroscopy (HF-ESR), which is known as an efficient tool to directly measure the magnetic anisotropy energy in single-molecule magnets. The measurements have been performed in magnetic fields up to 16 T and excitation frequencies up to 750 GHz. HF-ESR results clearly evidence easy-plane magnetic behavior and enable to determine a Co-ion magnetic anisotropy gap of 972 GHz, in agreement with *ab initio* quantum chemical calculations. Different from the case of the $Li_2(Li_{1-x}Fe_x)N$ compound, where first-order spin-orbit coupling plays the main role, the magnetic anisotropy of Co ions in $Li_2(Li_{1-x}Co_x)N$ is related to second-order effects. [1] A. Jesche et al. Nat. Commun. 5, 3333 (2014); [2] A. Jesche et al. Phys. Rev. B 91, 180403(R) (2015).

MA 15.22 Tue 10:00 Poster E

Giant magnetic hyperfine field, spin dynamics and colossal transverse field sensitivity in the single-atomic magnet $Li_2(Li_{1-x}Fe_x)N$ with $x \ll 1$ — •Sascha Albert Bräuninger[1], Sirko Kamusella[1], Felix Seewald[1], Rajib Sarkar[1], Manuel Fix[2], Stephan Jantz[2], Anton Jesche[2], Andre Zvyagin[3], and Hans-Henning Klauss[1] — [1]Institute of Solid State and Materials Physics, TU Dresden, D-01069 Dresden, Germany — [2]Institute of Physics, University Augsburg, D-86135 Augsburg, Germany — [3]Max-Planck-Institute for the Physics of Complex Systems, Nöthnitzer Str., 38, D-01187 Dresden, Germany

We present ^{57}Fe Mössbauer studies on large single crystals of diluted Fe centers in $Li_2(Li_{1-x}Fe_x)N$ which forms a hexagonal symmetric α-Li_3N crystal matrix. The homogeneity of the nanoscale distributed isolated Fe centers is shown. The isolated Fe centers, e.g. for $x = 2.5(1)\%$, exhibit a giant magnetic hyperfine field of $B = 70.22(1)$ T parallel to the largest principle axis $V_{zz} = -154.10(19)$ V/Å^2 of the electric field gradient at 2 K, same for other $x \ll 1$. The magnetic hyperfine field fluctuates between 50 K and 300 K probed by Mössbauer spectroscopy described by a two-level relaxation model. The spin dynamics is similar to a behavior known from single-molecule magnets. An Arrhenius frequency plot $\nu = \nu_0 e^{-E_A/k_B T}$ yields a thermal activation barrier of $E_A = 542(8)$ K and $\nu_0 = 216(22)$ GHz which is consistent with magnetization investigations. An applied transverse magnetic field study up to 5 T at 70 K shows a sensitivity two orders of magnitude higher than expected from the conventional theory of nanomagnets.

MA 15.23 Tue 10:00 Poster E

Surface- and ligand-dependent quenching of the spin magnetic moment of Co porphyrins — Lucas M. Arruda[1], Matthias Bernien[1], Fabian Nickel[1], Nino Hatter[1], Lalminthang Kipgen[1], C. Felix Hermanns[1], Dennis Krüger[1], Timo Bisswanger[1], Enrico Schierle[2], Eugen Weschke[2], Katharina J. Franke[1], and •Wolfgang Kuch[1] — [1]Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin, Germany

The bonding flexibility of metalloporphyrin molecules makes them versatile candidates for spintronic applications. The magnetic properties of these molecules can be readily influenced by changes to their ligands. We investigate the electronic and magnetic properties of cobalt octaethylporphyrin (CoOEP), deposited on two similar surfaces, Cu(100) and Cu(111), with x-ray absorption spectroscopy and x-ray magnetic circular dichroism. A significant magnetic moment is observed from the cobalt ions of the molecules deposited on Cu(100), but it is completely quenched on Cu(111). Subjecting the molecules to an annealing process causes an intramolecular reaction, resulting in cobalt tetrabenzoporphyrin. The new molecules on both substrates have a quenched magnetic moment and similar electronic properties as the CoOEP molecules deposited on Cu(111). We propose that the CoOEP molecules on Cu(100) display an unusual mixed-valence configuration caused by the hybridization of the cobalt ion with the copper substrate, leading to the quench of the cobalt ions' magnetic spin moment.

MA 15.24 Tue 10:00 Poster E

Ligand-induced spin-state locking of a spin-crossover molecule on a graphite surface — Lalminthang Kipgen[1], Matthias Bernien[1], Andrew J. Britton[1], Holger Naggert[2], Sascha Ossinger[2], Fabian Nickel[1], Lucas M. Arruda[1], Evangelos Golias[1], •Ivar Kumberg[1], Chen Luo[3], Hanyo Ryll[4], Florin Radu[4], Felix Tuczek[2], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Anorganische Chemie, Christian-Albrechts-Universität zu Kiel, Max-Eyth-Straße 2, 24118 Kiel, Germany — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93053 Regensburg, Germany — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Straße 15, 12489 Berlin, Germany

Spin-crossover molecules (SCMs) have potential applications in optical memory and display elements as they can exist in two different magnetic states – high-spin (HS, S = 2) and low-spin (LS, S = 0) – which can be reversibly switched by temperature or light. The property of SCMs can be largely altered by suitably modifying the ligands; this is interesting especially for SCMs deposited on a surface — a prerequisite for device fabrication. Herein, four methyl groups are added to the SCM [$Fe(H_2B(pz)_2bipy)$] (pz = pyrazole; bipy = bipyridine) at the bipy ligand. While the original molecule is reported to undergo both optical- and thermal-induced spin switching on a graphite surface, the modified molecule is locked in the HS state on the same surface; only molecules lying at the second-monolayer onward retain their spin-crossover.

MA 15.25 Tue 10:00 Poster E

Suppression and revival of long-range ferromagnetic order in the multiorbital Fermi-Hubbard model — •Agnieszka Cichy[1,2] and Andrii Sotnikov[3] — [1]Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznan, Poland — [2]Institut fuer Physik, Johannes Gutenberg-Universitaet Mainz, Staudingerweg 7, D-55099 Mainz, Germany — [3]Institute of Solid State Physics, TU Wien, Wiedner Hauptstrasse 8, 1020 Vienna, Austria

By means of dynamical mean-field theory allowing for complete account of SU(2) rotational symmetry of interactions between spin-1/2 particles, we observe a strong effect of suppression of ferromagnetic order in the multiorbital Fermi-Hubbard model in comparison with a widely used restriction to density-density interactions. In the case of orbital degeneracy, we show that the suppression effect is the strongest in the two-orbital model (with effective spin S=1) and significantly decreases when considering three orbitals (S=3/2), thus magnetic ordering can effectively revive for the same range of parameters, in agreement with arguments based on vanishing of quantum fluctuations in the limit of classical spins. We analyze a connection to the double-exchange model and observe high importance of spin-flip processes there as well.

MA 15.26 Tue 10:00 Poster E

The Cyclotron resonance as a smoking gun for U(1) spin liquids with gapless fermions — •Peng Rao — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Certain U(1) spin liquids with gapless neutral fermions are expected to have the mind-boggling property that their optical conductivity vanishes as a power law of frequency. Thus, they are insulators to DC electric fields but without a "hard" optical gap, allowing them to absorb light at low frequencies. Additionally, they can also develop Landau levels in a magnetic field. In this work, we show that they can also have cyclotron resonance peaks in their optical spectrum analogous to metals, even though they are charge insulators. Interestingly, we have found that in contrast to metals, the principal Kohn harmonic of the cyclotron resonance is missing. The cyclotron resonance could therefore serve as a beautiful smoking gun test for the existence of these states which have been proposed in 2D organic materials and SmB_6.

MA 15.27 Tue 10:00 Poster E

Self-energy contribution of electron-magnon coupling in the homogeneous electron gas — •Maximilian Kulke and Arno Schindlmayr — Department Physik, Universität Paderborn, 33095 Paderborn, Germany

Electronic band structures of ferromagnetic materials are not only affected by electronic correlation but also by the coupling to magnons. This coupling can be treated as part of the electronic self-energy, where the magnon propagator is either described by many-body perturbation theory or by time-dependent density-functional theory. The latter is computationally simpler, because the self-energy can be evaluated analogous to the *GW* approximation for electronic correlation, but the quality of the results depends on the accuracy of the exchange-correlation kernel. In practice, the adiabatic local-density approximation (ALDA) is used almost universally until now. To study the influence of the kernel, we focus on the spin-polarized homogeneous electron gas and evaluate the electron-magnon coupling with different wave-vector-dependent exchange-correlation kernels that go beyond the ALDA. As further numerical approximations that are typically required for real materials can be avoided in this case, we are thus able to assess the essential features of the exchange-correlation kernel that are relevant for the electron-magnon coupling.

MA 15.28 Tue 10:00 Poster E

Transport in graphene and possible Cooper pair formation — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN,Campus Universitário Lagoa nova,59078-970 Natal, Brazil

Based on the quantum kinetic equations for systems with SU(2) structure, regularization-free density and pseudospin currents are calculated in graphene realized as the infinite mass-limit of electrons with quadratic dispersion and a proper spin-orbit coupling. The currents possess no quasiparticle part but only anomalous parts. The intraband and interband conductivities are discussed with respect to magnetic fields and magnetic domain puddles. For large Zeeman fields the dynamical conductivities become independent of the density and are universal. The optical conductivity agrees well with the experimental values using screened impurity scattering and an effective Zeeman field. The universal value of Hall conductivity is shown to be modified due to the Zeeman field. The pseudospin current reveals an anomaly since a quasiparticle part appears though it vanishes for particle currents. The density and pseudospin response functions to an external electric field are calculated. A frequency and wave-vector range is identified where the dielectric function changes sign and the repulsive Coulomb potential becomes effectively attractive allowing Cooper pairing. Phys. Rev. B 94 (2016) 165415, Phys. Rev. B 92 (2015) 245425 errata: Phys. Rev. B93 (2016) 239904(E), Phys. Rev. B 92 (2015) 245426

MA 15.29 Tue 10:00 Poster E

Towards nanoscale magnetic resonance imaging using single spins in diamond — •Tetyana Shalomayeva[1], Dominik Schmid-Lorch[1], Thomas Oeckinghaus[1], Qi-Chao Sun[1], Rainer Stöhr[1], and Jörg Wrachtrup[1,2] — [1]3rd Institute of Physics, University of Stuttgart — [2]Max Planck Institute for Solid State Research

Due to amazing advances in the development of 2D magnetic materials [1], Heusler compounds [2], multiferroic materials [3], etc., the need for quantitative real-space imaging techniques of magnetic textures is greater than ever before. We use the nitrogen vacancy (NV) centre in diamond as an atom-sized magnetic field sensor by monitoring the Zeeman-shift of its spin sublevels. By integrating the NV centre into an AFM tip consisting of a diamond cantilever with a monolithic nanopillar, magnetic field maps with a spatial resolution of tens of nanometers are obtained at ambient conditions.

In this contribution, we will demonstrate the general principle of this technique by emphasizing its strengths and limitations. We will show examples where we measure quantities such as noise and excitation spectra, which are inaccessible to other techniques.

[1] M. Bonilla et al. Nature Nanotechnology 13, 289*293 (2018) [2] A.K. Nayak et al. Nature 548, 561*566 (2017) [3] J.A. Mundy et al. Nature 537, 523*527 (2016)

MA 15.30 Tue 10:00 Poster E

Levitating antennas to excite magnetization dynamics for optical and non-optical spectroscopy — •Toni Hache[1,2], Marek Vanatka[3], Lukas Flajsman[3], Michal Urbanek[3], and Helmut Schultheiss[1,4] — [1]HZDR — [2]TU Chemnitz — [3]CEITEC — [4]TU Dresden

Modern spectroscopic techniques for the investigation of magnetization dynamics in microstructures use usually microwave antennas which are directly patterned on the sample using electron-beam-lithography (EBL). Following this approach every magnetic structure on the sample needs its own antenna and insulation layer requiring additional EBL and layer deposition. We demonstrate a new device for magnetization excitation compatible with optical methods based on antennas on a flexible glass cantilever. Since we use flexible transparent glass as substrate, optical spectroscopic techniques like Brillouin-light-scattering microscopy (BLS) and time resolved magneto-optical Kerr effect measurements (TRMOKE) can be performed. This cantilever is connected to adapters with standard SMA connectors and is positionable in all three dimensions to get access to all magnetic structures on the sample under investigation. We show the functionality of these antennas using BLS. We excite the magnetization in a 5 nm thick Permalloy film and compare the intensity with the intensity of only thermally excited magnons. A increase by a factor of 400 could be achieved, showing the high impact of the magnetization excitation by the antenna. The authors acknowledge financial support from the Deutsche Forschungsgemeinschaft within programme SCHU 2922/1-1

MA 15.31 Tue 10:00 Poster E

Towards machine-learning-based far-field phase-retrieval for dichroic imaging — •Michael Lohmann, Ofer Kfir, Sergey Zayko, and Claus Ropers — Georg August Universität Göttingen

Machine learning (ML) is a highly powerful tool for data analysis and classification, across many fields and platforms. First demonstrations of ML for lensless imaging by phase-retrieval of diffraction patterns show great potential [1], however, they do not necessarily provide for a consistent solution, and require a vast amount of training data.

Here, we propose the use of a known forward operator, linking the sample and its diffraction, that is, the Fourier transform, to improve the image retrieval. The resulting reduction of complexity could relieve the need for a large training set, and could reduce the algorithm convergence time. In the case of dichroic imaging, such as in magnetic circular dichroism, advanced algorithms can jointly solve the two dichroic diffraction patterns, and directly access the magnetic information separately from the non-magnetic background. Furthermore, combining magnetic imaging with standard ML applications, as de-noising, would enhance the image quality and sensitivity.

[1] Mathew J. Cherukara, Youssef S. G. Nashed & Ross J. Harder; Scientific Reports **8** 16520 (2018), Real-time coherent diffraction inversion using deep generative networks

MA 15.32 Tue 10:00 Poster E

Ab initio calculations on the Intrinsic Spin Hall effect — •Alexander Fabian, Michael Czerner, and Christian Heiliger — Institut für theoretische Physik, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen

Spintronic devices gain much attention for applications, since the additional spin degree of freedom can be used to manufacture even more efficient and faster devices. For such applications, a spin polarized current is neccessary. To generate such currents it is most suitable to use physical effects such as the Spin Hall effect. We show here the application of ab initio calculations in the framework of a full relativistic Korringa-Kohn-Rostoker density functional theory to describe the intrinsic Spin Hall effect in materials with strong spin orbit coupling. Whereas typical methods rely on the implementation of a semiclassical Boltzmann formalism in conjunction with an additional term resulting from the Berry curvature, we describe the intrinsic Spin Hall effect by only relying on the full relativistic Kohn-Sham-Dirac Hamiltonian, which evokes a spin orbit coupling in the material, and the non-equilibrium Greens function formalism. Within this framework it is possible to give a prediction of Spin Hall angles in different materials for use in applications. By expanding the method with scattering times and spin flip scattering it should be possible to also give a prediction of extrinsic Spin Hall effects as well. To prove the applicability of this method, the magnetization distribution of a thin film of a material with strong spin orbit coupling like Platinum is calculated under an applied bias voltage.

MA 15.33 Tue 10:00 Poster E

Local projection of the intrinsic spin Hall conductivity in heterostructures — •Franziska Töpler[1], Tomáš Rauch[2], and Ingrid Mertig[1,3] — [1]Martin Luther University Halle-Wittenberg, Halle, Germany — [2]Friedrich-Schiller University Jena, Jena, Germany — [3]Max Planck Institute of Microstructure Physics, Halle, Germany

We study the intrinsic contribution to the spin Hall conductivity (SHC) in a system with a magnetic/nonmagnetic interface. On that account we use an extended unit cell composed of n and m atomic layers of Cu and Co, respectively. The electronic structure is calculated within the tight-binding approach. We use the Kubo formula to describe the transverse spin current in linear response to an external electric field [1]. To obtain a better understanding of the role of the Cu/Co interface in the spin Hall effect, we derive and test different formulations of the local SHC. The local projection methods are introduced in analogy to Ref. [2] and Ref. [3] wherein a local marker is used to probe the anomalous Hall effect in inhomogeneous systems. We compare the results of the different approaches and discuss there significance with respect to the chosen model system.

[1] Gradhand *et al.*, J. Phys.: Condens. Matter **24**, 213202 (2012)
[2] Rauch *et al.*, Phys. Rev. B **98**, 115108 (2018)
[3] Marrazzo *et al.*, Phys. Rev. B **95**, 121114(R) (2017)

MA 15.34 Tue 10:00 Poster E

Photoinduced modulation of resistivity in metallic wires under DC Bias — Lea Apel, Şaban Tirpanci, •Palvan Seyidov, and Georg Woltersdorf — Institutte of Physics, Martin-Luther-Universität Halle-Wittenberg

Charge to spin current conversion due to the spin Hall effect (SHE) was intensely studied in the last decade. Even in metallic wires direct magneto-optic detection of the current-induced spin accumulation has been reported [1]. Recently, Yang et al. demonstrated the direct visualization of current-induced spin accumulation at wire edges using a novel light helicity-dependent scanning photovoltage measurement technique at room temperature [2]. Unfortunately a reasonable physical explanation of observed signals was not presented.

In our experiments we reproduce the results by Yang et al. qualitatively for Pt wires with a spatial resolution of 300 nm. Using a very similar setup as discussed in [2] we compare the spatial dependence of the photovoltages in Pt, Ta and Cu wire structures under DC bias. In Pt we find signals at the wire edges, which have a similiar magnitude and the same symmetry as in [2] upon switching the current direction. However, we also observe very similar helicity dependent photo voltage signals also for Cu and Ta wires under DC bias. Therefore, we conclude that most of the signals we observed at the wire edges are not caused by the SHE induced spin accumulation. We perform a careful analysis of the possible origins of these signals.

[1]C.Stamm et al. Phyy. Rev. Lett. 119,087207(2017)
[2]L. Yang et al., Nat. Commun. 9,2492(2018)

MA 15.35 Tue 10:00 Poster E

Characterization of individual YIG/Pt nano-structures via Spin Transfer Torque-FMR — •Steffen Steinert[1], Björn Heinz[1,2], Thomas Brächer[1], Michael Schneider[1], Philipp Pirro[1], Bert Lägel[1], Anna M. Friedel[1], David Breitbach[1], Carsten Dubs[3], Burkard Hillebrands[1], and Andrii V. Chumak[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]INNOVENT e.V., Technologieentwicklung Jena, 07745 Jena, Germany

Yttrium iron garnet (YIG) is a unique material with outstanding magnetic properties such as the lowest known spin-wave damping. It is therefore well suited for the investigation of fundamental spin-wave dynamics and a promising candidate for the application in spin-wave based circuits and logic devices. In this work, we investigate spin-wave conduits fabricated from a thin YIG(27nm)/Pt(10nm) bi-layer system with varying width ranging from microns down to about 100nm. The investigation of the magnetic properties, e.g. the ferromagnetic resonance linewidth (FMR), in dependency of the width of the structure is carried out by means of spin transfer torque ferromagnetic resonance spectroscopy (ST-FMR). In addition, the impact of an applied dc-current on the linewidth is examined. This research has been supported by ERC Starting Grant 678309 MagnonCircuits and DFG Grant DU 1427/2-1.

MA 15.36 Tue 10:00 Poster E

Electronic and magnetic structure of ultrathin SrRuO3 film grown on SrTiO3 (001) substrate — •Kartik Samanta, Marjana Ležaić, Yuriy Mokrousov, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Oxides interfaces offer a new perspective to stabilize the skyrmion due to their response to electric fields, low Ohmic losses, variety of interface symmetry as well as the prospective anisotropic Dzyaloshinskii-Moriya interaction (DMI). We investigate by virtue of spin density functional theory (DFT) as realized in the FLEUR code [1], magnetic structure of the ultrathin film of SrRuO3 grown on the SrTiO3 (001) substrate in c(2 x 2) unit cell to search the interface stabilized skyrmion in oxide structure. At the ultrathin limit of three monolayers the SrRuO3, the film is found to show a metal to insulating (MIT) ground state with antiferromagnetic magnetic order. The t2g level difference, lattice distortion, as well as the layer thickness, play together a crucial role in determining this magnetic ground state. At the ultrathin limit of three monolayers of the SrRuO3 film, a reasonable amount of orbital magnetic moment is found at the Ru sites compared the bulk SrRuO3. We have also calculated the anomalous Hall conductivity for bulk as well as the thin film. We hope that strong spin-orbit coupling ant Ru site together with broken inversion symmetry in the ultrathin film will give rise DMI which can stabilize the Skyrmion in this system.

[1] www.flapw.de

MA 15.37 Tue 10:00 Poster E

Magnon Chemical Potential Evolution in the BEC Formation by Rapid Cooling — •Michael Schneider[1], Thomas Brächer[1], Viktor Lauer[1], Phillip Pirro[1], Dmytro A. Bozhko[1], Alexander A. Serga[1], Halyna Yu. Musiienko-Shmarova[1], Björn

Heinz[1,2], Qi Wang[1], Thomas Meyer[3], Frank Heussner[1], Sascha Keller[1], Evangelos Th. Papaioannou[1], Bert Lägel[1], Thomas Löber[1], Vasyl S. Tiberkevich[4], Andrei N. Slavin[4], Carsten Dubs[5], Burkard Hillebrands[1], and Andrii V. Chumak[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern — [2]Graduate School Materials Science in Mainz, Staudingerweg 9, D-55128 Mainz — [3]THATec Innovation GmbH, Bautzner Landstraße 400, D-01328 Dresden — [4]Department of Physics, Oakland University, Rochester — [5]INNOVENT e.V. Technologieentwicklung, Prüssingstraße 27B, D-07745 Jena

Recently we presented a fundamentally new approach for the formation of a magnon Bose-Einstein Condensate (BEC) due to the rapid cooling of a preheated magnetic nano-structure. Using time-resolved Brillouin light scattering spectroscopy (BLS), a strong increase of the magnon population at the bottom of the spectrum is observed. Here we show the direct measurement of the chemical potential by means of BLS. The potential is found to reach the minimum magnon energy confirming the BEC formation. This research has been supported by ERC StG 678309 MagnonCircuits, ERC AdG 694709 SuperMagnonics and DFG Grant DU 1427/2-1.

MA 15.38 Tue 10:00 Poster E

Realization of a micro-scaled spin-wave majority gate — •Martin Kewenig[1], Thomas Brächer[1], Carsten Dubs[2], Philipp Pirro[1], Andrii Chumak[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Kaiserslautern, Germany — [2]INNOVENT e.V. Technologieentwicklung Jena, 07745 Jena, Germany

Spin-wave logic devices offer large advantages compared to modern CMOS-based elements. An example for such a logic element is the majority gate, in which the logical output is given by the majority of the logical inputs. The operation of a macroscopic spin-wave majority gate made from a 5.4 μm-thick yttrium iron garnet (YIG) film is already proven, the output phase of the signal was defined by the majority of the input phases. The miniaturization of the device is naturally the next step and the functionality of a micro-scaled spin-wave majority gate has already been investigated by numerical methods. We will show spin-wave dynamics in microstructured YIG waveguides and microstructured combiner areas. In addition, we will present the fabrication and investigation of a micro-scaled spin-wave majority gate device made from a 70 nm and a 85 nm thick YIG film. This research has been supported by: DFG SFB/TRR 173 Spin+X, Project B01, ERC Starting Grant 678309 MagnonCircuit, DFG (DU 1427/2-1)and the EU Horizon 2020 research and innovation programme within the CHIRON project (contract number 801055).

MA 15.39 Tue 10:00 Poster E

Two-dimensional magnon supercurrents — •Alexander J. E. Kreil, Dmytro A. Bozhko, Alexander A. Serga, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Earlier, we reported on supercurrent transport of a room-temperature magnon Bose-Einstein condensate (BEC) observed in yttrium iron garnet films by means of time- and space-resolved Brillouin light scattering spectroscopy (BLS) [1-3]. By locally heating the sample, a spatially variation of the saturation magnetization was induced, which lead to a magnon supercurrent flowing out of the heated spot. The condensed magnons being propelled out of the heated area formed compact humps of BEC density, which propagated many hundreds of micrometers in the form of second sound Bogoliubov waves. Our theoretical estimations predict a strong anisotropy in the propagation characteristics of the magnon supercurrents. In the current work, we show the results of a two-dimensional spatially resolved BLS probing the magnon BEC formed in a magnetically non-uniform sample and compare the experimental data with theoretical estimations.

[1] D.A. Bozhko *et al.*, *Supercurrent in a room temperature Bose-Einstein magnon condensate*, Nat. Phys. **12**, 1057 (2016).
[2] A.J.E. Kreil *et al.*, *From kinetic instability to Bose-Einstein condensation and magnon supercurrents*, PRL **121**, 077203 (2018).
[3] D.A. Bozhko *et al.*, *Long-distance supercurrent transport in a room-temperature Bose-Einstein magnon condensate*, arXiv:1808.07407.

MA 15.40 Tue 10:00 Poster E

Surface acoustic wave mediated magneto elastic investigation of magnetic thin films — •Matthias Küss[1], Michael Heigl[2], Andreas Hörner[1], Manfred Albrecht[2], and Achim Wixforth[1] — [1]Lehrstuhl für Experimentalphysik I, Universität Augsburg — [2]Lehrstuhl für Experimentalphysik IV, Universität Augsburg

Magnetostriction describes the geometrical deformation of a magnet, caused by an applied magnetic field. The effect vice versa is named inverse magnetostriction. This mechanism in combination with surface acoustic strain waves (SAW) enables the manipulation of the magnetization on short time scales ($\sim$ ns) and on micrometer distances. Since the SAW and magnonic modes are typically excited in the same radio frequency regime, both degrees of freedom have the potential to become strongly or even resonantly coupled [1]. Therefore, not only the magnetization, but also the properties of the SAW itself are mutually and characteristically changed. This can be easily measured in a delay line setup, made up of two interdigital transducers (IDT).

We use a vector network analyzer to study the interaction between GHz Rayleigh type SAWs and a ferromagnetic cobalt film as a function of magnetic field and sample orientation. On the one hand these experiments show the typical fourfold symmetry of elastically driven ferromagnetic resonance, which is caused by the longitudinal strain, accompanying the Rayleigh wave [1]. On the other hand, clear signature of vertical shear strain is observed, which gives rise to phenomena like nonreciprocal SAW propagation.

[1] M. Weiler et al., Phys. Rev. Lett. **106**, 117601 (2011).

MA 15.41 Tue 10:00 Poster E

Investigation of non-linear spin-wave excitation at low magnetic bias field — •Lea Apel, Rouven Dreyer, and Georg Woltersdorf — Institutte of Physics, Martin-Luther-Universität Halle-Wittenberg

Recently, it was demonstrated that the Suhl instability processes describing parametric spin wave excitations are not an adequate model at low magnetic bias fields [1]. In the low field regime a novel instability process dominates the response at high excitation amplitudes. This process leads to critical spin-wave modes which can be parametrically driven at half integer multiplies of excitation frequency.

Here we use micro-focus Brillouin light scattering (μBLS) to study the formation of $3/2\ \omega$ and $5/2\ \omega$ non-linear spin-wave excitations and the corresponding threshold rf-amplitudes for this parametric process in Permalloy microstructures. Simultaneously we detect the spatial dependence of the uniform mode as well as the parametrically excited spin waves. Overall we find agreement with the critical behavior prediction in [1] at small magnetic bias fields. Our results are supported by magneto-optical microscopy expriments which map the spin waves in a phase resolved fashion.

[1]H.G. Bauer et al., Nat. Commun. 6, 8274(2015)

MA 15.42 Tue 10:00 Poster E

Reflectionless magnonic crystal — •Pascal Frey[1], Aleksei Nikitin[2], Qi Wang[1], Florin Ciubotaru[3], Sergey A. Bunyaev[4], Gleb N. Kakazei[4], Boris A. Kalinikos[2], Andrii V. Chumak[1], Aleksandr A. Serha[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Kaiserslautern, Germany — [2]Department of Physical Electronics and Technology, St. Petersburg Electrotechnical University St. Petersburg, Russia — [3]Imec, Leuven, Belgium — [4]IFIMUP and IN-Institute of Nanoscience and Nanotechnology, Departamento de Física e Astronomia, Universidade do Porto, Porto, Portugal

The interest in artificial magnetic media like magnonic crystals visibly increased during the recent years in view of their application for information processing at microwave frequencies. The main features of these crystals are the presence of bandgaps in the spin wave spectra. The bandgaps are formed due to the Bragg reflections from the artificially created periodic structures. We studied spin wave propagation in longitudinally magnetized width-modulated yttrium iron garnet waveguides by means of both Brillouin light scattering and microwave techniques in the cw and pulsed regime. 30 ns pulses of backward volume magnetostatic spin waves were excited close to the ferromagnetic resonance frequency and their propagation was visualized and measured, both in pass and rejection frequency bands. No pronounced Bragg reflection was observed. The effect is discussed in comparison with results of micromagnetic simulations. Financial support by the DFG (B01 and DE 639) as well as by DAAD grant 57213643 is gratefully acknowledged.

MA 15.43 Tue 10:00 Poster E

Controlling spin transmission in collinear ferroic magnetic multilayer systems — Joel Cramer[1], •Felix Fuhrmann[1], Ulrike Ritzmann[1], Ulrich Nowak[2], Eiji Saitoh[3], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg-University Mainz, 55128 Mainz, Germany — [2]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [3]WPI Advanced Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

In the research field of spintronics, devices can use spin currents rather than charge currents [1]. In particular in insulators, pure spin currents can be employed and we report on spin pumping [2] measurements in collinear magnetic yttrium iron garnet (YIG)/CoO/Co multilayers. By means of microwaves and external magnetic fields, YIG is brought into ferromagnetic resonance, resulting in a pure spin current that propagates through the sample stack and is finally detected in the Co layer via the inverse spin Hall effect [3]. The CoO layer enables the spin current transmission and de-coupling of the ferromagnets and furthermore increases the coercive field of the Co layer by exchange bias. This allows for the switching between a parallel or antiparallel alignment of the YIG and Co magnetization. Depending on the alignment of the YIG and Co magnetization, we observe a strongly different spin transport signal amplitude and thus a magnon spin-valve-like behavior is observed [4]. [1] S.A. Wolf et al., Science 294, 1488 (2001). [2] Y. Tserkovnyak et al., Phys. Rev. Lett. 88,117601 (2002). [3] J. Sinova et al., Rev. Mod. Phys. 87, 1213 (2015). [4] J. Cramer et al., Nature Commun. 9, 1089 (2018).

MA 15.44 Tue 10:00 Poster E

Theoretical description of spin waves in disordered materials — Pawel Buczek[1], •Martin Hoffmann[2], Stefan Thomas[3], and Arthur Ernst[2,3] — [1]Fakultät Technik und Informatik, Hochschule für Angewandte Wissenschaften Hamburg, Germany — [2]Institute for Theoretical Physics, Johannes Kepler University Linz, Austria — [3]Max Planck Institute of Microstructure Physics, Halle, Germany

In order to study spin waves in disordered materials, we present two theoretical approaches based on a Heisenberg model. Both complement each other in the description of magnon properties in spin systems with disorder of arbitrary kind and concentration of impurities. Firstly, magnons in systems with substitutional (uncorrelated) disorder can be efficiently calculated within a single-site coherent potential approximation for the Heisenberg model. From the computational point of view, this method has several advantages, is inexpensive, and directly applicable to systems like alloys and doped materials. We show that it performs exceedingly well across all concentrations and wave vectors. However, we need another approach for more complex systems like layers forming island or short-range order. Therefore, we will present a second possibility using a configurational average over possible realizations of large supercells in direct numerical simulations. The effective interaction between magnetic moments entering the Heisenberg model in both methods can be obtained from first-principles using a self-consistent Green function method within the density functional theory. Thus, our method can be viewed as an *ab initio* approach and can be used for calculations of magnons in real materials.

MA 15.45 Tue 10:00 Poster E

An analog magnon adder for all-magnonic neurons — Thomas Brächer and •Philipp Pirro — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern

Neuromorphic computing is one of the most promising more-than-Moore technologies that can greatly outperform conventional CMOS computing architecture for an important set of tasks like pattern recognition, machine learning and cognitive tasks. Spintronics constitutes a highly interesting platform for neuromorphic networks since its non-volatility allows for a straight-forward integration of the data processing and memory functionality on the same level, one of the key features of brain-inspired computation. Spin-waves are a highly promising data carrier to convey information in a neural network, as they are ultra-low in energy and as they can travel over large distances without the need for spin-to-charge or charge-to-spin interconversion. In this work, we demonstrate that a leaky resonator together with a parametric amplifier can perform the action of an analogue addition over incoming spin-wave pulses. For this operation, the losses in the resonator are just compensated by the parametric amplification process. The signal integration in the spin-wave domain is similar to the signal integration in neurons in spiking neural networks and the biological original, where a nonlinearity triggers the neuron to '*fire*' and release its energy. By adjusting the gain of the amplifier, various applications for such an adder can be envisioned. Together with the intrinsic nonlinearity of the spin-wave dynamics, magnonic neurons can, thus, be envisioned.

MA 15.46 Tue 10:00 Poster E

Spin-wave propagation in individual sub-micron YIG magnonic conduits — •Björn Heinz[1,2], Thomas Brächer[1], Michael Schneider[1], Philipp Pirro[1], Bert Lägel[1], David Breitbach[1], Anna M. Friedel[1], Carsten Dubs[3], and Andrii V. Chumak[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]INNOVENT e.V., Technologieentwicklung Jena, 07745 Jena, Germany

Yttrium iron garnet (YIG) is a unique material with outstanding magnetic properties such as the lowest known spin-wave damping. It is therefore well suited for the investigation of fundamental spin-wave dynamics and a promising candidate for the application in spin-wave based circuits and logic devices. In this work, we study the impact of nanostructuring by means of electron beam lithography and successive ion milling on individual spin-wave waveguides. These structures are fabricated from a 44 nm thin film grown by liquid phase epitaxy (LPE). Their width varies from a few microns down to the sub-100 nm regime. By exciting the magnetization dynamics with a coplanar waveguide antenna and performing spacial resolved Brillouin light scattering (BLS) microscopy measurements, we investigate the spin-wave decay length in these conduits in dependency on the conduit width. Additionally the spin-wave mode spectra are extracted by means of thermal BLS measurements. This research has been supported by ERC Starting Grant 678309 MagnonCircuits and DFG Grant DU 1427/2-1.

MA 15.47 Tue 10:00 Poster E

Influence of chiral interactions on domain wall creation by electric current — •Nils Sommer, Davi Rohe Rodrigues, and Karin Everschor-Sitte — Institute of Physics, Johannes Gutenberg-University, Mainz, Germany

We show how the presence of Dzyaloshinskii-Moriya interaction modifies the critical current density necessary to inject domain walls into a nanowire at a pinned domain wall: The creation of domain walls by electric means is of critical importance to the proposal of future magnetic domain wall based racetrack memories. In a recent work, [1] it was shown that domain walls can be periodically injected into nanowires in the presence of inohomogeneities without the aid of any twisting contribution, such as dipole-dipole and chiral interactions. In this work, we demonstrate that it is possible to reduce the critical current density by introducing Dzyaloshinskii-Moriya interaction. Moreover, we find a split in the critical current density depending on the chirality of the generated domain walls. We investigate the motion of the periodically created domain walls in the chiral nanowire due to the current and their interaction between each other. The reduced critical current density might allow the domain wall shedding in experimentally observable real chiral ferromagnetic nanowires.

[1] Sitte, M. et al., Physical Review B **94** (2016) 064422.

MA 15.48 Tue 10:00 Poster E

Dynamic imaging of the delay- and tilt-free motion of Néel domain walls with 200 ps time resolution — Simone Finizio[1], Sebastian Wintz[1,2], Katharina Zeissler[3], Alexandr Sadovnikov[4,5], Sina Mayr[1,6], Sergej Nikitov[4,5], Christopher Marrows[3], and •Jörg Raabe[1] — [1]Paul Scherrer Institut, 5232 Villigen PSI, Switzerland — [2]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [3]University of Leeds, Leeds LS2 9JT, UK — [4]Saratov State University, 410012 Saratov, Russia — [5]Russian Academy of Sciences, 125009 Moskow, Russia — [6]ETH Zürich, 8093 Zürich, Switzerland

In this contribution, we present a time-resolved scanning-transmission x-ray microscopy investigation of the current- and magnetic field-induced domain wall motion of Néel-type domain walls in perpendicularly magnetized microwires fabricated out of Pt/CoB/Ir multilayer superlattice stacks exhibiting anti-symmetric exchange interaction. A time step of 200 ps, combined with a spatial resolution of 25 nm, was employed for the time-resolved imaging experiments, providing a first direct imaging of the dynamics of the domain wall motion with sub-ns temporal resolution. For both the current- and magnetic field-induced processes, the domain wall motion occurs synchronously with the excitation, indicating that an inertia-free motion of the domain wall. Furthermore, it was observed that, in the case of short current and magnetic field excitations, the domain wall remains perpendicular to the wire axis, providing a potential mechanism for a fast, tilt-free motion of magnetic domain walls in perpendicularly magnetized systems.

MA 15.49 Tue 10:00 Poster E

Simulations of magnetic domain wall propagation in width-modulated wires — •Olga Lozhkina, Pascal Kraunscheid, Robert Reeve, Gerhard Jacob, and Mathias Kläui — Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany

Magnetic domain walls (DWs) are of interest to the sensor industry due to their stability at room temperature and their ability to be nucleated and propagated by fields in wires, attributes which can be exploited for multi-turn sensors [1]. DW propagation and pinning depend on many factors that must be carefully controlled for reliable devices. DW propagation below the Walker field is the most robust, but in most cases the Walker field is close to the field required to propagate the DWs, resulting in a small operating window. Periodic modulations of the wire width have been proposed to suppress the Walker breakdown [2], which would be advantageous for such sensors. We performed simulations of DW propagation through Py wires with modulated width using mumax3 . Our simulations show that the longitudinal distance before DW transformation (Walker period) gradually drops with increasing field and tends to a certain limit depending on the wire cross-section. For thinner wires with energetically stable transverse DWs, width modulation with a period smaller than this limit leads to a significant increase of the Walker field. Thereby magnetic wire modulation may enhance the robustness of sensor operation and enlarge in particular the field operation window. [1] B. Borie et al., Appl. Phys. Lett. 111, 242402 (2017) [2] J. Ieda et al. J. Magn. Magn. Mater. 322, 1363 (2010)

MA 15.50 Tue 10:00 Poster E

Imaging domain wall motion using time-resolved SEMPA — •Daniel Schönke[1], Andreas Oelsner[2], Pascal Krautscheid[1,3], Robert Reeve[1,3], and Mathias Kläui[1,3] — [1]Institut für Physik, Johannes Gutenberg-University, 55128 Mainz, Germany — [2]Surface Concept GmbH, 55099 Mainz, Germany — [3]Graduate School of Excellence Materials Science in Mainz (MAINZ), 55128 Mainz, Germany

Scanning electron microscopy with polarization analysis (SEMPA) is a magnetic imaging technique with a high spatial resolution. While conventional setups only provide quasi-static imaging modes, which have limited the adoption of the technique, recent developments have enabled dynamic measurements and allow SEMPA to favorably compete with a range of synchrotron based techniques [1]. Here we show that with our upgraded SEMPA system we can perform new time-resolved imaging schemes including phase-sensitive detection of periodically changing magnetic states with up to 5x demonstrated enhanced signal-to-noise ratio and full dynamic imaging with a temporal resolution of 2 ns [2]. This novel SEMPA system can be used for a variety of measurement applications and fulfills the desire for high spatial and temporal resolution in a laboratory setting. We take advantage of the new system to study geometry-induced automotive domain wall dynamics in asymmetric permalloy rings [3] at different temperatures. [1] Frömter et al., Appl. Phys. Lett. 108, 142401 (2016) [2] Schönke et al., Rev. Sci. Instrum. 89, 083703 (2018) [3] Mawass et al., Phys. Rev. Applied 7, 044009 (2017)

MA 15.51 Tue 10:00 Poster E

Phase transition dynamics of CMR manganites — •Tommaso Pincelli[1,2], Gian Marco Pierantozzi[2], Chiara Bigi[2,3], Riccardo Cucini[2], Francesco Borgatti[4], Aleksandr Yu. Petrov[2], Christian H. Back[5], Masaki Oura[6], Giorgio Rossi[2,3], and Giancarlo Panaccione[2] — [1]Fritz-Haber-Institut of MPG, Faradayweg 4-6, 14195 Berlin, Germany — [2]Istituto Officina dei Materiali of CNR, c/o Area Science Park, S.S.14 km 163,5 - I-34149 Trieste, Italy — [3]Dipartimento di Fisica, Università di Milano, Via Celoria 16, I-20133 Milano - Italy — [4]Istituto per lo Studio dei Materiali Nanostrutturati of CNR, via P. Gobetti 101, I-40129 Bologna, Italy — [5]Department of Physics, Technical University Munich, D-85748 Garching b. München, Germany — [6]RIKEN SPring-8 Center, Kouto 1-1-1, Sayo-cho, Sayogun, Hyogo 679-5148, Japan

In CMR manganites, delocalization of electronic states results from competing double-exchange-driven delocalization and polaronic trapping. We explore the dynamics of the ferromagnetic metal-paramagnetic bad-metal phase transition. In the wide-band half-metallic La(1-x)Sr(x)MnO3 we isolate the evolution of delocalized electronic states with time-resolved hard x-ray photoemission, showing that the slow collapse of magnetization keeps the double-exchange interaction active for several hundreds of picoseconds, suggesting a slow timescale evolution of electronic correlation. When competing polaron trapping is brought into play in the narrow-band La(1-x)Ca(x)MnO3, new metastable phases emerge, optically accessible on ultrafast timescales.

MA 15.52 Tue 10:00 Poster E

Monitoring picosecond strain pulse echos in magnetostrictive heterostructures — •Steffen Peer Zeuschner[1,2], Tymur Parpiiev[3], Thomas Pezeril[3], Jan-Etienne Pudell[2], Marc Herzog[2], Alexander von Reppert[2], and Matias Bargheer[1,2] — [1]Helmholtz-Zentrum Berlin, BESSY II, Berlin, Germany — [2]Institut für Physik und Astronomie, University of Potsdam, Potsdam, Germany — [3]Institut des Molécules et Matériaux du Mans (UMR CNRS 6283), Université du Maine, Le Mans cedex, France

We investigate picosecond strain pulses in laser-excited highly magnetostrictive $TbFe_2$/Nb heterostructures with time-resolved magneto-optical Kerr-effect (MOKE) probing and ultrafast X-ray diffraction (UXRD). Burying the Nb layer underneath the laser excitation region in $TbFe_2$ allows for a heat-background free characterization of the laser-generated strain pulses. We clearly observe a decomposition of the strain transient into an asymmetric bipolar and a unipolar pulse, when an amorphous SiO_2 capping layer covers the excited $TbFe_2$. The inverse magnetostriction of the temporally separated unipolar strain pulses leads to a MOKE signal from the $TbFe_2$ surface that linearly depends on the strain pulse amplitude, giving an estimate of the magneto-acoustic coupling strength. Linear chain model simulations accurately predict the timing and shape of UXRD and MOKE signals that are caused by the strain reflections from multiple interfaces in the heterostructure. A second excitation pulse allows the construction of an inverted bipolar strain pulse which is expected to exhibit drastically different nonlinear acoustic propagation.

MA 15.53 Tue 10:00 Poster E

Non-equilbrium spin-orbit physics at high frequencies — •Hanan Hamamera, Filipe Souza Mendes Guimarães, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany

The field of spintronics is driven by the desire to develop new spin-based devices with performances surpassing the ones used in present-day technologies. It is then important to understand the ultrafast dynamical properties of such devices. This is challenging, as the electronic and spin dynamics have very different intrinsic time scales and simultaneously being intricately coupled — and so, they are best described by a unified theory. We build such a theory by parametrizing a realistic tight-binding hamiltonian based on first-principles electronic structure calculations, and then solving it for the real-time evolution of the system. We benchmark this approach with a simple model, meant to abstract the main features of the spin-polarized electronic structure. We then perform calculations for Co/Pt(001) and Fe/W(110) bilayers, and compare and contrast the results of the time-dependent approach with existing linear response ones [1]. This work was supported by the Palestinian-German Science Bridge BMBF program and the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator Grant No. 681405-DYNASORE).

[1] F.S.M. Guimarães *et al.*, Sci. Rep. **7**, 3686 (2017)

MA 15.54 Tue 10:00 Poster E

Picosecond Strain Dynamics driven by Ultrafast Demagnetization in Dysprosium — •Alexander von Reppert[1], Jan-Etienne Pudell[1], Steffen Zeuschner[1,2], Karine Dumesnil[3], and Matias Bargheer[1,2] — [1]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany — [2]Helmholtz-Zentrum Berlin, Berlin, Germany — [3]Institut Jean Lamour (UMR CNRS 7198), Université Lorraine, Nancy, France

We investigate the effects of the ultrafast demagnetization on the picosecond strain pulses launched in the highly magnetostrictive material Dysprosium (Dy). The laser-induced spin-disorder in heavy rare earth materials triggers a large negative stress, which dominates the c-axis lattice dynamics over the expansive stress that originates from (in)-coherent phonon excitations. The application of an in-plane B-field shifts the FM-AFM phase transition to higher temperatures and enhances the laser-induced contraction. By observing the coherent strain pulses spatially separated from the laser excited region, we eliminate the thermal background. We find strong changes to the characteristic bipolar strain pulse that is observed in the high temperature paramagnetic region, which we attributed to the depth dependent magnetostrictive stress in the inhomogeneously heated Dy layer. Our systematic exploration of the different magnetic phases characterizes to which extend the magnetostrictive stress in this material class can be used as a transducer for novel picosecond strain experiments with unipolar, or even inverted bipolar strain pulses.

MA 15.55 Tue 10:00 Poster E

Ultrafast Demagnetization: Role of Transport and Substrates
— •S. Ashok, S. T. Weber, C. Seibel, J. Briones, and B. Rethfeld — Department of Physics and Optimas Research Center, University of Kaiserslautern, Germany

Ultrafast demagnetization [1], its mechanism and the spin-resolved currents generated during it, have attracted immense attention and posses great technological applicability. The non-equillibrium in the spin-resolved chemical potentials can be described as a driving force behind ultrafast demagnetization [2]. Using this observation, the thermodynamic μT-model traces the spin-resolved non-equillibrium electron temperatures, chemical potentials and demagnetization dynamics [3]. The demagnetization in thin Nickel ferromagnetic films was studied, when the material is uniformly heated and all transport effects can be neglected.

We extend the model to the case of thicker ferromagnetic films where the role of transport becomes prominent. Here, we present the role of particle and energy transport in the ultrafast demagnetization by observing the temporal and spatial evolution of temperatures, chemical potentials and magnetization. We also present preliminary results on the role of substrates.

[1] Beaurepaire E. et al., PRL 76, 4250 (1996)
[2] Mueller B. et al., PRL 111, 167204 (2013)
[3] Mueller B. and B. Rethfeld, PRB 90, 144420 (2014).

MA 15.56 Tue 10:00 Poster E

Ultrafast negative thermal expansion driven by spin-disorder in antiferromagnetic Holmium
— •Jan-Etienne Pudell[1], Alexander von Reppert[1], Daniel Schick[2], Flavio Zamponi[1], Matthias Rössle[3], Marc Herzog[1], Hartmut Zabel[4], and Matias Bargheer[1,3] — [1]Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht- Str. 24-25, 14476 Potsdam, Germany — [2]Max-Born-Institut, Max-Born-Strasse 2A, 12489 Berlin, Germany — [3]Helmholtz Zentrum Berlin, Albert-Einstein-Str. 15, 12489 Berlin, Germany — [4]Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany

We measure the transient strain profile in a nanoscale multilayer system composed of Yttrium, Holmium and Niobium after femtosecond laser excitation using ultrafast X-ray diffraction (UXRD) at a laser-driven Plasma X-ray Source (PXS) setup. The strain propagation through each layer is determined by transient changes of the material-specific Bragg angles. We experimentally derive the exponentially decreasing stress profile driving the strain wave and show that it closely matches the optical penetration depth. Below the Neel temperature of Ho, the optical excitation triggers negative thermal expansion caused by a decrease of the strong magnetostriction in Holmium, which is induced by a quasi-instantaneous contractive stress, and a second contractive stress contribution rising on a 12 ps timescale. These two timescales have recently been measured for the spin-disordering in Ho [Rettig et al, PRL 116, 257202 (2016)]. As a consequence, we observe an unconventional bipolar strain pulse with an inverted sign.

MA 15.57 Tue 10:00 Poster E

Investigation of the interaction between magnetic nanoparticles in different geometries by using FMR
— •Nils Neugebauer[1], Matthias Elm[1,2,3], Peter Klar[1,2], Detlev Hofmann[1,2], Alexander Fabian[2,4], Michael Czerner[2,4], and Christian Heiliger[2,4] — [1]Institute of Experimental Physics I, Heinrich-Buff-Ring 16, 35392 Gießen, Germany — [2]Center for Materials Research (LaMa), Heinrich-Buff-Ring 16, 35392 Gießen, Germany — [3]Institute of Physical Chemistry, Heinrich-Buff-Ring 17, 35392 Gießen, Germany — [4]4Institute for Theoretical Physics, Justus Liebig University Gießen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

Assemblies with well defined sizes and spacings consisting of magnetite nanoparticles (Fe3O4) with an average diameter of 20 nm were created by using meniscus force deposition method on substrates pre-patterned by electron beam lithography. To study the magnetic properties of the nanoparticle arrangements, angle-dependent ferromagnetic resonance experiments (FMR) were carried out for different measurement geometries. The analysis of the FMR spectra reveals that there are two resonances present. In in-plane geometry one resonance exhibits a clear angular dependence, while the second one remains constant. In order to get a deeper understanding of the results, micromagnetic simulations were carried out. By studying the dynamic properties in terms of solving the Landau-Lifschitz-Gilbert equation numerically it has been possible to assign these signals to different areas within the magnetic structures.

MA 15.58 Tue 10:00 Poster E

Magnetization dynamics in LSMO-heavy-metal bilayers
— •Christopher Heins, Cinja Seick, Vitaly Bruchmann-Bamberg, Daniel Steil, Vasily Moshnyaga, and Henning Ulrichs — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Goettingen, Germany

On this poster, we report on magnetization dynamics in a bilayer of $La_{1-X}Sr_XMnO_3$ (LSMO) and a heavy metal (Pt, beta-W). As a necessary prerequisite for further experimental investigations of this sample system, we in particular report on the implementation and application of stripline Ferromagnetic Resonance. With this technique we characterize the spin conductance of the interface between the two materials in the bilayer. When depositing Pt on LSMO, we find a significant increase of the Gilbert damping, whereas the magnetization is not affected. These results serve as guidelines for material selection and sample growth procedures regarding the prospect of time-resolved MOKE experiments including spin current generation in the heavy metal.

We acknowledge financial support by the Deutsche Forschungsgemeinschaft within SFB 1073.

MA 15.59 Tue 10:00 Poster E

Spin Pumping and Low Gilbert Damping in $Co_{25}Fe_{75}$ Heterostructures
— •Luis Flacke[1,2], Lukas Liensberger[1,2], David Rogerson[1,2], Matthias Althammer[1,2], Hans Huebl[1,2,3], Stephan Gerprägs[2], Katrin Schultheiss[4], Aleksandr Buzdakov[4], Tobias Hula[4], Helmut Schultheiss[4], Eric Edwards[5], Hans Nembach[5], Justin Shaw[5], Rudolf Gross[1,2,3], and Mathias Weiler[1,2] — [1]Physics-Department, Technical University of Munich, Garching, Germany — [2]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [3]Nanosystems Initiative Munich, Munich, Germany — [4]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [5]National Institue of Standards and Technology, Boulder, CO, USA

Itinerant ferromagnets offer advantages for magnonic and spintronic devices, but typically suffer from drastically higher Gilbert damping than insulating ferrimagnets. We fabricated and investigated low-damping $Co_{25}Fe_{75}$-heterostructures and separated Gilbert damping and spin pumping contributions to the total damping using broadband ferromagnetic resonance spectroscopy. From our measurements, we extrapolate that the intrinsic damping of the magnetic alloy reaches the low 10^{-3} regime. The extracted damping is in agreement with microfocused Brillouin-Light-Scattering experiments, which spatially resolve the spin wave propagation in patterned devices.

Financial support by Deutsche Forschungsgemeinschaft via projects WE5386/4 and WE5386/5 is gratefully acknowledged.

MA 15.60 Tue 10:00 Poster E

3D check board pattern formation of martensite/austenite domains in NiCoMnAl shape memory alloys
— •Andreas Becker, Daniela Ramermann, Martin Gottschalk, Inga Ennen, Björn Büker, Tristan Matalla-Wagner, Andreas Hütten, and Günter Reiss — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, 33615 Bielefeld, Germany

NiMnX (X=Al,Ga,Sn,In) magnetic shape memory Heusler alloys are considered as promising materials for magnetocaloric cooling applications due to their magnetoelastic coupling near room temperature. However most of them show a very large thermal hysteresis, which limits their potential in future applications.

Thin martensite interclations in thin films could be benificial for transforming films, because the formation energy during martensite nucleation is reduced. Our aim is to decrease the thermal hysteresis in off-stoichiometric NiCoMnAl thin films by preparing multilayer systems, which consist of alternatively grown martensite intercalations and active transforming austenitic layers. The stoichiometry of these two layers is chosen in such a way that their thermal hysteresis do not overlap.

Temperature dependent magnetization measurements show a significant decrease in hysteresis width as a function of the number of martensite intercalations. If the austenite active layers have a similar thickness compared to the martensite intercalations a 3D check board pattern becomes visible in HRTEM cross section images. The contrast is due to alternating martensite/austenite domains.

MA 15.61 Tue 10:00 Poster E

Heusler compound layer systems analysed with different HRTEM techniques — •Daniela Ramermann, Andreas Becker, Inga Ennen, Martin Gottschalk, Björn Büker, and Andreas Hütten — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, 33615 Bielefeld, Germany

Heusler compounds are with their strong magnetic properties promising candidates for thin film devices as also for magnetocaloric applications. Needed are custom-tailored magnetic properties, where the electron microscope helps with evaluation of the properties on a nanoscopic scale. Especially **NiCoMnAl** in intercalating layers of martensite/austenite crystal structure show unexpected behavior: a reproducable checkerboard pattern when certain layer thickness requirements are met. This pattern is investigated with HR-TEM methods also including energy-loss magnetic dichroism and differential phase contrast imaging, revealing slightly twisted against each other alternating stacked structures of martensite and austenite and magnetism centering on the **Mn** atoms.

MA 15.62 Tue 10:00 Poster E

Temperature-dependent red-shift of the absorption edge of thin ferromagnetic EuO-layers — Marcel Ney[1], Paul Rosenberger[2], Patrick Lömker[2], •Günther Prinz[1], Martina Müller[2,3], and Axel Lorke[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, D-47057 Duisburg — [2]Peter Grünberg Institut, Forschungszentrum Jülich GmbH, D-52428 Jülich — [3]Faculty of Physics, TU Dortmund, D-44227 Dortmund

EuO-layers are interesting candidates for spin-filter applications in spintronic research. Below the Curie temperature of T_C=69K, EuO becomes ferromagnetic, which has a strong influence on its optical band-gap.

We investigate the optical transmission of EuO-layers with thicknesses below 50nm from room temperature down to ≈25K. The EuO-layers are grown by a molecular-beam-epitaxy process on YSZ-substrates. Below the T_C we observe a step-like shift of the absorption edge towards lower energies. This behavior can be explained by the magnetic exchange interaction, which leads to a splitting of the conduction band. Thinner layers not only show a blue-shift towards higher band-gap energies due to quantum confinement effects, but also exhibit a larger red-shift of the absorption edge during cooling below T_C. This stronger red-shift of the absorption edge starts at lower temperatures compared with thicker samples, which is attributed to a reduced magnetic exchange interaction for very thin EuO-layers. In contrast to reports in the literature, we observe a monotonic red-shift of the absorption edge for different layer thicknesses.

MA 15.63 Tue 10:00 Poster E

Influence of granularity on the magnetotransport-properties of manganese-monosilicide — •Sebastian Kölsch and Michael Huth — Goethe Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Germany

Silicon-based alloys with 3d magnetic metals offer the potential for applications in spintronics and magnetic storage devices. Recently the manganese-monosilicide (MnSi) of B20-type attracted high interest due to a topological non-trivial magnetic phase in bulk MnSi at low temperatures (<30K), which could be identified as magnetic whirls known as skyrmions [1].

Considering potential applications, a reduction of dimensionality in terms of thin magnetic/semiconducting films is mandatory. In this case change of the magnetic phase diagram due to surface anisotropy and strain effects have to be taken into account. So far research has focused on optimizing the thin film growth conditions to obtain ideally monocrystalline epitaxial thin films. However, polycrystalline thin films grown by pulsed laser deposition (PLD) with increased degree of disorder, e.g. caused by non stoichiometric proportions of Mn and Si show a high-temperature (>300K) ferromagnetic phase near an insulator-metal-transition [2].

Here we present recent results on the successful growth of epitaxial but nano-granular MnSi thin films showing an unexpectedly high magnetoresistance effect.

[1] Mühlbauer, S. et al. Science 323, 915-919 (2009)
[2] Nikolaev, S. N. et al. AIP Advances 6, 015020 (2016)

MA 15.64 Tue 10:00 Poster E

Quantum entanglement of charge and spin in frustrated κ-(BEDT-TTF)2Hg(SCN)2Br — •Mamoun Hemmida[1,2], Hans-Albrecht Krug von Nidda[2], Björn Miksch[1], Leonid Samoilenko[1], Andrej Pustogow[1], Sebastian Widmann[2], Alois Loidl[2], and Martin Dressel[1] — [1]1. Phys. Inst., Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]EP V, EKM, Universität Augsburg, 86135 Augsburg, Germany

Detailed static and dynamic spin susceptibilities as well as transport investigations [1] of the two-dimensional frustrated organic metal κ-(BEDT-TTF)2Hg(SCN)2Br exhibit unusual properties below the metal-insulator transition temperature of 90 K of both charge and spin degrees of freedom. Such properties like weak ferromagnetism and glassy state seem to result from the dominant role of quantum fluctuations associated with frustration and disorder at low temperatures. Based on the experimental observations, a strong entanglement between spin and charge degrees of freedom has been suggested in Ref. 2. We gratefully acknowledge sample preparation and structural characterization by A. Henderson, T. Siegrist and J. A. Schlueter.

[1] T. Ivek et al., Phys. Rev. B 96, 085116 (2017).
[2] M. Hemmida et al., arXiv:1710.04028 (2017).

MA 15.65 Tue 10:00 Poster E

Spin reduction in covalent chain antiferromagnet $RbFeSe_2$ — •Hans-Albrecht Krug von Nidda[1], Airat Kiiamov[2], Lenar Tagirov[2,3], Yury Lysogorsky[2,5], Dmitrii Tayurskii[2], Zakir Seidov[1], Vladimir Tsurkan[1,4], Dorina Croitori[4], Axel Günther[1], Farit Vagizov[2], Franz Mayr[1], and Alois Loidl[1] — [1]EP V, EKM, University of Augsburg, D-86135 Augsburg — [2]Institute of Physics, Kazan Federal University, RUS-420008 Kazan — [3]Zavoisky Physical-Technical Institute, Kazan FRC of RAS, 420029 Kazan — [4]Institute of Applied Physics, MD-20208 Chisinau — [5]ICAMS, Ruhr-University Bochum, D-44801 Bochum

SQUID susceptibility, Mössbauer and specific-heat measurements show that $RbFeSe_2$ exhibits antiferromagnetic order below T_N=248 K. The magnetic specific heat of $RbFeSe_2$ and the spin state of Fe^{3+} ions in the compound have been analyzed. Phonon dispersion and PDOS, were evaluated from first-principles calculations. It is shown that iron atoms in quasi-one-dimensional chains have dramatically different vibrational properties against Rb and Se atoms. Analysis of our Mössbauer data, utilizing the calculated Fe PDOS, as well as our optical absorption measurements have shown full agreement with the location of the high-frequency optical-type lattice vibrations within the $FeSe_4$ tetrahedra. The phonon heat capacity has been used to evaluate the magnetic specific heat of the quasi 1D antiferromagnetically correlated Fe^{3+} ion chains. The magnetic entropy suggests an intermediate spin state S=3/2 for Fe^{3+} ions in agreement with the reduced hyperfine field of 216 kOe at 4.2 K detected by Mössbauer spectroscopy.

MA 15.66 Tue 10:00 Poster E

MBE growth of Sr(Mn,As)2 — •Martin Brajer[1,2] and Vít Novák[1] — [1]Institute of Physics ASCR, v.v.i., Cukrovarnicka 10, 162 53 Praha, Czech Republic — [2]Faculty of Mathematics and Physics, Charles University in Prague, Ke Karlovu 3, 121 16 Prague, Czech Republic

We report on growth of antiferromacnetic (AF) semiconductor by means of molecular beam epitaxy: trigonal Sr(Mn,As)2, extending the I-Mn-V family of room-temperature AFs. It has broken inversion symmetry, allowing for current-induced switching of AF moments. It can be successfully grown on lattice-matched zinc-blende semiconductor substrate, (111)InAs, which allows for a stable 2D growth, but hinders its basic transport characterization because of the high substrate conductivity. We study growth, crystal quality and surface morphology of the material depending on the growth parameters.

MA 15.67 Tue 10:00 Poster E

Reversible tuning of structural, magnetic and transport properties via oxygen desorption/absorption in epitaxial La(0.7)Sr(0.3)MnO(3-δ) thin films — Lei Cao[1], •Oleg Petracic[1], Paul Zakalek[1], Alexander Weber[2], Ulrich Rücker[1], Jürgen Schubert[3], Alexandros Koutsioubas[2], Stefan Mattauch[2], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ) Forschungszentrum Jülich GmbH, Garching, Germany — [3]Peter Grünberg Institute (PGI9-IT), JARA-Fundamentals of Future Information

Technology Forschungszentrum Jülich GmbH, Jülich, Germany

An oxygen vacancy induced topotactic transition from perovskite to brownmillerite and vice versa in epitaxial La(0.7)Sr(0.3)MnO(3-δ) thin films is identified by real-time x-ray diffraction. A novel intermediate phase with a non-centered crystal structure is observed for the first time during the topotactic phase conversion which indicates a distinctive transition route. Polarized neutron reflectometry confirms an oxygen deficient interfacial layer with drastically reduced nuclear scattering length density, further enabling a quantitative determination of the oxygen stoichiometry (La(0.7)Sr(0.3)MnO(2.65)) for the intermediate state. Associated physical properties of distinct topotactic phases (i.e. ferromagnetic metal and anti-ferromagnetic insulator) can be switched reversibly by an oxygen desorption/absorption cycling process.

MA 15.68 Tue 10:00 Poster E

Thickness dependence of the anomalous Hall effect in thin films of the magnetic Weyl Co_2MnGa — •Anastasios Markou, Liguo Zhang, Dominik Kriegner, Yi-Chen Cheng, Jacob Gayles, Yan Sun, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Magnetic Weyl semimetals with broken time-reversal symmetry show exotic transport properties, due to the Weyl points and the associated large Berry curvature in their electronic structure [1]. Therefore, the anomalous Hall effect is expected to be large, and due to the intrinsic contribution that derives from the net Berry curvature. Here, we present the thickness dependence of the structural, magnetic, and transport properties of thin films in the magnetic Weyl semimetal Co_2MnGa. We find a large anomalous Hall conductivity and anomalous Hall angle up to 1187 $\Omega^{-1}cm^{-1}$ and 13%, respectively, which is an order of magnitude larger than typical magnetic systems.

[1]K. Manna *et al.*, Nature Reviews Materials **3**, 244 (2018)

MA 15.69 Tue 10:00 Poster E

Spin-resolved ACAR measurements of Co_2MnGa — •Josef Ketels[1], Michael Leitner[2], Kaustuv Manna[3], Rolf Stinshoff[3], Claudia Felser[3], and Christoph Hugenschmidt[1,2] — [1]Physik Department E21, Technische Universität München, Garching, Germany — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching, Germany — [3]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

The ferromagnetic compound Co_2MnGa crystallizes in the full Heusler $L2_1$ structure. This material is expected to be a half-semimetal due to a small Fermi surface in the minority spin channel. The spin polarization was experimentally determined to be close to $4.0\mu_B$/formula unit [1]. Furthermore this Heusler compound was one of the first materials to show the anomalous Nernst effect beyond the magnetization scaling relation due to the large net Berry curvature close to the Fermi energy originating from Weyl points and nodal lines [2]. The measurement of the angular correlation of positron annihilation radiation (ACAR) is a very powerful tool to investigate the bulk electronic structure. Based on the spin polarization of the positrons from a Na^{22} source, the minority and majority spin-channels can be determined separately. Here we present the first spin-resolved ACAR experiments showing the anisotropy of the Fermi surface of Co_2MnGa.

[1] Kolbe, M. *et al.*, Phys. Rev. B 86, 024422 (2012)
[2] Guin, S.N. *et al.*, arXiv:1806.06753 [cond-mat.mtrl-sci], (2018)

MA 15.70 Tue 10:00 Poster E

Structural characterization and magneto-transport properties of magnetron co-sputtered Weyl semimetal candidate Co2TiGe — •Denis Dyck[1], Andreas Becker[1], Jan Krieft[1], Anish Rai[2], Robin-Pierré Klett[1], Jungwoo Koo[1], Karsten Rott[1], Jan-Michael Schmalhorst[1], Tim Mewes[2], and Günter Reiss[1] — [1]Center for Spinelectronic Materials and Devices, Bielefeld University, Germany, Bielefeld — [2]Center for Materials for Information Technology, The University of Alabama, United States of America, Tuscaloosa

Weyl semimetals theoretically promise exotic transport properties and are also interesting for spintronic devices. Thus, the research is pursued with high effort in the recent years. Implementation in real life applications requires a scalable and energy efficient approach. As a highly tunable material class, Heusler compounds are particularly interesting in this respect. Here, we investigate the Weyl semimetal candidate and transition metal based Full Heusler compound Co2TiGe. X-ray diffraction (XRD) analysis and phi scans of the magnetron co-sputtered thin films show a highly textured L21 structure of the 225 (Fm-3m) space group with a lattice constant close to the literature value. Transmission electron microscopy (TEM) confirms the crystallographic quality. The magnetic properties have been examined by magneto-optical Kerr effect (MOKE), vibrating sample magnetometry (VSM) and ferromagnetic resonance (FMR). In addition, anomalous and planar Hall effect, and tunnel magneto resistance (TMR) measurements have been carried out.

MA 15.71 Tue 10:00 Poster E

Ferromagnetic ordering and heavy fermion behavior in $Ce_2Ru_3Ge_5$ — Ramesh Kumar Kamadurai[1,2], Djoumessi Fobasso Redrisse[2], and •Andre M Strydom[2] — [1]Institute of Physics, Chinese Academy of Sciences, Beijing, China — [2]Department of Physics, University of Johannesburg, South Africa

The series of intermetallic compounds $Ce_2T_3Si_5$ (T- Transition metal X - Si, Ge) exhibit wide range of magnetic behaviour such as magnetic ordering, heavy fermion behaviour and Kondo effect. We present the magnetic susceptibility (χ), specific heat (C_P), resistivity (ρ) thermopower (S) and magnetoresistivity (MR) properties of $Ce_2Ru_3Ge_5$. The refined lattice parameter was observed to be *a = 9.9497 (4) , b = 12.416 (4), c = 5.8978 (2) . By means of $\chi(T)$, $C_P(T)$ $\rho(T)$, $S(T)$ and MR measurements we show that the system exhibits ferromagnetic-like long-range ordering below 7.9 K with localized Ce^{3+} ions and Sommerfeld coefficient $\gamma = 85$ mJ/mol.K. A strong influence of field dependent $\chi(T)$, $\rho(T)$ and reduced saturation moment (0.32 μ_B) suggest that the crystalline electric field (CEF) plays a role in the ground state properties. The CEF splitting energies are estimated to be $\Delta_1 = 567$ K and $\Delta_2 = 1491$ K for the first and second excited states respectively. Absence of logarithmic variation of ρ_{mag} at low temperatures, negative MR at 2 K indicate that the Kondo energy scales are small ($\approx$ 10 K) the system exhibit incoherent Kondo scattering.

MA 15.72 Tue 10:00 Poster E

Correlating structural and magnetic properties of polycrystalline exchange bias systems — •Maximilian Merkel[1], Jonas Zehner[2], Karin Leistner[2], Dennis Holzinger[1], and Arno Ehresmann[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]Leibniz Institute for Solid State and Materials Research Dresden, IFW Dresden, Helmholtzstr. 20, D-01069 Dresden

Magnetic properties of sputter-deposited polycrystalline exchange bias thin films evolve from a complex interplay of different individual magnetic anisotropies which are directly connected to the grain size distribution, crystallite texture and interface structure of the layer system. These structural characteristics can be controlled via deposition parameters or manipulated during a thermal activation procedure in an external magnetic field. Angular-resolved hysteresis measurements using Kerr magnetometry in comparison to an extended Stoner-Wohlfarth model [1], X-ray diffraction experiments and interface roughness characterization allowed for the quantification of material properties in dependence of the layer thickness, deposition parameters and the field cooling temperature, supporting common structure zone models.

[1] Müglich, N. D., Gaul, A., Meyl M., Ehresmann, A. , Götz, G., Reiss, G., Kuschel T., Time-dependent rotatable magnetic anisotropy in polycrystalline exchange-bias systems: Dependence on grain-size distribution, Physical Review B **94**, 184407 (2016)

MA 15.73 Tue 10:00 Poster E

Influence of layer thickness on exchange-spring behavior of $SrRuO_3$-$La_{0.7}Sr_{0.3}MnO_3$ bilayers — •Martin Michael Koch, Lukas Bergmann, Aurora Diana Rata, and Kathrin Dörr — Martin-Luther-Universität Halle-Wittenberg, Deutschland

Thin epitaxial bilayers of $SrRuO_3/La_{0.7}Sr_{0.3}MnO_3$ on $SrTiO_3(001)$ substrates have been suggested to form an exchange spring in $SrRuO_3$ at the interface where strong antiferromagnetic exchange coupling with the adjacent manganite layer is present. We analyze temperature- and field-dependent magnetization data in sample series of systematically varied layer thicknesses of both components grown by pulsed laser deposition on TiO_2-terminated substrates. Magnetic switching of such bilayers is strongly different from that of a conventional exchange-bias-coupled bilayer. A model of the interfacial spin structure is suggested as a vertical Bloch wall with gradually increasing out-of-plane spin canting, with in-plane magnetic easy axes at the interface and strained-bulk-like $SrRuO_3$ characteristics in sufficient distance from the interface. Results indicate a maximum extension of the exchange spring of about 10 unit cells (4 nm) into the $SrRuO_3$ layer. We discuss the impact of such interfacial spin textures on magnetic switching as well as on further properties which are important for spintronics applications.

MA 15.74 Tue 10:00 Poster E

Interlayer Exchange Coupling Dependent Variation of the Saturation Magnetization of Multilayered Systems — •Frank Schulz[1], Erol Girt[2], Zachary Nunn[2], and Eberhard Goering[1] — [1]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany — [2]Simon Fraser University, Burnaby, Canada

The effect of interlayer exchange coupling in magnetic thin films has proven to be of great technological use, enabling the development of hard drives with very high storage densities. And yet, there are aspects of this effect that are still not fully understood. Recent studies have found that the interlayer thickness of Co/RuFe/Co sandwiches does not only affect the type of interlayer coupling and its strength, but also causes a non-monotonous variation of the saturation magnetization of these systems. In order to investigate this effect, X-ray absorption spectra have been measured in total electron yield. Making use of the X-ray magnetic circular dichroism (XMCD) effect, this gives an element specific method of measuring the magnetic properties of the samples. Additionally, magnetometric measurements have been performed using a superconducting quantum interference device (SQUID), which were combined with simulations using an enhanced Stoner-Wohlfarth model. With these methods, it could be shown that the change in saturation magnetization does not stem from the magnetic contribution of the Fe in the interlayer, but instead can be attributed to a non-magnetic *dead layer* of Co near the interface of Co and RuFe. The thickness of this dead layer was estimated, under consideration of self absorption effects, to be approximately 0.1 nm.

MA 15.75 Tue 10:00 Poster E

Ferromagnetism in $LaMnO_3/SrMnO_3$ superlattices: role of structural layout — •Robert Gruhl[1], Vitaly Bruchmann-Bamberg[1], Jan Philipp Bange[1], Vladimir Roddatis[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]Institut für Materialphysik, Georg-August-Universität Göttingen, Germany

Interfaces in the heterostructures of transition metal oxides show unique properties which cannot be observed in the constituent bulk materials. The prominent example is a 2D electron gas in $LaAlO_3/SrTiO_3$. These emergent interfacial phenomena are believed to arise due to the complex charge, spin and orbital reconstructions at the interfaces. Superlattices (SLs) of $LaMnO_3$ (LMO) and $SrMnO_3$ (SMO) were prepared on $SrTiO_3$(100) substrates using the metalorganic aerosol deposition. The growth, controlled in-situ by optical ellipsometry, results in superlattices with flat and chemically sharp interfaces as well as in an atomically smooth surface morphology. The prepared SLs, composed from two antiferromagnets, show complex magnetic behavior with high- and low-temperature ferromagnetic phases. Samples with a constant bilayer and total thickness but with varying thicknesses of LMO and SMO were studied to determine the mutual influence of the LMO/SMO thicknesses on the interfacial magnetic properties as well as on the magnetism of the whole superlattice. Financial support of the Deutsche Forschungsgemeinschaft via SFB 1073 TP A02 is acknowledged.

MA 15.76 Tue 10:00 Poster E

Influence of defects inside the (Ni_xMn_{1-x}) antiferromagnetic layer on exchange bias in Ni_xMn_{1-x}/Co bilayers — •Tauqir Tauqir[1], M. Yaqoob Khan[2], Ismet Gelen[1], Ivar Kumberg[1], Yasser A. Shokr[1], Evangelos Golias[1], and Wolfgang Kuch[1] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Kohat University of Science and Technology, Kohat 26000, Khyber Pakhtunkhwa, Pakistan

A series of experiments are carried out to identify the fundamental mechanism leading to the exchange bias effect in ultrathin epitaxial ferromagnetic/antiferromagnetic (FM/AFM) Co/Ni_xMn_{1-x} (x=0; 0.25; 0.35; 0.5) bilayer samples on a Cu_3Au(001) substrate. Structural or chemical defects are deliberately introduced by Ar^+ ion bombardment for short times at a certain depth of the AFM layer. The approach is to influence the pinning sites inside the AFM material by the controlled insertion of disorder. Comparison of the magnetic properties measured by magneto-optical Kerr effect then allows a precise determination of the influence of the Ar^+ ion bombardment of the AFM layer. We find that for each sample, defects result in an increase of coercivity and exchange bias field (H_{eb}). We interpret this by the formation of domains within the AFM layer by the defects, which in turn give rise to uncompensated pinned moments that are responsible for the increased H_{eb} as predicted in the domain-state model.

MA 15.77 Tue 10:00 Poster E

Investigation of Granular Magnetic Exchange Coupled Nano-Composites — •Runbang Shao, Siming Zou, Balati Kuerbanjiang, and Ulrich Herr — Institut für Mikro- und Nanomaterialien, Universität Ulm, Ulm, Deutschland

Exchange coupling of ferromagnetic (FM) nanoparticles to antiferromagnets (AF) can increase the coercivity and the stability against superparamagnetic fluctuations. It has potential applications in further increasing the storage density of hard disk drive and manufacturing permanent magnets with high energy products. We have studied nano-composites with FM Co or Ni nanoparticles embedded in AF FeMn or IrMn thin films. To determine the average size of nanoparticles, the superparamagnetic room-temperature m-H curves of reference samples with FM nanoparticles embedded in non-magnetic Cu films are fitted using a superposition of Langevin functions calculated for varying particle size. The fitted size distribution agrees well with the result obtained by T-SEM analysis of free standing nanoparticles. After application of a field cooling procedure, exchange bias is observed for both Ni/IrMn and Co/FeMn samples at 10K. We observe a pronounced dependence of the exchange bias on FM volume filling factor. Blocking temperatures are determined via zero field cooled (ZFC) and field cooled (FC) measurements. Comparison of the blocking temperatures of nanoparticles embedded in AF films and nanoparticles embedded in non-magnetic films reveals the influence of the exchange coupling on the magnetic energy landscape.

MA 15.78 Tue 10:00 Poster E

Magnetic and structural properties of MBE grown Fe/Gd films on W(110) investigated with XRR and XMCD-R — •Dominic Lawrenz[1], Wibke Bronsch[1], Markus Gleich[1], Xinwei Zheng[1], Abdallah Elkalash[1], Christian Schüssler-Langeheine[2], Emmanuelle Jal[3], Nele Thielemann-Kühn[1], and Martin Weinelt[1] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Strasse 15, 12489 Berlin — [3]Laboratoire de Chimie Physique-Matiere et Rayonnement, 4 place Jussieu, 75252 Paris Cedex 05

We studied bilayers of Fe/Gd on W(110) grown via molecular beam epitaxy (MBE). Thickness as well as roughness of the overall film and its constituent layers can be determined from an analysis of X-ray reflectrometry (XRR) measurements. Employing the dichroic response of the Fe L_3 and the Gd M_5 edges measured with XMCD in reflection, we examined the temperature-dependent magnetization of the bilayer element specifically. Our results show a ferrimagnetic coupling between the Fe and Gd layers in agreement with previous investigations [1]. Close to room temperature we observe that both layers first demagnetize and at slightly higher temperatures remagnetize in the opposite direction. This is very promising as it hints at the possibility of single shot all-optical switching of such layers with short laser pulses, shown for FeGd alloys before [2].

[1] Haskel *et al.*, *Phys. Rev. Lett.* **87**, 207201 (2001)
[2] Stanciu *et al.*, *Phys. Rev. Lett.* **99**, 047601 (2007)

MA 15.79 Tue 10:00 Poster E

Fabrication of tunnel junctions using a combination of sputtering and atomic layer deposition — •L. P. Potapov[1,2], K. Geishendorf[3], R. Schlitz[1,2], K. Nielsch[3,4], S. Fabretti[1,2], S. T. B. Goennenwein[1,2], and A. Thomas[3] — [1]Institute for Solid State and Materials Physics, Technical University of Dresden — [2]Center for Transport and Devices of Emergent Materials, Technical University of Dresden — [3]Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Institute for Metallic Materials — [4]Institute of Materials Science, Technical University of Dresden

Since more than 20 years, magnetic tunnel junctions are attracting great attention in spin electronics research. One of the key challenges for the fabrication of high-quality tunnel elements is the deposition of ultrathin, homogeneous and pinhole free tunnel barriers.

Atomic layer deposition (ALD) seems to be very promising for that, since it allows for conformal and robust coating of arbitrarily shaped surfaces. Following up on a recent publication [1], this work investigates the fabrication and properties of magnetic tunnel junctions fabri-

cated by a combination of magnetron sputtering and ALD. Specifically, we look into the combination of shadow masks and ALD deposition in view of high-quality (magnetic) tunnel junctions. The characterization of the tunnel junctions is performed using complementary structural and electrical methods.
[1] S. Fabretti *et. al.*, Appl. Phys. Lett. **105**, 132405 (2014)

MA 15.80 Tue 10:00 Poster E

Strain-induced perpendicular magnetic anisotropy and Gilbert damping in Tm3Fe5O12 thin films — •Oana Ciubotariu[1], Anna Semisalova[2], Killian Lenz[2], and Manfred Albrecht[1] — [1]Institute of Physics, University of Augsburg, Universitätsstraße 1, 86135 Augsburg, Germany — [2]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, BautznerLandstr. 400, 01328 Dresden, Germany

In the attempt of implementing iron garnets with perpendicular magnetic anisotropy (PMA) in spintronics, the attention turned towards strain-grown iron garnets. One candidate is Tm3Fe5O12 (TmIG) which shows strain-induced PMA when grown under tensile strain [1]. Possible substrate choices are GGG(111) and substituted-GGG(111) substrates, where the latter generated a higher in-plane tensile strain for the growth of TmIG. TmIG films with thicknesses between 20 and 300 nm were grown by PLD on sGGG(111) substrates. XRD measurements showed that films thinner than 200 nm exhibit in-plane tensile strain, thus, they meet the requirement for PMA. As expected, these films show PMA due to strain-induced magneto-elastic anisotropy. However, with increasing film thickness a relaxation of the unit cell towards its bulk structure is observed resulting in a rotation of the magnetic easy axis from out of the sample plane towards the sample plane. The Gilbert damping parameter extracted from FMR measurements is in the range of 0.03 independent of the film thickness.

[1] Kubota, M. et al. App. Phys. Exp. 5, 103002 (2012)

MA 15.81 Tue 10:00 Poster E

Interface coupling between 3*d*-$La_{0.67}Sr_{0.33}MnO_3$ and 5*d*-$SrIrO_3$ — •Lukas Bergmann, Diana Rata, Pia Düring, and Kathrin Dörr — Martin Luther University Halle-Wittenberg, Institute of Physics, Halle (Saale), Germany

Iridate compounds are of high scientific interest, since they show emergent phenomena due to competition between the relevant energy scales of electron correlation, bandwidth and, most importantly, strong spin-orbit coupling. We investigate how the interface coupling between 3*d*-$La_{0.67}Sr_{0.33}MnO_3$ (LSMO) and 5*d*-$SrIrO_3$ (SIO) alters the magnetic properties such as magnetic order and anisotropy of LSMO which is a bulk collinear ferromagnet with high spin polarization.

High-quality superlattices and bilayers of LSMO and SIO were coherently grown with systematically varied layer thicknesses by pulsed laser deposition on TiO_2 terminated (100) $SrTiO_3$ substrate. The structure characterization was done by XRD. The magnetic and electrical properties were investigated by SQUID and transport measurements. Bilayers of reversed growth sequence show strongly different magnetic properties. Depending on layer thickness and sample type, the saturated magnetic moment and the Curie temperature of LSMO is strongly suppressed. Our results suggest the occurrence of non-collinear Mn spin textures at the LSMO/SIO interfaces.

MA 15.82 Tue 10:00 Poster E

Investigation of tunneling anisotropic magnetoresistance (TAMR) in fully epitaxial oxide stacks — •Kevin Lancaster[1], Camillo Ballani[1], Christoph Hauser[1], Philip Trempler[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle (Saale), Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg 06120 Halle (Saale), Germany

Tunneling anisotropic magnetoresistance (TAMR) [1] can appear in stacks with a single crystalline ferromagnetic electrode, a tunnel barrier and a non-magnetic counter electrode. Especially for fully epitaxial stacks an increase in magnetoresistance is expected because of increased k-parallel conservation. More complex effects may appear when a ferroelectric tunnel barrier is used. We present an optimization for the thin film pulsed laser deposition of $SrTiO_3$ and $BaTiO_3$ tunnel barriers on $La_{0,7}Sr_{0,3}MnO_3$ for (001)-oriented $SrTiO_3$ substrates. After deposition the layer stacks were processed by means of lithography, etching and electron beam evaporation. Besides structural characterization we will present magnetotransport measurements done at low temperatures in a cryostat equipped with a 3D vector magnet.

[1] C. Gould, C. Ruester, G. Schmidt, L. Molenkamp: "Tunnelling Anisotropic MagnetoResistance (TAMR)", INTERMAG 2006 - IEEE International Magnetics Conference 4261550 (2006), 116

[2] J. D. Burton, Evgeny Y. Tsymbal: "Tunneling anisotropic magnetoresistance in a magnetic tunnel junction with half-metallic electrodes", Physical Review B93, 024419, 2016

MA 15.83 Tue 10:00 Poster E

X-ray resonant magnetic reflectometry (XRMR) study of the interface between ferromagnetic transition metals and MgO — Daan Benjamin Boltje[1,2], •Sven Erik Ilse[1], Gisela Schütz[1], and Eberhard Goering[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]Delmic BV, Delft, Netherlands

Multilayer systems of ferromagnetic transition metals and MgO attract a lot of attention in the last years because of their application in STT-MRAMs. The chemical and magnetic properties at the interface between the transition metal and MgO are of exceptional interest in STT-MRAM cells. Those properties determine for example the strength of the interfacial perpendicular magnetic anisotropy and the thickness of possible magnetic dead layers, which are important parameters for the performance of MRAMs. With X-ray resonant magnetic reflectometry (XRMR) we combine the advantages reflectometry and X-ray magnetic circular dichroism (XMCD). Thus, we are able to determine element specific chemical and magnetic depth profiles including roughness at interfaces with XRMR. We performed X-ray absorption spectroscopy (XAS), XMCD and XRMR measurements on Ta|CoFeB|MgO|Al2O3|Au stacks. The chemical depth profile revealed a pronounced roughness at the Ta|CoFeB interface and that especially Fe intermixes largely with other species at the interfaces. The magnetic depth profile revealed a 10 Å and a 4 Å thick magnetic dead layer for Fe and Co, respectively, at the CoFeB|MgO interface.

MA 15.84 Tue 10:00 Poster E

Characterization of the exchange bias system Fe_3O_4/CoO via SQUID and VSM — •Kevin Ruwisch, Jari Rodewald, and Joachim Wollschläger — Fachbereich Physik, Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück

Spintronics is a rising field of research in physics. Here, magnetite as a ferrimagnet and cobaltoxide as an antiferromagnet have become more important for industrial applications in spintronics over the years. For instance, magnetite is used in magnetoresistive random-access memory (MRAM) consisting of magnetic tunnel junctions (MTJ). Thus, improving the magnetic properties of ferrimagnetic/antiferromagnetic bilayers for spintronic devices is very important since antiferromagnetic films serve as pinning layers, e.g., for MTJs due to exchange bias.

Hence, in this work Fe_3O_4/CoO bilayers, grown by reactive molecular beam epitaxy (RMBE) on MgO(001), are investigated via temperature-dependent vibrating sample magnetometry (VSM) and superconducting quantum interference device (SQUID). Hysteresis as well as temperature dependent magnetization measurements were performed. The composition as well as the surface structure have been characterized by in-situ x-ray photoelectron spectroscopy (XPS) and low-energy electron diffraction (LEED), respectively. One approach of characterizing the magnetic features of Fe_3O_4/CoO is to evaluate the impact of CoO towards coercivity, remanence, magnetocrystalline anisotropy and especially the exchange bias. Additionally the blocking temperature with respect to the film thickness of the antiferromagnetic layer is investigated.

MA 15.85 Tue 10:00 Poster E

Metadynamics study on the reorientation transition in magnetic thin films — •László Udvardi[1,2], Balázs Nagyfalusi[1], and László Szunyogh[1,2] — [1]Department of Theoretical Physics, Buapest University of Technology and Economics — [2]MTA-BME Condensed Matter Research Group, Budapest University of Technology and Economics

The competition between different type of anisotropies often leads to a reorientation of the magnetization direction. The temperature driven spin reorientation transition in thin films is usually explained by competing uniaxial on-site anisotropy and shape anisotropy. In the study we present the results of Monte Carlo simulations based on a classical Heisenberg model. The free energy landscape is sampled along a path relevant for the reorientation by means of well tempered metadynamics[1]. The simulation has been performed using model parameters and exchange tensors and anisotropy parameters obtained from *ab-initio* calculations. We demonstrate that the competing magnetic anisotropies result in both first and second order transitions.

[1] Barducci, A. and Bussi, G. and Parrinello, M., Phys. Rev. Lett.

100, 020603 (2008)

MA 15.86 Tue 10:00 Poster E

Temperature and angular dependence of the anisotropic magnetoresistance in epitaxial Mn5Ge3 film — •Yufang Xie[1,3], ye yuan[2], mao wang[1,3], chi xu[1,3], manfred helm[1,3], shengqiang zhou[1], and Slawomir Prucnal[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, D-01328 Dresden, Germany — [2]Physical Science and Engineering Division, King Abdullah University of Science and Technology, 23955-6900 Thuwal, Saudi Arabia — [3]Technische Universität Dresden, D-01062 Dresden, Germany

The (100) epitaxial ferromagnetic Mn5Ge3 films are made by ms-range diffusion of Mn into Ge (100) [1] . Temperature and angular dependent magnetoresistance (MR) measurements performed on the ferromagnetic Mn5Ge3 films reveal strong anisotropy when applied field is parallel to the film plane. More interestingly, the angular dependence of the MR at H =30 kOe change strongly with temperature. The characteristic feature of the angular dependent MR is a twofold symmetry at temperature below 170 K. As the temperature increases from 170 K to 270 K an additional set of peaks appears and the observed anisotropy becomes more and more prominent. At this temperature range the MR shows an overall fourfold symmetry. At the temperature higher than 270 K the angular dependent MR shows a twofold symmetry again.

[1] Y. Xie, Y. Yuan, M. Wang, C. Xu, R. Hübner, J. Grenzer, Y. Zeng, M. Helm, S. Zhou and S. Prucnal, Appl. Phys. Lett. 113, 222401 (2018)

MA 16: Surface Magnetism (joint session O/MA)

Time: Tuesday 10:30–13:00 Location: H37

MA 16.1 Tue 10:30 H37

Unoccupied surface and interface states in thin film of Pd deposited on Fe/Ir(111) surface — •Mohammed Bouhassoune, Imara Lima Fernandes, Stefan Blügel, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

Pd layer deposited on Fe/Ir(111) substrate has been recently subject to intensive investigations since it hosts small swirling spin-textures named skyrmions that have potential interest in spintronic devices as magnetic bits for information technology. To manipulate and stabilize such non-collinear magetic objects it is of important demand to conduct a quantitaive study of their electronic structure. Here we aim to investigate the unoccupied states in Pd thin layers deposited on Fe/Ir(111) substrate using density functional theory. These unoccupied states are behind the large spin-mixing magnetoresisatnce (XMR) signature measured using non spin-polarized scanning tunnelling microscopy (STM) [1,2]. By analysing the electronic band structure we demonstrate the emergence of surface and interface states after deposition of Pd monolayers, which are very sensitive to the large spin-orbit coupling of Ir surface giving rise to the XMR signal.

This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (ERC-consolidator Grant No. 681405 DYNASORE).

[1] D. M. Crum, M. Bouhassoune, J. Bouaziz, B. Schweflinghaus, S. Blügel, and S. Lounis, Nat. Commun. 6 8541 (2015)

[2] C. Hanneken et al, Nat, Nanotech. 10, 1039 (2015)

MA 16.2 Tue 10:45 H37

Investigation of Fe/Pt (110) magnetic structure by first-principles methods — •Vasily Tseplyaev, Jens Bröder, Markus Hoffmann, Daniel Wortmann, Bernd Zimmermann, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

While skyrmions - localized and topologically protected vortex-like magnetic textures - are the main focus within the current research field of chiral magnets, we have discussed in a recent work [1] the possible emergence of interface stabilized *antiparticles*, so-called antiskyrmions, magnetic textures with a topological charge and one-dimensional winding number opposite to the one of skyrmions. For instance, antiskyrmions can appear in ultrathin magnetic films grown on heavy metal substrates with C_{2v} symmetry, if the electronic structure supports a Dzyaloshinskii spiralization tensor that fulfils additional conditions e.g. its determinant is smaller than zero. With the motivation to find interesting antiskyrmion systems we investigate magnetic systems with C_{2v} interface symmetry, e.g. Fe/Pt(110), using relativistic and non-collinear first-principles theory implemented in the FLEUR code (www.flapw.de).

[1] M. Hoffmann *et al.*, Nat. Commun. **8**, 308 (2017)

MA 16.3 Tue 11:00 H37

Yu-Shiba-Rusinov states of Fe atoms on 2H-NbSe$_2$ — •Eva Liebhaber[1], Rojhat Baba[1], Jannik Steinborn[1], Gaël Reecht[1], Sebastian Rohlf[2], Kai Rossnagel[2], Benjamin W. Heinrich[1], Felix von Oppen[1,3], and Katharina J. Franke[1] — [1]Fachbereich Physik, Freie Universität Berlin, Germany. — [2]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany. — [3]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Germany.

A magnetic impurity adsorbed on a superconducting substrate induces Yu-Shiba-Rusinov (YSR) states. These are low-energy bound states inside the superconducting energy gap. The symmetry and extent of the YSR wave function depends on the adsorption site (i.e. crystal field), the nature of the orbital hosting the impurity's spin and the shape of the Fermi surface of the substrate.

We investigate single Fe atoms on 2H-NbSe$_2$. 2H-NbSe$_2$ belongs to the class of transition metal dichalcogenides (TMDCs) and is a layered van der Waals material with strong 2D character. In this material, superconductivity coexists with a charge density wave (CDW) at low temperatures. As the CDW is incommensurate with the lattice there are different local charge modulations present on the surface. Hence, adatoms sitting in identical hollow sites differ in their position relative to the CDW leading to variations in symmetry and energy of the YSR resonances.

MA 16.4 Tue 11:15 H37

Epitaxial growth of the ultrathin EuS films on the InAs(001) and magnetic coupling between these films and organometallic phthalocyanine monolayers — •Carmen González Orellana, Maxim Ilin, and Celia Rogero — Centro de Física de Materiales, San Sebastián, Spain

EuS has recently attracted a lot of interest because of its ability of creating strong exchange fields when its placed in contact with non-ferromagnetic materials. For instance, at the interface between EuS and the topological insulator Bi_2Se_3, interfacial ferromagnetism was found to persist up to room temperature, despite the low Tc of bulk EuS (16.6 K). Furthermore, the formation of a new ferromagnetic ground state of the Dirac electrons in graphene was inferred on the basis of the electrical characterization of devices featuring a graphene/EuS interface.

I will present results of our work aimed to study the properties of the ultrathin EuS films and the interfaces between EuS and the organometallic pthalocyanines. We have optimized the epitaxial growth of EuS ultrathin films (< 1nm) on single crystal semiconducting InAs(001) substrates and characterized their structural and magnetic properties using LEED, STM, XPS, ex-situ magnetometry and in-situ XMCD techniques. Furthermore, we have grown monolayers of organometallic pthalocyanines (CuPC and MnPC) and performed XMCD measurements to probe the difference in the exchange coupling of the paramagnetic molecules with metallic (Ni, Co) and semiconducting (EuS) ferromagnets.

MA 16.5 Tue 11:30 H37

Coordination-induced spin-state switching of a Ni complex on Ag(111) — •Manuel Gruber[1], Alexander Köbke[1], Florian Gutzeit[2], Rainer Herges[2], and Richard Berndt[1] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Germany — [2]Institut für Organische Chemie, Christian-Albrechts-Universität zu Kiel, Germany

The spin state of a transition-metal complexes (TMC) can be controlled by changing its coordination state. For TMC on surfaces, this was so far realized by adding/removing gaseous molecules [1] or by transferring a ligand (e.g. Cl) with the tip of a scanning tunneling microscope (STM) [2]. Alternatively, a switching unit within the TMCs itself may be employed to change the coordination state of the complex [3], but so far the interaction with the substrate was detrimental for the molecular structure and switching properties [4].

In the present study, we have designed and investigated robust Ni complexes, which can intrinsically switch their coordination state. Combining low-temperature scanning tunneling microscopy, near-edge x-ray absorption spectroscopy along with density functional theory calculations, we evidence the switching of these complexes on Ag(111) between the S=0 and S=1 spin states.

This work was supported by the DFG through SFB 677 and the European Union's Horizon 2020 programme (No. 766726). [1] Gopakumar et al., J. Am. Chem. Soc. **134**, 11844 (2012) [2] Wäckerlin et al., Adv. Mater. **25**, 2404 (2013) [3] Venkataramani et al., Science **331**, 445 (2011) [4] Matino et al., Chem. Commun. **46**, 6780 (2010)

MA 16.6 Tue 11:45 H37

Magnetic order in Nd(0001): a new type of spin glass? — •Umut Kamber, Andreas Eich, Nadine Hauptmann, Daniel Wegner, and Alexander A. Khajetoorians — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

Lanthanide metals can exhibit complex magnetic structures, e.g. helical/conical spin spirals or linear spin waves. Neodymium (Nd) shows the most complicated behavior exhibiting several magnetic phase transitions below TN = 19.9 K, resulting in multi-q order according to interpretations based on magnetic neutron or X-ray diffraction experiments [1]. However, as these techniques lack spatial resolution, the variations in magnetic properties of Nd at the atomic length scale are unexplored. The local surface electronic structure of Nd(0001) has been studied only using spin-integrated STS [2,3]. Here, we present ultra-low temperature SP-STM measurements of bulk-like Nd(0001) films grown on W(110). We observe multi-q magnetic behavior on the surface as evidenced by strong short-range order, but without the existence of long-range order. Magnetic field and temperature-dependent measurements reveal high sensitivity of the spectral weight of q-states to applied fields, without any clear unique ground state, as well as evidence of aging behavior in the magnetic state. We discuss our findings in the context of unconventional spin-glass behavior. [1] R. M. Moon & R. M. Nicklow, J. Magn. Magn. Mater. 100, 139 (1991). [2] D. Wegner et al., Phys. Rev. B 73, 165415 (2006). [3] D. Wegner et al., Jpn. J. Appl. Phys. 45, 1941 (2006).

MA 16.7 Tue 12:00 H37

On the magnetic coupling characteristics of endohedral fullerenes on Au(111) and Cu(111) by scanning tunneling microscopy (STM)/ spectroscopy (STS) and X-ray magnetic circular dichroism (XMCD) — •Emmanouil Koutsouflakis, Lukas Spree, Georgios Velkos, Yaofeng Wang, Sebastian Schimmel, Danny Baumann, Bernd Büchner, Christian Hess, and Alexey Popov — IFW-Dresden, 01069 Dresden, Germany

Single-Molecule Magnets (SMMs) are molecular materials whose molecules may exhibit magnetic properties such as magnetization under zero-field conditions, large relaxation times and high blocking temperatures. Towards molecular electronics and the subsequent controlled manipulation of single spins in SMMs, the obstacle of the insufficient chemical stability of many SMM architectures has to be overcome, in order to facilitate both their organization on substrates and the preservation of their properties.

We report on the alternatives of Trimetallic Nitrides (TNTs) and Dimetallic Fullerenes. TNTs are of the type $A_{3-n}B_nN@C_{80}$ (n=0-3; A, B rare earth metals or transition metals) where a carbon cage encapsulates a triangular cluster of three rare earth/ transition metal atoms and a nitrogen at its center. In dimetallic fullerenes the cluster is consisted of two lanthanide ions forming a covalent bond by an unpaired electron. In situ sub-monolayers on Au(111) and Cu(111) substrate have been developed under UHV conditions and STM/ STS and XMCD techniques have been applied to investigate the disruptive effects that arise on depositing SMMs onto reactive metal surfaces.

MA 16.8 Tue 12:15 H37

Effect of the Li doping on the Curie temperature of the GdAu2 surface alloy — •M. Ilyn[1,2], M. Gobbi[1,2], C. Rogero[1,2], P. Gargiani[3], M. Valbuena[4], C. Moreno[4], A. Mugarza[4,5], and F. Schiller[1,2] — [1]Materials Physics Center CSIC-UPV-EHU — [2]Donostia International Physics Center — [3]ALBA Synchrotron — [4]Catalan Institute of Nanoscience and Nanotechnology (ICN2) — [5]ICREA Institució Catalana de Recerca i Estudis Avançats

Magnetic surface alloys REAu2 (where RE stands for the rare-earth elements) are the two-dimensional counterparts of the 3-D intermetallic compounds. They were found to be a model system to study the magnetic phenomena in 2-D metallic materials. Indeed, grown on the single-crystal substrates they have atomically-flat surface and a long-range crystallographic order, allowing for use of all standard surface science techniques. On the other hand, magnetic properties of this system can be tuned via choosing the RE element or a noble metal of the substrate.

In this talk I will present results that show the effect of Li doping on the magnetic properties of GdAu2 surface alloy. Previously we have seen that GdAu2 retains its magnetic properties when it is interfaced with organic layers and sustains a thermally activated dehalogenation reaction, but its Curie temperature (Tc) decreases. New XMCD measurements demonstrate a strong (by 60%) growth of the Tc in GdAu2 due to the evaporation of the submonolayer amount of Li. These data together with results of the XPS and ARPES measurements will be used to discuss the mechanism of the observed phenomena.

MA 16.9 Tue 12:30 H37

Disentangling spin-dependent scattering processes in thin Tb and Gd films — Gesa Siemann, •Wibke Bronsch, Beatrice Andres, and Martin Weinelt — Freie Universität Berlin, Deutschland

Studying the magnetic phase transition in thin Gd and Tb films by spin-resolved photoemission spectroscopy, we evaluated the linewidth of the (0001) surface state as a function of temperature in accordance with Ref.[1]. We observe different linewidths for the majority and minority spin components of the spin-mixed occupied surface state indicating differing scattering channels and concomitant spin-dependent lifetimes. A linear increase of the linewidth with temperature for $T > T_{\mathrm{Debye}}$ allows us to evaluate the electron-phonon scattering rate. We find a larger slope for the majority-spin channel compatible with the higher density of bulk states for majority spin electrons at $T < T_{\mathrm{Curie}}$. Furthermore, we observed a greater Lorentz width for the minority-spin component, which is attributed to electron-magnon scattering. The contributions of electron-phonon and electron-magnon scattering to the linewidth of the surface state are comparable for Gd and Tb.

[1] Fedorov *et al.*, Phys. Rev. B **65**, 212409 (2002)

MA 16.10 Tue 12:45 H37

Disentangling the double-exchange and superexchange interactions in quantum anomalous Hall insulators — •Thiago R. F. Peixoto[1], Hendrik Bentmann[1], Abdul-Vakhab Tcakaev[2], Philipp Rüssmann[3], Raphael Crespo Vidal[1], Sonja Schatz[1], Fabian Stier[2], Volodymyr Zabolotnyy[2], Martin Winnerlein[4], Steffen Schreyeck[4], Charles Gould[4], Karl Brunner[4], Stefan Blügel[3], Laurens W. Molenkamp[4], Vladimir Hinkov[2], and Friedrich Reinert[1] — [1]Experimentelle Physik VII, Universität Würzburg — [2]Experimentelle Physik IV, Universität Würzburg — [3]Peter Grünberg Institut (PGI-1), Forschungszentrum Jülich — [4]Experimentelle Physik III, Universität Würzburg

We report on the electronic origin of the magnetic properties of the quantum Hall insulators $(V,Cr):(Bi,Sb)_2Te_3$. By combining x-ray magnetic circular dichroism (XMCD), resonant photoemission spectroscopy (resPES) and density functional theory (DFT), we trace element-specific fingerprints in the valence band and magnetic coupling mechanisms. Our results show that while the low spectral weight of Cr $3d$ states at the Fermi level (E_F) support the presence of ferromagnetic superexchange interactions, an additional double-exchange interaction is intimately related to a highly localised V $3d$ impurity band at E_F. Furthermore, we show that a Bi-rich host increases the covalency of the transition metal ions, thereby mitigating Hund's rule stabilisation. The competition between charge-transfer and pd-exchange ultimately determines the magnetic ground-state in these systems [1].

[1] Larson and Lambrecht, Phys. Rev. B **78**, 195207 (2008).

MA 17: INNOMAG e.V. Diplom-/Master Prize 2019

Die Arbeitsgemeinschaft Magnetismus der DPG hat einen Diplom-/Masterpreis ausgeschrieben, welcher auf der Frühjahrstagung der DPG im März 2019 in Regensburg vergeben wird. Ziel des Preises ist die Anerkennung herausragender Forschung im Rahmen einer Diplom-/Masterarbeit und deren exzellente Vermittlung in Wort und Schrift. Im Rahmen dieser Sitzung tragen die drei besten der für ihre an einer deutschen Hochschule durchgeführten Masterarbeit Nominierten vor. Im direkten Anschluss entscheidet das Preiskommittee über den Gewinner bzw. die Gewinnerin des INNOMAG e.V. Diplom/Master-Preises 2019 in Höhe von 500 EURO. Talks will be given in English!

Time: Tuesday 11:30–12:30 Location: H48

MA 17.1 Tue 11:30 H48

Annealing methods for rapidly quenched ribbons using exothermic self-heating — •Findan Block[1], Jeffrey McCord[1], and Mie Marsilius[2] — [1]CAU Kiel, Institute for Materials Science, Nanoscale Magnetic Materials-Magnetic Domains, Kaiserstr. 2, 24143 Kiel, Germany — [2]Vacuumschmelze GmbH & Co. KG, Grüner Weg 37, 63450 Hanau, Germany

Since their development 30 years ago nanocrystalline ribbon wounded cores are used in electronic devices due to their superior soft magnetic properties. These are essentially influenced by parameters like the heating and cooling rate, during the transformation from an amorphous into a nanocrystalline material. Here, the development of a fast annealing process for ribbon wounded cores is introduced, which delivers comparable magnetic properties for the cores as for ribbons treated by the continuous annealing method. Cores out of $Fe_{75.7}Cu_{0.8}Nb_{1.5}B_{6.5}Si_{15.5}$ are brought in contact to a sheathed thermocouple, so that the exothermic effect during the crystal formation is observable. This is irrelevant for normal ribbon annealing, but leads to a rise of over 100 $^{\circ}C$ in the larger cores. By exploiting this effect and using short times and high heating rates it was possible to achieve smaller coercivity and magnetostriction in comparison with ribbon samples annealed under similar conditions, what enables faster production and the usage of a broader spectrum of alloys. In addition the structure parameters grain size and crystalline volume fraction could be linked to the magnetic property gradients inside the core, which are neglectable for the best combination of annealing parameters.

MA 17.2 Tue 11:50 H48

Design of cavity optomagnonic systems with magnetic textures: Coupling a magnetic vortex to light — •Jasmin Graf — Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany

In optomagnonics, light coherently couples to collective magnetic excitations in solid state systems. This topic is currently of high interest for quantum information processing at the nanoscale. A unique feature of optomagnonic systems is the possibility of coupling light to magnetic excitations on top of a textured magnetic ground state. A paradigmatic example of a magnetic texture is a vortex, which is the ground state configuration of a magnetic microdisk. The lowest energy magnetic excitations of this system are localized at the vortex core. In our work, we derive the optomagnonic coupling for magnetic textures and develop a numerical method to evaluate the coupling. We apply our results to the case of the micromagnetic disk. We show that the localized magnon modes can coherently couple to light confined in whispering gallery modes of the disk. The resulting optomagnonic coupling has a rich structure, and can be tuned by an externally applied static magnetic field. Our results predict cooperativities at maximum photon density (an important figure of merit in these systems) of the order of $\mathcal{C} \approx 0.01$ by proper engineering of these structures. These values show promise for future design of cavity optomagnonic systems.

Reference: J. Graf, H. Pfeifer, F. Marquardt, S. Viola-Kusminskiy; PRB 98, 241406(R) (2018)

MA 17.3 Tue 12:10 H48

Spin-Pumping and Spin Wave Damping in $Co_{25}Fe_{75}$ Thin-Film Heterostructures — •Luis Flacke — Walther-Meißner-Institut, Garching, Germany — Physics-Department, Technical University of Munich, Garching, Germany

Itinerant ferromagnets offer advantages in spintronic and magnonic devices, like e.g. compatibility with charge transport based technology. Typically they also suffer from drastically higher Gilbert damping than insulating ferrimagnets, which leads to an apparent trade-off. M. Schoen reported on "Ultra-low magnetic damping" in $Co_{25}Fe_{75}$ alloys [1], which could merge the two properties of low damping with the benefits of electrical conducting materials. During my master thesis I fabricated low-damping $Co_{25}Fe_{75}$-heterostructures by sputter deposition and separated Gilbert damping and spin pumping to the total damping using broadband ferromagnetic resonance spectroscopy. From the measurements, it was extrapolated that the intrinsic damping of the magnetic alloy reaches the low 10^{-4} regime. With Brillouin light scattering we confirmed low damping in structured $Co_{25}Fe_{75}$ by finding spin propagation length scales of more than $5.5\,\mu$m. The easy and fast fabrication process and its beneficial properties make $Co_{25}Fe_{75}$ a promising candidate for future, novel technologies in the field of spintronics.

[1] M. Schoen *et al.*, Nat. Phys. **12**, 839 (2016)

Financial support by Deutsche Forschungsgemeinschaft via projects WE5386/4 and WE5386/5 is gratefully acknowledged.

MA 18: Frustrated Magnets - General 2 (joint session TT/MA)

Time: Tuesday 14:00–16:00 Location: Theater

MA 18.1 Tue 14:00 Theater

Strong quantum interactions prevent quasiparticle decay — •Ruben Verresen[1,2], Roderich Moessner[1], and Frank Pollmann[2] — [1]Max-Planck-Institute for the Physics of Complex Systems — [2]Technical University of Munich

Quantum states of matter typically exhibit collective excitations known as quasiparticles. Known to be long-lived at the lowest energies, common wisdom says that quasiparticles become unstable when they encounter the inevitable continuum of many-particle excited states at high energies. Whilst correct for weak interactions, we show that this is far from the whole story: strong interactions generically stabilise quasiparticles by pushing them out of the continuum. This general mechanism is straightforwardly illustrated in an exactly solvable model. Using state-of-the-art numerics, we find it at work also in the spin-1/2 triangular lattice Heisenberg antiferromagnet (TLHAF) near the isotropic point—this is surprising given the common expectation of magnon decay in this paradigmatic frustrated magnet. Turning to existing experimental data, we identify the detailed phenomenology of avoided decay in the TLHAF material Ba3CoSb2O9, and even in liquid helium—one of the earliest instances of quasiparticle decay.

MA 18.2 Tue 14:15 Theater

Spin-1/2 Heisenberg antiferromagnet on the star lattice: Competing valence-bond-solid phases studied by means of tensor networks — •Saeed Jahromi and Roman Orus — Donostia International Physics Center (DIPC) Paseo Manuel de Lardizabal 4 20018 Donostia - San Sebastian (Guipuzkoa), Spain

Using the infinite projected entangled pair states algorithm, we study the ground-state properties of the spin-1/2 quantum Heisenberg antiferromagnet on the star lattice in the thermodynamic limit. By analyzing the ground-state energy of the two inequivalent bonds of the lattice in different unit-cell structures, we identify two competing valence-bond-solid (VBS) phases for different antiferromagnetic Heisenberg exchange couplings. More precisely, we observe (i) a VBS state which respects the full symmetries of the Hamiltonian, and (ii) a resonating VBS state which, in contrast to previous predictions, has a six-site unit-cell order and breaks C3 symmetry. We also studied the ground-state phase diagram by measuring the ground-state fidelity and energy derivatives, and further confirmed the continuous nature of the quantum phase transition in the system. Moreover, an analysis of the isotropic point shows that its ground state is also a VBS as in (i), which is as well in contrast with previous predictions.

MA 18.3 Tue 14:30 Theater

Quantum Monte-Carlo simulation of SU(2N) Spin systems — •Jonas Schwab, Francesco Parisen Toldin, and Fakher F. Assaad — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany

We consider the spin-S, SU(2N) Heisenberg model corresponding to the irreducible representation of SU(2N) consisting of a Young tableau of N rows and 2S columns. In the large-S limit the spin wave approximation leads to spin ordering, whereas in the large-N limit a saddle point approximation favors dimerization. We show that this generalized SU(2N) spin model can be solved with sign-problem free determinantal quantum Monte-Carlo methods on any bipartite lattice so that the phase diagram in the S versus N plane can in principle be mapped out.

MA 18.4 Tue 14:45 Theater

Doping a 2d Mott insulator - Study of a quantum dimer model — •Sebastian Huber[1], Fabian Grusdt[2,3], and Matthias Punk[1] — [1]Arnold Sommerfeld Center, Ludwig-Maximilians University, 80333 Munich, Germany — [2]Department of Physics, Harvard University, Cambridge, MA 02138, USA — [3]Department of Physics and Institute for Advanced Study, Technical University of Munich, 85748 Garching, Germany

Experiments with quantum gas microscopes have started to explore the antiferromagnetic phase of the Fermi-Hubbard model and effects of doping with holes away from half filling [1]. We show in this talk that the system averaged local two-spin density matrix enables to distinguish magnetically ordered and interesting topologically ordered spin-liquid phases, which might occur in the Hubbard model close to half filling.

Fractionalized Fermi liquids (FL*) are a promising candidate for this parameter regime. The generalized quantum dimer model introduced in Ref. [2] is an effective lattice realization of such an FL* with a Hilbert space spanned by configurations of fermionic and bosonic short-range bound states. We construct a rather unconventional dynamical cluster approximation (DCA) by making explicit use of the dimer Hilbert space and show first results of spectral data for a minimal cluster of two lattice sites.

[1] A. Mazurenko, C. Chiu et al., Nature 545, 7655 (2017)
[2] M. Punk, A. Allais and S. Sachdev, PNAS 112, 31 (2015)

MA 18.5 Tue 15:00 Theater

The evolution of spin – orbital entanglement in the approximate SU(2)⊗SU(2) model — •Dorota Gotfryd[1,2], Ekaterina Paerschke[3], Andrzej M. Oles[2,4], and Krzysztof Wohlfeld[1] — [1]Institute of Theoretical Physics, University of Warsaw, Warsaw, Poland — [2]Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland — [3]Department of Physics, University of Alabama at Birmingham, Birmingham, USA — [4]Max Planck Institute for Solid State Research, Stuttgart, Germany

In insulating states of transition metal oxides with orbital degeneracy spin – orbital superexchange describes the effective interactions [1]. In such a frustrated environment the quasi – empirical Goodenough – Kanamori rules may be violated leading to inter – site spin – orbital entanglement [2]. In this talk we analyse the phase diagram of an SU(2)⊗SU(2) symmetric model [3, 4] perturbed with a less symmetric term. Even though such conditions create more complicated type of entanglement, interestingly the underlying physics becomes much simpler. We present extensive numerical studies supported also by analytical calculations.

This work is supported by Narodowe Centrum Nauki (NCN, Poland) under Projects No. 2016/23/B/ST3/00839 and No. 2016/22/E/ST3/00560.

[1] A.M. Oles, J. Phys.: Condensed Matter **24**, 313201 (2012)
[2] A.M. Oles *et al.*, Phys. Rev. Lett. **96**, 147205 (2006)
[3] S.K. Pati, R.R.P. Singh, D. Khomskii, Phys. Rev. Lett. **81**, 5406 (1998)
[4] W.-L. You, P. Horsch, A.M. Oles, Phys. Rev. B **92**, 054423 (2015)

MA 18.6 Tue 15:15 Theater

Asymptotical high-field saturation in spin-1/2 systems with XYZ spin-anisotropy and/or Dzyaloshinskii Moriya interactions — •Stefan-Ludwig Drechsler[1], Rolf Schumann[2], Richter Johannes[3], Ullrich Roessler[1], Roman Kuzian[4], Helge Rosner[5], Alexander Tsirlin[6], and Satoshi Nishimoto[1,2] — [1]ITF at the IFW-Dresden, Dresden, Germany — [2]TU Dresden, Theoret. Phys., Germany — [3]Universität Magdeburg, Inst. Theo. Phys. — [4]Inst. f. Material Sciences, Kyiv, Ukraine — [5]MPI-CPfS. Dresden, Germany — [6]Exp. Physik, Augsburg, Germany

We consider the high-field saturation of longitudinal and transversal magnetizations $M(B)$ of a wide class of spin-1/2 systems with low lattice symmetry leading to XYZ spin anisotropy and/or the presence of Dzyaloishnskii-Moriya (DM) interaction between nearest neighbor (NN) spins. Exact analytical, exact doagonalization and DMRG results are presented for small and large clusters as well as extended 1D and 2D systems. Above the last inflection point of the longitudinal magnetization only a power-law universal magnetization $\propto 1/B^2$ in leading order is found. We provide also higher order terms and focus on the influence of boundary conditions and the cases of staggered magnetizations and transversal DM components. Applications to various spin-chain compounds such as linarite and qubit/qutrit quantum dots being of interest in the field of quantum computing are discussed and compared critically with results published so far. Fitting experimental data within improper spin-symmetries, such as XXZ, may lead to unphysical large DM terms overestimated by an order of magnitude.

MA 18.7 Tue 15:30 Theater

Nonlocal probes for topological phase transitions from world-line braiding in path-integral quantum Monte Carlo — •Wei Wang[1], Fabio Lingua[2], Liana Shpani[2], and Barbara Capogrosso-Sansone[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Physics, Clark University, Worcester, U.S.A.

We propose non-local probes to study quantum and topological phase transitions in bosonic lattice spin-1/2 models. These probes can be explained as certain properties of braids of bosons' world-lines in configurations of path-integral quantum Monte Carlo (PIQMC). These new probes have been demonstrated to be good alternatives to order parameters for topologically trivial quantum phase transitions, and also have been shown to be efficient methods in studying topologically nontrivial phase transition. Furthermore, numerical results indicate that the world-line braids in configurations of PIQMC give a concrete meaning of so called "patterns" of short and long-range entanglement.

MA 18.8 Tue 15:45 Theater

Multi-loop contributions in the pseudo-fermion functional renormalization group for quantum spin systems: implementation and consequences — •Tobias Müller[1], Yasir Iqbal[2], Johannes Reuther[3,4], and Ronny Thomale[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians University of Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Department of Physics, Indian Institute of Technology Madras, Chennai 600036, India — [3]Dahlem Center for Complex Quantum Systems and Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [4]Helmholtz-Zentrum für Materialien und Energie, Hahn-Meitner-Platz 1, 14019 Berlin, Germany

We extend the pseudo-fermion functional renormalization group (PFFRG) treatment of quantum spin systems by including diagrammatic higher loop contributions into the renormalization group flow. This allows us to consistently account for all contributions of parquet-type diagrams in the two-particle vertex and self-energy derivatives within the two-particle truncated PFFRG flow. We will discuss the impact of these corrections in different quantum spin models within PFFRG, especially in the light of the Mermin-Wagner theorem.

MA 19: Spintronics (joint session TT/MA/DY)

Time: Tuesday 14:00–16:00 Location: H23

MA 19.1 Tue 14:00 H23

Long-lived chirality states in low-temperature strongly-coupled Rashba systems — •Philipp C. Verpoort, James R. A. Dann, Gareth J. Conduit, and Vijay Narayan — Department of Physics, University of Cambridge, J.J. Thomson Avenue, Cambridge CB3 0HE, UK

We observe ultra-slow magnetoresistance dynamics at sub-Kelvin temperatures in various systems that display strong Rashba spin-orbit coupling. These dynamics display a striking magnetoresistance curve that follows different traces depending on direction and speed of a magnetic field sweep. This novel effect cannot be explained by magnetisation or magnetocaloric effects. We suggest that the dynamics arise from detuning of the Fermi levels of the two Rashba bands and the slowness of their relaxation into equilibrium due to the suppression of inter-band scattering mechanisms that would be expected in conventional systems. Surprisingly, the relaxation timescale of this non-equilibrium state is 10 seconds so exceeds typical electronic relaxation timescales by several orders of magnitude, which makes this effect intriguing to study and relevant for potential applications in information processing.

MA 19.2 Tue 14:15 H23

Channel analysis of atomic Pd contacts by Andreev Reflections — •Martin Prestel[1], Torsten Pietsch[1,2], and Elke Scheer[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]now at: Carl Zeiss AG, 73447 Oberkochen, Germany

For the strong paramagnetic material palladium (Pd) theoretical calculations predicted a local magnetic ordering [1]. In transport measurements a strong non-monotonic magneto-transport behaviour as well as indications for Kondo resonances have been reported for atomic contacts in Pd [2]. To get a more detailed view of the nature of this magnetic ordering we want to investigate the transport channel distribution and their spin polarisation in such contacts. Therefore we add superconducting leads to apply the method of multiple Andreev reflections [3, 4, 5]. In this talk I will present first experimental superconducting current-voltage characteristics revealing superconducting proximity effect into Pd depending on the exact atomic configuration.

[1] Delin et al., Phys. Rev. Lett. 92, 057201 (2004)
[2] Strigl et al., Phys. Rev. B 94, 144431 (2016)
[3] Scheer et al., Nature 394, 154 (1998)
[4] Andersson et al., Physica C 367, 117-122 (2002)
[5] Martin-Rodero et al., Physica C 352, 67-72 (2001)

MA 19.3 Tue 14:30 H23

Quasiparticle cooling using a Topological insulator-Superconductor hybrid junction — •D. Bercioux[1,2] and P. Lucignano[3,4] — [1]Donostia International Physics Center, Paseo Manuel de Lardizbal 4, E-20018 San Sebastián, Spain — [2]IKERBASQUE, Basque Foundation of Science, 48011 Bilbao, Spain — [3]CNR-SPIN, Monte S.Angelo, via Cinthia, I-80126 Napoli, Italy — [4]Dipartimento di Fisica "E. Pancini", Universitá di Napoli "Federico II", Monte S.Angelo, I-80126 Napoli, Italy

We investigate the thermoelectric properties of a hybrid junction realised coupling surface states of a three-dimensional topological insulator with a conventional *s*-wave superconductor. We focus on the ballistic devices and study the quasiparticle flow, carrying both electric and thermal currents, adopting a scattering matrix approach based on conventional Blonder-Tinkham-Klapwijk formalism [1]. We calculate the cooling efficiency of the junction as a function of the microscopic parameters of the normal region (*i.e.* the chemical potential etc.). The cooling power increases when moving from a regime of Andreev specular-reflection to a regime where Andreev retro-reflection dominates. Differently from the case of a conventional N/S interface [2], we can achieve efficient cooling of the normal region, without including any explicit impurity scattering at the interface, to increase normal reflection [3].

[1] Blonder, Tinkham & Klapwijk, Phys. Rev. B **25**, 4515 (1982).
[2] Bardas & Averin, Phys. Rev. B **52**, 12873 (1995).
[3] Bercioux & Lucignano, arXiv:1804.07170, EPJ ST, *in press* (2018).

MA 19.4 Tue 14:45 H23

Magnetism in atomic Gd contacts: Noise and transport measurements — •Marcel Strohmeier, Martin Prestel, and Elke Scheer — Department of Physics, University of Konstanz, 78457 Konstanz, Germany

Materials with partially filled f shells bear interesting electronic and magnetic properties, wich have been intensively studied in bulk. Yet, on the atomic scale they are still a widely unexplored topic. For gadolinium (Gd) first transport measurements and theoretical calculations on the influence of f electrons on the electronic transport have been carried out [1]. To get a deeper insight into the magnetic ordering at the atomic scale we use the mechanically controllable break junction (MCBJ) technique at low temperatures to produce tunable atomic-size contacts. Here we present first measurements on magnetic transport behavior as well as shot noise measurements. Shot noise is known to reveal the exact channel configuration [2] and is even sensitive to spin polarization [3].

[1] Olivera et al., Phys. Rev. B 95, 075409 (2017)
[2] Kumar et al., Phys. Rev. Lett. 108, 146602 (2012)
[3] Burtzlaff et al., Phys. Rev. Lett. 114, 016602 (2015)

MA 19.5 Tue 15:00 H23

Magnetoconductance in Bi quantum well states: coupling of interfaces — •Doaa Abdelbarey and Herbert Pfnür — Institut für Festkörperphysik, Leibniz Universität Hannover

Ultrathin epitaxial Bi films are governed by strongly spin-polarized bands that determine to a large extent their magneto-transport properties. Magneto-conductance of films grown epitaxially on Si(111) with a thickness of 10 to 100 bilayers (BL) was measured mostly at T= 8 K in magnetic fields up to 4T and with orientations both perpendicular and parallel to the surface plane. For B-fields normal to the surface weak anti-localization (WAL) was observed. Analysis within the theory by Hikami et al. [1] indicates strong coupling of the interfaces up to 50 BL, whereas above 80 BL two independently conducting channels were observed. For the in-plane B-field orientation, the magneto conductivity turned out to be anisotropic. Whereas for in-plane B-fields parallel to the current direction and for films up to 70 BL mainly weak localization is seen, it switches to WAL for larger thicknesses. For in-plane B-fields perpendicular to the current only WAL was observed irrespective of thickness. Both curves merge close to 100 BL, i.e. WAL becomes independent of B-field direction. These phenomena are explained within the framework of interface scattering, including superimposed effects of band structure and spin polarization due to the Rashba effect.

[1] Hikami S., et al., Prog. Theor. Phys. 63, 707 (1980)

MA 19.6 Tue 15:15 H23

Manipulating orbitals with magnetic fields — xionghua liu, •chun-fu chang, alexander komarek, steffen wirth, and liu hao tjeng — Max Planck Institute for Chemical Physics of Solids, Nöthnitzerstr. 40, 01187 Dresden, Germany

Magnetite (Fe_3O_4) is one of most controversially discussed materials in solid state physics due to its enigmatic Verwey transition, while being heavily studied as thin film for spintronic applications. Here, we report on our study of the Verwey transition under magnetic fields in Fe_3O_4 thin films on spinel substrates $Co_{2-x-y}Mn_xFe_yTiO_4$ and non-magnetic Mg_2TiO_4. The Verwey transition of these films is highly tunable and anisotropic with applied magnetic fields. The strong magnetostriction evidences an active spin-orbit effect of the Fe^{2+} (d^6) ions in Fe_3O_4 which allows one to manipulate the Fe^{2+} orbital occupation via magnetic fields. Remarkably, the high magnetic tunability of the Verwey transition results in a closed magnetoresistance (MR)-loop with an MR as large as 88% at 0.5 Tesla, which is up to 2 order larger than the reported values of Fe_3O_4 films.

MA 19.7 Tue 15:30 H23

Noise of charge current generated by a precessing itinerant ferromagnet — •Tim Ludwig[1], Igor S. Burmistrov[2,3,1,4], Yuval Gefen[5], and Alexander Shnirman[1,4] — [1]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [2]L.D. Landau Institute for Theoretical Physics RAS, Kosygina street 2, 119334 Moscow, Russia — [3]Laboratory for Condensed Matter Physics, National Research University Higher School of Economics, 101000 Moscow, Russia — [4]Institut für Nan-

otechnologie, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [5]Department of Condensed Matter Physics, Weizmann Institute of Science, 76100 Rehovot, Israel

We determine the zero frequency noise of charge current that is generated by a precessing small itinerant ferromagnet which is tunnel-coupled to two normal metal leads. We assume the leads to be in equilibrium with each other, i.e. neither voltage nor thermal bias is applied. In this situation, the average charge current vanishes. However, the noise of charge current remains. While at high temperatures, we obtain the standard thermal noise; for low temperatures we find the noise of charge current to be governed by the precession frequency of the magnetization and the angle between magnetization and precession axis. We propose that this result can be used in FMR-type experiments to gain additional information about the magnetization dynamics.

MA 19.8 Tue 15:45 H23

Time stable remanence in Dzyaloshinskii Moriya Interaction driven canted antiferromagnets — Namrata Pattanayak[1], AAkanksha Kapoor[1], Arun kumar Nigam[2], and •Ashna Bajpai[1] — [1]Indian Institute of Science Education and Research, Pune, India — [2]Tata Institute of Fundamental Research , India

We report remanence measurements conducted on a number of magnetic oxides which are Dzyaloshinskii-Moriya Interaction (DMI) driven canted antiferromagnets or weak ferromagnets (WFM). All these systems are also symmetry allowed piezomagnets (PzM). We consistently observe an ultra-slow magnetization dynamics with a counter-intuitive magnetic field dependence in these WFM or PzM. This ultra- slow magnetization dynamics manifests itself in the form of a time-stable remanence and appears exclusive to these WFM. Though the effect is tunable with nano scaling, it is intrinsic in nature as these features are also observed in bulk single crystal. We further demonstrate that the magnitude of this unique remanence can be significantly enhanced at the room temperature by encapsulation of these WFM inside carbon nanotubes. These results illustrate why encapsulation of these functional magnetic oxides within carbon nanotubes is interesting from fundamental point of view and it can lead to nano spintronic devices tunable by electric field, magnetic field and possibly by stress.

MA 20: Multiferroics and Magnetoelectric coupling I (joint session MA/KFM)

Time: Tuesday 14:00–15:45 Location: H37

Invited Talk MA 20.1 Tue 14:00 H37

Magnetoelectric Inversion of Domain Patterns — •Naëmi Leo[1,2,3], Vera Carolus[4], Jonathan White[3], Michel Kenzelmann[3], Matthias Hudl[5], Pierre Toledano[6], Takashi Honda[7], Tsuyoshi Kimura[8], Sergey Ivanov[9], Matthias Weil[10], Thomas Lottermoser[2], Dennis Meier[11], and Manfred Fiebig[2] — [1]CIC nanoGUNE, Spain — [2]ETH Zürich, Switzerland — [3]Paul Scherrer Institute, Switzerland — [4]Bonn University, Germany — [5]Stockholm University, Sweden — [6]Université de Picardie, France — [7]High Energy Accelerator Research Organization (KEK), Japan — [8]University of Tokyo, Japan — [9]Karpov Insitute of Physical Chemistry, Russia — [10]TU Wien, Austria — [11]Norwegian University of Science and Technology, Norway

The global inversion of an inhomogeneous distribution of ferromagnetic or ferroelectric domains within a material is surprisingly difficult: Field poling creates a single-domain state, and piece-by-piece inversion using a scanning tip is impractical. Here we report inversion of entire domain patterns in the magnetoelectric material Co_3TeO_6 and the multiferroic material Mn_2GeO_4. In these materials, an applied magnetic field reverses the magnetization or polarization, respectively, of each domain, but leaves the overall domain pattern intact. This effect originates from a trilinear coupling term containing a "hidden" order parameter which retains the relative orientation of the field-driven and the observed order parameters. Such behaviour might also occur in other complex materials where coexisting order parameters are available for combination.

MA 20.2 Tue 14:30 H37

Dielectric response of a vector-chiral magnetic ordering — •David Rivas Gongora[1], Martina Dragičević[1], Željko Rapljenović[1], Mirta Herak[1], Tomislav Ivek[1], Matej Pregelj[2], Andrej Zorko[2], Helmuth Berger[3], and Denis Arčon[2] — [1]Institute of Physics, Bijenička cesta 46, HR-10000 Zagreb, Croatia — [2]Jožef Stefan Institute, Jamova c. 39, 1000 Ljubljana, Slovenia — [3]Ecole polytechnique federale de Lausanne, CH-1015 Lausanne, Switzerland

β-TeVO4 is a zig-zag spin-1/2 quasi-one-dimensional system with a rich low-temperature phase diagram. Its vanadium spins interact through a nearest ferromagnetic (V-O-V) and next-nearest antiferromagnetic (V-O-Te-O-V) superexchange. The resulting frustration assisted by quantum fluctuations gives rise to three magnetic phase transitions [1]: paramagnetic to incommensurate spin density wave at TN1=4.65 K, followed by the so-called stripe phase under TN2=3.28 K, and lastly at TN3=2.28 K the system enters the vector-chiral ground state [2]. Interestingly, the complex magnetic landscape makes β-TeVO4 an ideal candidate for non-conventional magnetoelectric phases due to a symmetry which does not forbid the formation of electric dipoles [2,3]. We present the dynamic dielectric response of β-TeVO4 single crystal samples in the presence of a magnetic field and discuss it in the context of low-temperature magnetic ordering as a potentially multiferroic phase.

[1] Y. Savina et al. Phys. Rev. B 84, 104447 (2011). [2] M. Pregelj et al. Nature Communications 6 (2015), 10.1038/ncomms8255. [3] K. F. Wang et at. Adv. Phys 58, 321-448 (2009).

MA 20.3 Tue 14:45 H37

Magnetoelectric Red-Ox switching of magnetism in iron oxide/iron nanostructures — •Jonas Zehner[1,2], Ivan Soldatov[1], Rudolf Schäfer[1], Sebastian Fähler[1], Kornelius Nielsch[1,2], and Karin Leistner[1,2] — [1]IFW Dresden — [2]TU Dresden - Institute of Material Science

Low power voltage-control of magnetism in metals can be achieved by electrical gating of magnetic nanostructures. Recent approaches focus on ion displacement and electrochemical reactions in oxide/metal films[1,2]. All solid state architectures suffer from a low ion mobility at room temperature (RT) and focus on ultrathin films so far[3]. Utilizing liquid electrolytes allows us to overcome these limitations and achieve large voltage induced changes of magnetization and anisotropy within several nanometer thick oxide/metal heterostructures[4]. In this case, typical alkaline battery electrolytes are used and merely 1V is applied to induce electrochemical RedOx processes in nanostructured FeOx/Fe films[4,5]. For FeOx/Fe nanoislands, ON/OFF switching of magnetization has been probed by two independent integral methods: in situ AHE and in situ FMR. A novel in situ Kerr set up has been developed, which allows us to observe also local changes of the magnetic microstructure during the RedOx operations. We find, for the first time, significant voltage-induced changes of the domain size in continuous FeOx/Fe thin films upon RedOx reactions. [1]Song et al., Prog. Mater Sci. 87, 33,2017, [2]Leistner et al., PRB 87, 224411,2013, [3]Bauer et al., Nat. Mater. 14, 174,2015, [4]Duschek et al. APL Mater.4, 32301,2016 [5]Duschek et al., J. Mater. Chem. C 6, 8411,2018

MA 20.4 Tue 15:00 H37

Switchable one-way transparency via coupled magnetic and electric resonances — •David Szaller[1], Artem Kuz'menko[2], Alexander A. Mukhin[2], Alexey Shuvaev[1], Urmas Nagel[3], Toomas Rõõm[3], and Andrei Pimenov[1] — [1]Institute of Solid State Physics, TU Wien, Vienna, Austria — [2]Prokhorov General Physics Institute, Russian Academy of Sciences, Moscow, Russia — [3]National Institute of Chemical Physics and Biophysics, Tallinn, Estonia

The strong anisotropy in the absorption of counter-propagating light beams approaching the limit of one-way transparency[1] became an intensively studied topic of simultaneously magnetic and polar (i.e. multiferroic) crystals, motivated by both the fundamentals of nonreciprocity and the possible information-technology applications. However, due to the limited understanding of the phenomenon the design of one-way transparent devices with specified optical spectrum is still an open task. On the basis of symmetry analysis and statistical physical considerations[2], it is possible to construct a minimal model of one-way transparency consisting of a pair of coupled magnetic and electric resonances. This model can be realized in certain multiferroic crystals and also in metamaterial structures, opening the path to custom-designed, electrically[3] or magnetically[1] switchable optical response.

[1] I. Kézsmárki, D. Szaller et al., Nat. Commun. 5, 3203 (2014)
[2] D. Szaller et al., PRB 87, 014421 (2013) and PRB 89, 184419 (2014)
[3] A. M. Kuz'menko, D. Szaller et al., PRL 120, 027203 (2018)

MA 20.5 Tue 15:15 H37

Multiferroic domain inversion in $NaFeGe_2O_6$ — •Sebastian Biesenkamp[1], Dmitry Gorkov[1], Tobias Fröhlich[1], Jonas Stein[1], Karin Schmalzl[2], Wolfgang Schmidt[2], Yvan Sidis[3], and Markus Braden[1] — [1]Institute of Physics II, University of Cologne — [2]JCNS at ILL, Grenoble — [3]Laboratoire Léon Brillouin, CEA-CNRS, CEA/Saclay

Multiferroic materials attracted a considerable interest during the last decade, as the electric control of chiral magnetism implies a promising potential of applicability in the field of data storage devices or sensors. Fundamentally for all kind of applications is the knowledge of the relaxation times of multiferroic domain inversion, when switching applied external electric fields. Here we report time-resolved neutron scattering studies of the relaxations times in the multiferroic pyroxene $NaFeGe_2O_6$. They can be followed over a broad timescale, ranging from microseconds to several minutes and we found that the temperature and electric field dependence of the rise-times can be well described by a simple activation and Merz's law respectively.

MA 20.6 Tue 15:30 H37

Temperature- and pressure-dependent optical measurements on the photo-response in multiferroic $BiFeO_3$ — •Fabian Meggle[1], Jihaan Ebad-Allah[1,2], Michel Viret[3], Jens Kreisel[4,5], and Christine Kuntscher[1] — [1]Experimentalphysik II, Universität Augsburg, 86159 Augsburg, Germany — [2]Department of Physics, Tanta University, 31527 Tanta, Egypt — [3]Service de Physique de l'État Condenseé, SPEC, CEA Saclay, CNRS, Université Paris-Saclay, 91191 Gif sur Yvette, France — [4]Physics and Materials Science Research Unit, University of Luxembourg, 4422 Belvaux, Luxembourg — [5]Department Materials Research and Technology, Luxembourg Institute of Science and Technology, 41 Rue du Brill, 4422 Belvaux, Luxembourg

$BiFeO_3$ exhibits three absorption features in the optical transmission spectrum between 1.0 and 2.2 eV during laser illumination.[1] These features were ascribed to excitons, which are proposed to be relevant for the ultrafast photostriction effect in $BiFeO_3$.[2] We studied the impact of low temperature and high pressure on the photo-induced features by using optical spectroscopy. Our temperature-dependent findings suppose a possible coupling between absorption features and lattice vibrations, whereas the spin degree of freedom might be also involved. The pressure-dependent measurements show a vanishing of the absorption features above 3.5 GPa, where $BiFeO_3$ is reported to undergo a phase transition from polar to a non-ferroelectric phase.[3] [1]Burkert et al., Appl. Phys. Lett. **109**, 182903 (2016); [2]Schick et al., Phys. Rev. Lett. **112**, 97602 (2014); [3]Belik et al., Chem. Mater. **21**, 3400 (2009)

MA 21: Magnetic textures: Transport and dynamics I

Time: Tuesday 14:00–15:30 Location: H38

MA 21.1 Tue 14:00 H38

Formation of skyrmions and their interplay with magnetoelectric terms at a TI/FM heterostructure — •Marius Scholten[1], Ilya Eremin[1], and Flavio S. Nogueira[2] — [1]Institut für Theoretische Physik III, Ruhr-Universität Bochum,Bochum, Germany — [2]Institute for Theoretical Solid State Physics, IFW Dresden, Dresden, Germany

We investigate the interface of a hybrid heterostructure consisting of a topological insulator and ferromagnet. As has been shown recently, the interface of such a system can host skyrmions as a consequence of an emerging Dzyaloshinskii-Moriya interaction at temperatures above the Curie temperature [1]. Here, we analyze what happens in the magnetically ordered phase and in the presence of the long-range Coulomb interaction between the Dirac electrons. Due to the opening of the gap in the Dirac spectrum in the magnetically ordered phase the magnetoelectric Chern-Simons action emerges, which opens up the possibility of magnetoelectric manipulation of skyrmion structures on the interface.

[1] Flavio S. Nogueira, Ilya Eremin, Ferhat Katmis, Jagadeesh Moodera, Jeroen van den Brink, Volodymyr Kravchuk, Phys. Rev. B 98 060401(R) (2018).

MA 21.2 Tue 14:15 H38

Photoinduced magnetization dynamics in the skyrmion-host lacunar spinel GaV4S8 — •Fumiya Sekiguchi[1], Vladimir Tsurkan[2], István Kézsmárki[2], and Paul H. M. van Loosdrecht[1] — [1]Institute of Physics 2, University of Cologne, 50937 Cologne, Germany — [2]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany

Skyrmions are particle-like non-trivial spin textures with an intriguing topological nature. GaV4S8 is a multiferroic lacunar spinel hosting cycloid and Néel-type skyrmion magnetic ground states, in addition to a ferromagnetic state. Using time resolved magneto-optical Kerr effect experiments we have studied the magnetization dynamics in the ordered magnetic phases of this material induced by ultrafast modulation of the optical anisotropy. In this contribution we will focus on the change of the coherent spin precession and demagnetization dynamics across the phase transition among cycloid, skyrmion lattice and ferromagnetic phases.

MA 21.3 Tue 14:30 H38

Designing skyrmion dynamics by anisotropic spin-orbit torques — •Jan-Philipp Hanke[1], Frank Freimuth[1], Stefan Blügel[1], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

Skyrmions are perceived to hold bright promises as nano-scale information carriers in energy-efficient technologies. This renders a rigorous understanding and reliable control of their dynamics by the spin-orbit torques vital. Using advanced *ab initio* methods [1,2], we assess the role of these current-induced torques for the dynamics of topological spin textures in magnetic trilayers and topologically non-trivial materials. We discover that the common interpretation of the skyrmion Hall effect as a phenomenon originating in the damping-like torques has to be reformulated, as anisotropic field-like torques can alter the dynamical properties of skyrmions drastically [3]. While increasing the velocity of skyrmions typically relies on driving larger currents, we further elucidate a promising alternative that exploits emergent nodal points forming at the Fermi energy of transition metals to move skyrmions efficiently with low current densities [4]. We acknowledge funding under SPP 2137 "Skyrmionics" and project MO 1731/5-1 of Deutsche Forschungsgemeinschaft (DFG).
[1] J.-P. Hanke *et al*, Phys. Rev. B **91**, 184413 (2015). [2] J.-P. Hanke *et al*, J. Phys. Soc. Jpn. **87**, 041010 (2018). [3] J.-P. Hanke *et al*, under review (2019). [4] J.-P. Hanke *et al*, Nat. Commun. **8**, 1479 (2017).

MA 21.4 Tue 14:45 H38

Chirality-induced linear response properties in hexagonal Mn_3Ge — •Sebastian Wimmer, Sergiy Mankovsky, and Hubert Ebert — LMU München, Dept. Chemie, München, Deutschland

Taking the non-collinear antiferromagnetic hexagonal Heusler compound Mn_3Ge as a precursor, the contributions to linear response phenomena arising solely from the chiral coplanar and non-coplanar spin configurations are investigated in first-principles calculations. Orbital moments, X-ray absorption, anomalous and spin Hall effects, as well as corresponding spin-orbit torques and Edelstein polarizations are studied depending on a continuous variation of the polar angle relative to the Kagome planes of corner-sharing triangles between the non-collinear antiferromagnetic and the ferromagnetic limits. By scaling the speed of light from the relativistic Dirac case to the non-relativistic limit the chirality-induced or topological contributions can be identified in the absence of spin-orbit coupling.

MA 21.5 Tue 15:00 H38

Thermoelectrical detection of magnetization reversal in

Co/Ru/Pt nanowires with interfacial Dzyaloshinskii-Moriya interaction — •Alexander Fernández Scarioni[1], Sibylle Sievers[1], Xiukun Hu[1], William Legrand[2], Fernando Ajejas Bazan[2], Vincent Cros[2], and Hans W. Schumacher[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Unité Mixte de Physique, CNRS, Thales, Univ. Paris-Sud, Université Paris-Saclay, Palaiseau, France

Recently it was shown that inside a nanopatterned Hall cross individual skyrmion can be electrically detected by their contribution to the anomalous Hall effect (AHE) [1]. While AHE detection is intrinsically limited to Hall crosses it was recently shown that the anomalous Nernst effect (ANE), the thermoelectric analogue of the AHE, allows sensitive nano-scale characterization of the magnetization also in various nanowire geometries [2]. Here we compare ANE and AHE for the characterization of out-of-plane magnetization reversal loops in nanowires (ANE) and nanopatterned Hall crosses (AHE) of Co/Ru/Pt multilayers with interfacial Dzyaloshinskii-Moriya interaction. Both ANE and AHE loops show similar characteristics proving the suitability of ANE as a characterization tool. Comparison to magnetic force microscopy allows to correlate the loop features to the presence of stripe domains and skyrmions in the nano structures. The prospects for ANE detection of individual skyrmions inside the nanostructures will be discussed. [1] D. Maccariello, et al, Nat. Nanotech. 13, 233-237 (2018) [2] P. Krzysteczko, et al, Phys, Rev, B 95, 220410 (2017)

MA 21.6 Tue 15:15 H38

Nonreciprocity of spin waves due to the Dzyaloshinskii-Moriya interaction — •Flaviano José dos Santos, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, D-52428 Jülich, Germany

Can spin-wave measurements help to distinguish the occurrence of skyrmions from antiskyrmions in magnetic materials? The stabilization of one or the other is related to the details and symmetries of the Dzyaloshinskii-Moriya interaction (DMI) [1], which can be determined by measuring its effect on the spin-wave properties [2]. In ferromagnets, the DMI induces a chiral asymmetry on the spin-wave energies of opposite wavevector [3], we then say that the spin-wave spectrum is nonreciprocal [4]. This phenomenon allows us to determine the DMI strength and its sign. However, it is not clear how these DMI-induced asymmetries manifest in complex noncollinear magnetic structures, such as spin spirals and skyrmion lattices. We provide a complete picture on when and how the DMI induces nonreciprocal spin waves in these systems, and how they shall manifest in spin-resolved inelastic electron scattering experiments. Furthermore, we demonstrate an important connection between angular momentum and chiral handedness of a spin-wave mode, which allows us to predict the occurrence of nonreciprocal spin-wave spectrum. – [1] Hoffmann et al., Nat. Comm. 8, 308 (2017). [2] Di et al., PRL 114, 047201 (2015). [3] Udvardi et al., PRL 102, 207204 (2009). [4] Gitgeatpong et al., PRL 119, 047201 (2017). [5] Dos Santos et al., PRB 97, 024431 (2018).

MA 22: Terahertz spintronics

Time: Tuesday 14:00–15:45 Location: H52

MA 22.1 Tue 14:00 H52

Roadmap for THz Generation from Metallic Spintronic Emitter — •Laura Scheuer[1], Dennis Nenno[1], Garik Torosyan[2], Sascha Keller[1], Alexander Brodyanski[3], Rolf Binder[4], Hans Christian Schneider[1], René Beigang[1], and Evangelos Papaioannou[1] — [1]Fachbereich Physik der TU Kaiserslautern und Landesforschungszentrum OPTIMAS, 67663 Kaiserslautern, Germany — [2]Photonic Center Kaiserslautern, 67663 Kaiserslautern, Germany — [3]Institut für Oberächen- und Schichtanalytik (IFOS) and Landesforschungszentrum OPTIMAS, 67663 Kaiserslautern, Germany — [4]College of Optical Sciences, University of Arizona, Tucson, AZ 85721, USA

Spintronic ferromagnetic/nonmagnetic heterostructures are novel and easily fabricated sources for the generation of THz radiation with large bandwith.

The key technological and scientific challenge of THz spintronic emitters is to understand and engineer their THz emission amplitude and bandwidth. Here, we pave the way to define and manipulate both.

We correlate the THz signal amplitude and its bandwidth with the electron-defect scattering lifetime and the interface transmission for spin-polarized, non-equilibrium electrons.

We experimentally and theoretically prove that epitaxial heterostructures contribute to a significant enhancement of signal amplitude. The results of our study define a roadmap for the properties of the emitted and detected THz pulse shapes and spectra that is essential for future applications of metallic spintronic THz emitters.

MA 22.2 Tue 14:15 H52

Broadband THz time-domain spectrometer at 300 kHz repetition rate using spintronic emitter — •Sergei Sobolev, Gerhard Jakob, Mathias Kläui, and Jure Demsar — Institute of Physics, University of Mainz, Germany

The linear and time-resolved terahertz (0.1-20 THz) time-domain spectroscopies are powerful tools to study low frequency optical conductivities and their dynamics with the sub-picosecond time resolution. To achieve high sensitivity in both configurations, a system with high repetition rate, yet high enough pulse energy for photoexcitation, is required. Heterostructures composed of ferromagnetic and nonferromagnetic metal films - so called spintronic emitters - have been recently demonstrated as efficient broadband THz emitters when driven by both, low pulse energy high repetition rate femtosecond oscillators [1][2] and by a 1 kHz repetition rate mJ-level femtosecond laser amplifiers [3][4]. Here we report on a development and characterization of a spintronic emitter based broadband time-domain THz spectrometer built around a 300 kHz μJ-level laser system. The parameters of the generated THz electric field pulses, the bandwidth and the sensitivity of the time-domain set-up are benchmarked to the system using photoconductive interdigitated finger emitters [5].

[1] T. Seifert et al., Nat. Photonics 10, 483*488 (2016) [2] G. Torosyan et al., Scientific Reports 8, 1311 (2018) [3] T. Seifert et al., Appl. Phys. Lett. 110, 252402 (2017) [4] D. Yang et al., Adv. Opt. Mater. 4, 1906-1914 (2016) [5] M. Beck et al., Opt. Express 18, 9251-9257 (2010)

MA 22.3 Tue 14:30 H52

Simulation of Terahertz Radiation and Ultrafast Spin-Currents in Optically-Excited Magnetic Multilayers — •Dennis Nenno[1], Rolf Binder[2], and Hans Christian Schneider[1] — [1]Physics Department and Research Center OPTIMAS, TU Kaiserslautern — [2]College of Optical Sciences, University of Arizona

Thin metallic bilayers have been shown to emit strong terahertz pulses due to the interplay of optically excited spin currents in ferromagnets and the Spin-Hall effect in heavy metals [1]. We present a novel theoretical scheme that allows us to determine both spectrum and temporal shape of the emitted pulses. We use structural details and the laser pulse parameters as an input. Our model itself relies only on *ab initio* material data and does not use any fit parameters. Optical effects are calculated from the nanometer to the micrometer scale for absorption and emission. The electron dynamics after laser excitation is simulated using the Boltzmann transport equation and solved numerically combining Particle-In-Cell approach and operator splitting technique [2]. Our model reliably reproduces experimental findings studying the variation of layer thickness [3] and excitation wavelength. We show how the terahertz generation efficiency can be improved and optimized using stacked layers in conjunction with terahertz anti-reflection coatings.

[1] T. Seifert *et al.*, Nat. Photonics **10**, 483 (2016)

[2] D. M. Nenno, B. Rethfeld, and H. C. Schneider, Phys. Rev. B (in press, 2018); arXiv:1807.04733

[3] G. Torosyan *et al.*, Sci. Rep. **8**, 1311 (2018)

MA 22.4 Tue 14:45 H52

On-chip generation of unipolar THz current pulses by the inverse spin-Hall effect — •Wolfgang Hoppe[1], Jonathan Weber[2], Tobias Kampfrath[2], and Georg Woltersdorf[1] — [1]Martin Luther University Halle-Wittenberg, Physics, Halle, Germany, — [2]Free University of Berlin, Physics, Berlin, Germany

We use optical pump pulses to generate current pulses using the spin-dependent Seebeck effect and the inverse spin-Hall effect (ISHE) in heavy metal/ferromagnet bilayers. In our on-chip approach the bilayer structures are used to terminate coplanar waveguides. The optical excitation from an ultrafast amplified laser system injects ultrashort spin current pulses from the ferromagnet into the heavy metal layer via the spin-dependent Seebeck effect [1]. Subsequently, this spin current pulse is converted into a charge current pulse inside the heavy metal layer via the ISHE [2]. The direct measurement of the electric signal using a fast sampling oscilloscope with a bandwidth of 50 GHz provides already picoseconds time resolution but suppresses most of the THz signal. Subpicosecond time resolution is achieved by electro-optic sampling on the chip. Here we measure the change of polarization of linear polarized light induced by the electric pulse and observe a unipolar signal. We determine optical pulse to THz pulse energy conversion efficiency for both methods and compare them.

[1] A. Melnikov. et. al.: arXiv:1606.03614[physics.optics] (2016)
[2] T. Seifert, T. Kampfrath, et. al.: doi:10.1038/nphoton.2016.91

MA 22.5 Tue 15:00 H52

Terahertz spin dynamics with a field-derivative torque — •Ritwik Mondal[1], Andreas Donges[1], Ulrike Ritzmann[2], Peter M. Oppeneer[2], and Ulrich Nowak[1] — [1]Fachbereich Physik, Universität Konstanz, DE-78457 Konstanz, Germany — [2]Department of Physics and Astronomy, Uppsala University, P. O. Box 516, Uppsala, SE-75120, Sweden

Efficient manipulation of magnetization at the ultrashort timescales is of particular interest for future technology. In a previous work, we developed a relativistic Dirac theory to derive the Landau-Lifshitz-Gilbert equation of motion that showed an additional contribution, the "field-derivative torque" (FDT) that is frequency and damping dependent [1]. Our analytical results show that the FDT effects can become important for pulses at terahertz frequencies or higher. In this work, we numerically investigate the contribution of field-derivative torques to the magnetization dynamics. We propose that only considering the THz field underestimates the spin excitation in antiferromagnetic oxide systems (NiO, CoO etc.), however, accounting for both, the THz and the FDT, the theory can quantitatively explain earlier experiments [2]. We also study the damping dependence of FDT effects for spin excitation in these systems.

[1] R. Mondal, M. Berritta and P. M. Oppeneer Phys. Rev. B **94**, 144419 (2016) [2] Kamfrath *et al.*, Nature Photonics **5**, 31 (2011)

MA 22.6 Tue 15:15 H52

Magnetic-Field-Dependent THz Emission of Ferrimagnetic Rare Earth Transition Metal Alloys Combined with Pt — •Mario Fix[1], Robert Schneider[2], Richard Heming[2], Steffen Michaelis de Vasconcellos[2], Rudolf Bratschitsch[2], and Manfred Albrecht[1] — [1]Institute of Physics, University of Augsburg, Universitätsstr. 1 Nord, 86159 Augsburg, Germany — [2]Institute of Physics and Center for Nanotechnology, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Bi-/multilayer structures of ferro-/ferrimagnetic (FM) and non-magnetic (NM) metals have been shown to be THz emitters when excited by femtosecond laser pulses.[1-3] Amplitude and frequency of the emitted THz radiation depend on the film thickness, the electric and magnetic properties of the FM layer, and the spin-Hall conductivity of the NM layer and can therefore be tuned by changing the composition of the used layer stack.[4]

Here we report on the THz emission of ferrimagnetic rare earth transition metal alloys combined with Pt. All films were magnetron sputter deposited at room temperature. The dependence of the THz radiation on the sample magnetization has been investigated with respect to the composition of the ferrimagnetic layers.

References:
[1] T. Kampfrath *et al.*, Nature Nanotechnology 8, 256-260 (2013).
[2] R. Schneider *et al.*, ACS Photonics 5, 3936-3942 (2018).
[3] D. Yang *et al.*, Advanced Optical Materials 4, 1944-1949 (2016).
[4] T. Seifert *et al.*, Nature Photonics 10, 483-488 (2016).

MA 22.7 Tue 15:30 H52

Exchange stiffness of terahertz spin waves in iron — •Liane Brandt[1], Niklas Liebing[1], Ilya Razdolski[2], Georg Woltersdorf[1], and Alexey Melnikov[1] — [1]Martin Luther University Halle-Wittenberg, Institute of Physics — [2]Fritz Haber Institute of the Max Planck Society, Department of Physical Chemistry

Recently, we have demonstrated the excitation of perpendicular standing spin waves (PSSW) in Fe/Au/Fe tri-layers studied by the time-resolved magneto-optical Kerr effect in a back pump-front probe scheme [1]. This high-frequency spin dynamic is driven by interface-confined spin transfer torque (STT) exerted by 250 fs-short spin current pulses generated in the optically excited emitter Fe layer [2]. The frequency of the PSSWs is tuned up to 2 THz by continuously reducing the thickness of collector Fe layer from 17 to 1 nm. By analyzing the exchange stiffness of the first five PSSW modes we observe its decrease with decreasing collector thickness down to 50% for the thinnest collector, compared to the literature value of Fe. To model this stiffness behavior in Fe, we introduce modifications of the exchange interaction in the vicinity of the interfaces, and obtain important insights into the physics of itinerant ferromagnets by means of micromagnetic simulations using mumax3.

[1] I. Razdolski et al., Nature Commun. 8, 15007 (2017)
[2] A. Alekhin et al., PRL 119, 017202 (2017)

MA 23: Soft and hard permanent bulk magnets

Time: Tuesday 14:00–15:45 Location: H53

MA 23.1 Tue 14:00 H53

Nd(YCe)-based 1:12 phases – an ab intio study — •Heike C. Herper[1], Olga Yu. Vekilova[1], Alena Vishina[1], and Olle Eriksson[1,2] — [1]Department of Physics and Astronomy, Uppsala University, 75120 Uppsala, Sweden — [2]School of Science and Technology, Örebro University, 70182 Örebro, Sweden

The increase of environmental friendly energy production is coupled to an increasing demand of new magnetic materials and the identification of solutions based on abundant materials avoiding or reducing the amount of critical raw materials. In the present study we focus on the tetragonal 1:12 phase ($TmMn_{12}$ structure) which contains 35% less RE than the commercially used NdFeB compounds. Aiming to tune the magnetic performance towards large magneto crystalline anisotropy and high Curie temperatures systematic ab initio calculations have been performed. Starting from $NdFe_{11}Z$ the dependence of the magnetic performance on the type and concentration of the phase stabilizing element Z has been studied. To further reduce the RE concentration simultanously possible replacements for Nd were tested. A large composition range was found to be stable and especially doping on the RE site turned out to be suitable.

The systems were characterized using a combination of different state of the art first principles methods (VASP, RSPt). Finite temperature properties were obtained from mapping the system on a spin model using UppASD.

This work is supported by the European Research Project NOVAMAG (EU686056) and the Swedish Foundation for Strategic Research.

MA 23.2 Tue 14:15 H53

Ab initio **Study of Magnetic Properties of Rare-Earth lean 1:12 Alloys** — •Olga Vekilova[1], Olle Eriksson[1,2], and Heike C. Herper[1] — [1]Department of Physics and Astronomy, Uppsala University — [2]School of Science and Technology, Orebro University

Since the discovery of $Nd_2Fe_{14}B$, the best permanent magnet to date, magnets containing the combination of rare earth elements and Fe attract high scientific interest. The iron-rich compounds are specifically attractive as they have large magnetic moments due to the high concentration of Fe, rather high coercivity and high Curie temperature. One of the best candidates are the 1:12 compounds with the $ThMn_{12}$-type structure. It has been shown that light rare earths and iron cannot form a stable binary 1:12 compound, so a third element must be added to stabilize the ternary $RE(Fe,M)_{12}$ phase, where M=Ti, V, Si, Mo and etc. Such substitution results in a significant decrease in the saturation magnetization and can influence magnetocrystalline anisotropy and Curie temperature of the alloy. Recent experiments show that it is possible to stabilize the 1:12 phases with reduced concentrations of M. Magnetic properties of the 1:12 compounds were studied theoretically from first principles. Starting from the known stable $SmFe_{10}V_2$ and $NdFe_{11}Ti$ we improved the magnetic properties by reducing the content of V and Ti respectively. The phase stabilities, magnetizations, Curie temperature, magnetocrystalline anisotropies of $NdFe_{12-x}Ti_x$ and $SmFe_{12-x}V_x$ were calculated and compared to the available experimental data. This work is supported by the European Research Project NOVAMAG (EU686056) and STandUP for energy (Sweden).

MA 23.3 Tue 14:30 H53

Polymer bonded 3D-printed permanent magnets: A comparison of properties — •Georgia Gkouzia[1,2,3], Tobias Braun[1], Stefan Riegg[1], Konstantin P. Skokov[1], Dimitris Niarchos[3], and Oliver Gutfleisch[1] — [1]Funktionale Materialien, Institut für Materialwissenschaft, TU Darmstadt, Alarich-Weiss-Str. 16, D-64287 Darmstadt, Germany — [2]School of Chemical Engineering, National Technical University of Athens, Iroon Polytechniou 9, Zografou 15780, Athens, Greece — [3]AMEN Technologies, Neapoleos 27 and Patr. Grigoriou, 153 10 Athens, Greece

Recent developments in additive manufacturing (3D-printing) give the possibility of production of magnet structures which are not possible to obtain by using conventional methods. 3D-printing started as a pioneering method for polymer and ceramic materials giving the opportunity of rapid prototyping. First attempts have been made now in the production of permanent magnets. In this work, we used different polymers (PLA, PA12) and commercial magnet powders (MQA, MQP-S) for the production. We compare the properties of polymer bonded magnet with magnets made by Fused Deposition Modeling (FDM) and Laser Powder-Bed Fusion (LPBF). For the comparison of these different production routes, we investigate the microstructure and magnetic properties (B_r, H_c,$(BH)_{max}$) and the density (filling ratio of the magnetic material) of the produced samples.

MA 23.4 Tue 14:45 H53

Rare-earth lean exchange spring permanent magnets — •Stefan Riegg[1], Lukas Schäfer[1], Iuliia P. Novoselova[2], Tobias Braun[1], Marina Spasova[2], Iliya Radulov[1], Corinna Müller[1], Ralf Meckenstock[2], Konstantin P. Skokov[1], Michael Farle[2], and Oliver Gutfleisch[1] — [1]Funktionale Materialien, Fachbereich Material- und Geowissenschaften, Technische Universität Darmstadt, 64287 Darmstadt, Germany — [2]Fakultät für Physik und Center for Nanointegration (CENIDE), Universität Duisburg-Essen, 47057 Duisburg, Germany

Standard high performance permanent-magnet materials are based on rare-earth element – $3d$ metal compounds such as Nd-Fe-B and Sm-Co. To increase sustainability of these magnets, a reduction of the rare-earth element content could be one target. For instance, exchange spring magnets could be a reasonable solution to this task. In this class of materials the exchange interaction of a hard- and a soft-magnetic phase leads to a simultaneously high remanence and high coercivity, although only a relatively small fraction of the hard-magnetic material is present.

A rare-earth lean Nd-Fe-B related material is commercially available as gas-atomized powder: MQP-S. The production of magnets based on this powder will be shown for different routes (Polymer bonding, 3D printing, hot compaction), and the respective stabilities of the exchange coupling behavior and coercivity will be discussed. Advanced characterization of magnetic properties as well as detailed microstructural investigations will be presented.

MA 23.5 Tue 15:00 H53

A multiscale study of antiphase boundary of the MnAl τ-phase — •Sergiu Arapan[1], Pablo Nieves[2], and Thomas Schrefl[3] — [1]IT4Innovations, VSB-Technical University of Ostrava, 17. listopadu 15, CZ-70833 Ostrava-Poruba, Czech Republic — [2]ICCRAM, International Research Center in Critical Raw Materials and Advanced Industrial Technologies, University of Burgos, 09001 Burgos, Spain — [3]Department for Integrated Sensor Systems, Danube University Krems, 2700 Wiener Neustadt, Austria

We have implemented a multiscale model to design a realistic permanent magnet material. We quantify for the first time the exchange interaction strength across the antiphase boundary (APB) defect of the MnAl τ-phase with a simple approach derived from first-principles. The calculated exchange interaction at the APB of the MnAl τ-phase is strong enough to form an APB decorated with a domain wall, as it is always observed in experiments. This result is used in micromagnetic simulations for designing a microstructure of the MnAl τ-phase with APBs that optimizes the energy density product. The link between first-principle and micromagnetic calculations is porvided by atomistic spin dynamics. The developed multiscale modelling shows that ABPs deteriorate the loop shape through nucleation of reversed domains at very low field values and successive domain wall pinning. The energy density product decreases with increasing the number of antiphase boundaries.

MA 23.6 Tue 15:15 H53

Coercivity and anisotropy measurements on $GdCo_{5-x}Cu_x$ single crystals — •Stefan Giron, Léopold V.B. Diop, Iliya A. Radulov, Konstantin P. Skokov, and Oliver Gutfleisch — TU Darmstadt, FB Materialwissenschaft, Alarich-Weiss-Str. 16, 64287 Darmstadt, Germany

Rare-earth transition-metal permanent-magnets possess remarkably high anisotropy energies and therefore may express high coercivities necessary for permanent-magnet applications. Nonetheless, coercivity is limited to approximately one third of the anisotropy field (Brown's paradox). Coercivity mechanisms driven by exchange interaction (e.g. exchange bias) recently observed in compensated bulk Heuslers [1] and Heusler segregations [2] provide the means necessary to overcome Brown's paradox. Though not fully understood, the coexistence of FM and AFM clusters seems to be necessary in these systems. Materials with a compensation point (e.g. $GdCo_{5-x}Cu_x$ [3]) present themselves as model objects to study giant coercivity near the FM-AFM transition. We investigated a series of ferrimagnetic $GdCo_{5-x}Cu_x$ single crystals ($x \in 0.5, 1, 1.5, 2$), which traverse a composition dependent compensation point. We show that the fields needed to demagnetize the samples approach their maximum (above 14T) near the compensation point, where the respective anisotropy fields reach minimum values.

[1] Nayak et al. Nature Materials, 2015, 14, 679
[2] Çakir, Scientific Reports, 2016, 6
[3] Grechishkin et al. Applied Physics Letters, 2006, 89, 122505

MA 23.7 Tue 15:30 H53

Low-Dimensional Magnetic Properties of Natural and Synthetic Mixite (Bi,Ca)Cu6(OH)6(AsO4)3 * nH2O (n 3) and Goudeyite YCu6(OH)6(AsO4)3 * nH2O (n 3) — •Aleksandr Golubev[1], Eva Brücher[1], Armin Schulz[1], Reinhard Kremer[1], Franz Schmidt[2], Elija Gordon[3], and Myung-Hwan Whangbo[3] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]Staatliches Museum für Naturkunde, Stuttgart, Germany — [3]North Carolina State University, Raleigh. USA

The minerals mixite and goudeyite with composition $(Bi,Ca)Cu_6(OH)_6(AsO_4)3{*}nH_2O(n=3)$ and $YCu_6(OH)_6(AsO_4)_3{*}nH_2O$ (n = 3) crystallize in the space group P 6_3/m (no. 176) with a "zeolite-type" channel structure with a honeycomb arrangement of rings composed of six CuO_4 ribbon chains. The structural, vibrational and magnetic properties of natural and synthetic polycrystalline samples of the minerals mixite and goudeyite have been investigated. The magnetic susceptibilities are characterized by low-dimensional antiferromagnetic short range ordering and can be described as spin S=1/2 alternating Heisenberg chain with nearest-neighbor spin exchange ranging between 200 K and 130 K for natural mixite and synthetic goudeyite, respectively. The alternation parameters range between 0.52 for natural mixite and 0.75 for synthetic mixite and goudeyite, respectively. The experimentally observed spin exchange parameters are consistent with DFT calculations of the spin exchange parameters.

MA 24: Miscellaneous: Biomaterials, Magnetic Shape Memory Alloys, Sensors and Actuators (joint session MM/MA)

Time: Tuesday 14:15–15:45 Location: H46

MA 24.1 Tue 14:15 H46

Magnetic and chemical microstructures of Mn-based Heusler compounds studied by small-angle neutron scattering — •Ulrike Zweck, Michael Leitner, Pascal Neibecker, and Winfried Petry — Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Garching

Ni_2MnZ based Heusler compounds have attracted a considerable amount of attention due to their various appealing properties such as the ferromagnetic shape-memory effect or the magnetocaloric effect. Since the magnetic properties are very sensitive to the degree of structural order in these systems [1], understanding the correlation of these two ordering parameters is crucial.

The magnetic moments are mainly carried by the Mn atoms, which interact ferromagnetically in the $L2_1$-ordered state. However, it has been found that at structural anti-phase domain boundaries the magnetization tends to reverse, leading to atomically sharp ferromagnetic domain walls [2]. To study this interplay of magnetic and structural order as well as the mechanism of coupling of ferromagnetic domains across APD boundaries, we have investigated Ni_2MnAl and $Ni_2MnAl_{0.5}Ga_{0.5}$ powder samples in distinct ordering states via temperature-dependent small-angle neutron scattering (SANS), giving access to the magnetization microstructure. Further, we reproduce the correlation between structural and magnetic order by Monte Carlo simulations.

[1] P. Neibecker *et al.*, Appl. Phys. Lett. **105**, 261904 (2014).
[2] H. Ishikawa *et al.*, Acta Mater. **56**, 4789 (2008).

MA 24.2 Tue 14:30 H46

Atomic disorder in magnetocaloric materials: A roadmap for achieving better performance — •Biswanath Dutta[1,2], Bruno Weise[3], Niclas Teichert[4], Andreas Hütten[4], Anja Waske[3], Fritz Körmann[1,2], Tilmann Hickel[2], and Jörg Neugebauer[2] — [1]Materials Science and Engineering, Delft University of Technology, Delft, Netherlands — [2]Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany — [3]Institute for Complex Materials, IFW Dresden, Dresden, Germany — [4]Department of Physics, Bielefeld University, Bielefeld, Germany

Understanding and improving magnetic properties of magnetocaloric materials is of great importance for their practical applications. In the quest to enhance these properties, different design strategies have been employed in recent years. Using ab initio calculations, we study the impact of atomic disorder on the martensitic transformation and the magnetic properties in Ni-Mn-based magnetic shape memory alloys (B. Weise et al., Sci. Rep. 8:9147 (2018)). The calculations reveal a remarkable impact of atomic configuration on the structural and magnetic properties of the cubic austenite phase. We also find a delicate interplay of magnetic and chemical orders and the tetragonal distortion during the martensitic transformation, explaining the giant inverse magnetocaloric effect in these alloys. Based on these findings, we qualitatively explain the experimentally observed changes in the magnetocaloric properties after different annealing times. Our investigations thus provide a promising route, i.e., managing disorder with optimal annealing to achieve better magnetocaloric properties.

MA 24.3 Tue 14:45 H46

Stretchable Multidimensional Magnetic-Triboelectric Electronic Skin — •Tianxiao Xiao, Gilbert Santiago Cañón Bermúdez, Jürgen Fassbender, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany

Owing to their unique mechanical properties and abilities of touchless interaction with physical and virtual objects [1-3], magnetic field sensors became an integral part of the electronic skins (e-skins) concept [4,5]. In this work, we report a stretchable magnetic-triboelectric electronic skin (MTES) by the combination of giant magnetoresistive (GMR) sensors and triboelectric nanogenerators (TENG). Here, Co/Cu multilayers and polydimethylsiloxane (PDMS) layer not only form a flexible GMR sensor system but also serve as the electrode and dielectric layer of a single-electrode TENG. This work demonstrates the first sensor system based on both magnetic and triboelectric effects. [1] Makarov, D., et al., Appl. Phys. Rev. 3, 011101 (2016). [2] Cañón Bermúdez, G. S., et al., Nature Electronics 1, 589 (2018). [3] Cañón Bermúdez, G. S., et al., Science Advances 4, eaao2623 (2018). [4] Chortos, A., et al., Nature Materials 15, 937 (2016). [5] Amjadi, M., et al., Adv. Funct. Mater. 26, 1678 (2016).

MA 24.4 Tue 15:00 H46

Hybrid Materials Made from Nanoporous Metals and Electrically Conductive Polymers as Electro-Chemo-Mechanical Actuators — •Benedikt Roschning[1] and Jörg Weissmüller[1,2] — [1]Institute of Materials Physics and Technology, Hamburg University of Technology, Hamburg, Germany — [2]Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Nanoporous metals can be used as functional materials like sensors or actuators, due to their high intrinsic, externally accessible surface. The mechanism is based on surface stress variations as a consequence of an applied electrical potential. This stress variation acts on the underlying bulk atoms, resulting in actuation, scaling with the feature size. The environmental stability and structural coarsening due to surface diffusion restricts the materials choice to noble metals like gold or platinum and are still an issue in terms of long-term stability.

Another class of electro-chemo-mechanical actuators are conductive polymers. Their actuation is caused by the incorporation of co-ions between the polymer chains for charge balancing. Within thin films, fast ion exchange is possible, but the stiffness of the underlying substrate limits the effect of actuation.

A combination of both approaches, the coating of the intrinsic surface area of nanoporous metals with electrically conductive polymers, leads to superior electrochemical and actuatoric properties. Within this contribution, we address manufacturing approaches, the electrochemical properties as well as the underlying mechanisms for actuation.

MA 24.5 Tue 15:15 H46

Platform for quantitative analysis of biochemical processes in droplets using nano-sensors. — •Dmitry Belyaev[1], Larysa Baraban[1,2], and Gianaurelio Cuniberti[1,2] — [1]Institute for Materials Science TU Dresden, MBZ, Budapester Str. 27, 01069, Dresden, Germany — [2]Technische Universität Dresden Center for Advancing Electronics Dresden, 01062, Dresden, Germany

Real time monitoring of bio-chemical reactions and processes, e.g. related to the cancer development is highly relevant. This, can be done by implementing miniaturized lab-on-a-chip detecting systems, incorporating microfluidics and Si nanowire field effect transistor (SiNW FET) chip allowing droplet analysis[1]. Here, the chemical reaction of β-galactosidase and ortho-nitrophenol-galactose (ONPG) was detected in a label free format, and the kinetics was analyzed using SiNW EFT. SiNW FET is ion sensitive device and it is able to detect presence of charged molecules or ions in the liquid environment. The reaction was analyzed in a numerous emulsion droplets generated in a microfluidic flow-cell, by means of honeycomb shaped NW FET chip. The flow cell was produced via combination of laser, UV and soft lithography techniques and consists of the droplets generation module and the channel structure with width of about 300μm, and is successfully integrated on silicon chip. We attribute the shift of the Isd current to the change on ionic composition of the media. Comparative data proved successful detection of the reaction.

1)J. Schütt et al., Nano Lett. 2016, 16, 8, 4991-5000

MA 24.6 Tue 15:30 H46

Diamond-based materials interacting with DNA units — Miftahussurur Hamidi Putra[1], Di Liu[1], Chandra Shekar Sarap[1], Pouya Partovi-Azar[2], and •Maria Fyta[1] — [1]Institute for Computational Physics, University of Stuttgart, Stuttgart, Germany — [2]Institute of Chemistry, Martin Luther University Halle-Wittenberg, 06120 Halle (Saale), Germany

Using quantum-mechanical calculations implementing density functional theory, we model the interaction of DNA units with diamond-based structures. For the former, we consider the DNA canonical nucleobases and nucleotides, as well as their modified counterparts. For the material part, we focus on terminated surfaces and nanodiamonds. The latter involve defective spherical diamond particles, as well as diamond-cages, known as diamondoids. We model the interactions of these material structures to the DNA units taking into account the surface termination, bonding arrangement and DNA type. Through our computations, we assess the binding strength, electronic properties, as well as optical spectra and charge dynamics of these diamond/DNA hybrid complexes. In the end, we discuss the relevance of such hybrid materials in realizing novel biosensors for the detection of DNA sequences and their mutations.

MA 25: Topological Semimetals - Theory (joint session TT/MA)

Time: Wednesday 9:30–12:30 Location: H22

MA 25.1 Wed 9:30 H22

Semiclassical transport theory in Weyl semimetals beyond the relaxation time approximation — •Tobias Meng — Institute of Theoretical Physics, Technische Universität Dresden, 01062 Dresden, Germany

Transport is a frequently used tool to study the properties of topological semimetals. In Weyl semimetals, the negative magnetoresistance proportional to the square of the magnetic field is a famous example of such a transport property. However, experimental semimetals usually are multi band systems containing disorder. It is essential to further develop the description of transport in Weyl semimetals in order for theory to match the experimental progress. We report on some first steps towards this goal by extending the Boltzmann approach towards a more realistic description of disorder scattering, which in turn allows us to identify novel signatures of Berry phase physics in transport.

MA 25.2 Wed 9:45 H22

Topological crossings in magnetic space groups — •Darshan G. Joshi[1], Yang-hao Chan[2], and Andreas P. Schnyder[1] — [1]Max-Planck-Institute for Solid State Research, Stuttgart, Germany — [2]Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan

Non-symmorphic symmetry is known to enforce topological crossings in crystals. Using the elementary band irreducible representations nontrivial crossings in the form of hour-glass or accordian spectrum have been discovered in certain space groups. Here we extend such an analysis to a wider domain of magnetic space groups (MSGs). We show that the magnetic co-representations (coreps), which are derived from the non-magnetic irreducible representations, can be used to detect non-symmorphic symmetry enforced topological crossings in MSGs. We demonstrate this with two examples, where we find magnetic Weyl points and hour-glass dispersions. DFT band-structure calculation of corresponding magnetic materials confirms our findings. Furthermore, we compute the surface states and discuss other experimental consequences of the hourglass dispersion in magnetic materials.

MA 25.3 Wed 10:00 H22

Chiral anomaly in Weyl semimetals within a Fermi surface harmonics approach — •Annika Johansson[1,2], Jürgen Henk[2], and Ingrid Mertig[2,1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

In Weyl semimetals, external nonorthogonal magnetic and electric fields lead to nonconservation of the chiral charge, known as chiral anomaly [1-4]. This quantum phenomenon manifests itself in a negative longitudinal magnetoresistance. Using a Fermi surface harmonics approach [5] for solving the semiclassical Boltzmann equation, we calculate transport properties of type-I Weyl semimetals, including influences of chiral anomaly, Lorentz force as well as momentum-dependent scattering. Respecting a modified phase-space volume, we identify additional contributions to the chiral charge conductivity which can change the sign of the magnetoresistance in systems with broken inversion symmetry. Considering momentum-dependent scattering modifies the energy-dependence of the transport properties. On top of this, we show for TaAs that a misalignment of an applied magnetic field with the crystal axes can destroy the negative longitudinal magnetoresistance.

[1] S. Adler, Phys. Rev. **177**, 2426 (1969)
[2] J. S. Bell and R. Jackiw, Nuovo Cimento A **60**, 47 (1969)
[3] H. B. Nielsen and M. Ninomiya, Phys. Lett. B **130**, 389 (1983)
[4] D. T. Son and B. Z. Spivak, Phys. Rev. B **88**, 104412 (2013)
[5] P. B. Allen, Phys. Rev. B **13**, 1416 (1976)

MA 25.4 Wed 10:15 H22

Symmetry-Protected Nodal Phases in Non-Hermitian Systems — •Jan Carl Budich[1], Johan Carlström[2], Flore K Kunst[2], and Emil J Bergholtz[2] — [1]Institute of Theoretical Physics, TU Dresden, 01062 Dresden, Germany — [2]Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm, Sweden

Non-Hermitian (NH) Hamiltonians have become an important asset for the effective description of various physical systems that are subject to dissipation. Motivated by recent experimental progress on realizing the NH counterparts of gapless phases such as Weyl semimetals, here we investigate how NH symmetries affect the occurrence of exceptional points (EPs), that generalize the notion of nodal points in the spectrum beyond the Hermitian realm. Remarkably, we find that the dimension of the manifold of EPs is generically increased by one as compared to the case without symmetry. This leads to nodal surfaces formed by EPs that are stable as long as a protecting symmetry is preserved, and that are connected by open Fermi volumes. We illustrate our findings with analytically solvable two-band lattice models in one and two spatial dimensions, and show how they are readily generalized to generic NH crystalline systems.

MA 25.5 Wed 10:30 H22

Evolution of surface states of the Luttinger semimetal under strain and inversion symmetry breaking: Dirac and Weyl semimetals — •Benedikt Mayer, Maxim Kharitonov, and Ewelina Hankiewicz — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

Luttinger semimetal, the quadratic-node semimetal for $j = 3/2$ electrons under full cubic symmetry, is the parent highest-symmetry minimal model for a variety of topological and/or strongly correlated materials, such as HgTe, α-Sn, and iridate compounds. Recently, Luttinger semimetal has been demonstrated to exhibit surface states of topological origin that can be attributed to approximate chiral symmetry. In the present work, we theoretically study the effect of the symmetry-lowering perturbations on these surface states within an analytical model. Under compressive strain lowering rotational symmetry, Luttinger semimetal becomes a Dirac semimetal with a pair of double-degenerate linear nodes. Breaking further inversion symmetry, the system turns into a Weyl semimetal, with each Dirac node split into four Weyl nodes. We analyze the corresponding evolution of the surface states, connecting the surface-state structures in the linear regime near the nodes and in the quadratic regime of the Luttinger semimetal away from the nodes. In particular, we demonstrate agreement of the Chern numbers with the chiralities of the surface states.

MA 25.6 Wed 10:45 H22

Photo-induced anomalous Hall effect in nodal-line semimetals — •Andreas Leonhardt and Andreas P. Schnyder — Max Planck Institute for Solid State Research

Spatial symmetries like reflection or PT-symmetry are able to protect band crossings along closed lines in the Brillouin zone at momenta left invariant by the symmetry. These nodal-lines carry a topological charge, characterized by a quantized Berry phase. This implies a divergent Berry curvature at these topological defects.

In semi-classical transport theory, a non-vanishing Berry curvature is associated with an anomalous velocity. In most cases however, the contributions from opposite points in the Brillouin zone cancel exactly, such that no anomalous Hall effect can be observed. Since circular polarized light couples differently to positive and negative momenta, the cancellation of anti-symmetric terms can be lifted, leading to a non-vanishing Hall current that changes direction with switching the polarization.

We describe the lattice model of a nodal-line semimetal driven by circular polarized light in the Floquet formalism. Coupling this system to leads with a potential difference allows us to calculate the Hall current in the Keldysh formalism. We investigate the relation of the photo-induced Hall conductivity to material characteristics and light amplitude and frequency and provide estimates for the required intensities and magnitude of the effect for some known nodal-line compounds.

15 min. break.

MA 25.7 Wed 11:15 H22

Tuning the anomalous Hall effect in topological magnets via the Berry curvature design — •Kaustuv Manna, Lukas Muechler, Ting Hui Kao, Rolf Stinshoff, Nitesh Kumar, Jürgen Kübler, Chandra Shekhar, Yan Sun, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

For a long time anomalous Hall effect (AHE) has been considered as one of the characteristic signature of finite spontaneous magnetization in a material. It was considered to scale with sample's magnetization. However, the recent realization of the connection between the intrinsic AHE and the Berry curvature predicts other possibilities. AHE is an excellent method to understand the effect of various topological states and the Berry phase on the physical properties of material. Depending on the details of the band structure, the Hall conductivity can take a colossal value or even zero, independent of the corresponding magnetization of the sample. As a case study, we illustrate the situation in the Heusler compounds where one can easily tune the band structure by engineering the crystal symmetry and composition. With experimental evidences, we demonstrate how the Hall conductivity can be tuned from 0 to 2000 Ω-1cm-1 without disturbing sample's magnetization. With the help of the theoretical band structure calculations and ARPES data, we discover the first topological magnet with giant anomalous Hall conductivity (~ 1700 Ω-1cm-1) and an exceptionally high anomalous Hall angle up to 12% in a topological magnetic Heusler.

MA 25.8 Wed 11:30 H22

Disorder-driven exceptional lines and Fermi ribbons in tilted nodal-line semimetals — •Kristof Moors[1], Alexander A. Zyuzin[2,3], Alexander Yu. Zyuzin[3], Rakesh P. Tiwari[4], and Thomas L. Schmidt[1] — [1]University of Luxembourg, Luxembourg, Luxembourg — [2]Aalto University, Aalto, Finland — [3]Ioffe Physical-Technical Institute, St. Petersburg, Russia — [4]McGill University, Montréal, Québec

We consider the impact of disorder on the spectrum of three-dimensional nodal-line semimetals. We show that the combination of disorder and a tilted spectrum naturally leads to a non-Hermitian self-energy contribution that can split a nodal line into a pair of exceptional lines. These exceptional lines form the boundary of an open and orientable bulk Fermi ribbon in reciprocal space on which the energy gap vanishes. We find that the surface of such a disorder-induced bulk Fermi ribbon in general lies orthogonal to the direction of the tilt, which can be exploited to realize a bulk Fermi ribbon with non-trivial topology by means of a tilt vector that twists along a nodal loop. Our results put forward a new paradigm for the exploration of non-Hermitian topological phases of matter.

MA 25.9 Wed 11:45 H22

Hopf-link topological nodal-loop semimetals — •Feng Xiong[1,2] and Yao Zhou[2] — [1]Institute for Theoretical solid state physics, RWTH Aachen. — [2]National Laboratory of Solid State Microstructures, Department of Physics, Nanjing University, Nanjing 210093, China

We construct a generic two-band model which can describe topological semimetals with multiple closed nodal loops. All the existing multi-nodal-loop semimetals, including the nodal-net, nodal-chain, and Hopf-link states, can be examined within the same framework. Based on a two-nodal-loop model, the corresponding drumhead surface states for these topologically different bulk states are studied and compared with each other. The connection of our model with Hopf insulators is also discussed. Furthermore, to identify experimentally these topologically different semimetal states, especially to distinguish the Hopf-link from unlinked ones, we also investigate their Landau levels. It is found that the Hopf-link state can be characterized by the existence of a quadruply degenerate zero-energy Landau band, regardless of the direction of the magnetic field.

MA 25.10 Wed 12:00 H22

Access to Weyl point properties revealed by anomalous Nernst effect — •Steffen Sykora[1], Christoph Wuttke[1], Federico Caglieris[1], Bernd Büchner[1,2,3], and Christian Hess[1,3] — [1]IFW Dresden, 01069 Dresden, Germany — [2]Institute for Solid State Physics, TU Dresden, 01069 Dresden, Germany — [3]Center for Transport and Devices, TU Dresden, 01069 Dresden, Germany

In Weyl semimetals the Nernst coefficient is dominated by anomalous contributions to the thermal particle transport which originate from a specific property of the conduction electrons, the Berry curvature. Here we extend our recently developed theoretical approach of the anomalous Nernst effect to find explicit expressions for the temperature dependence of the thermal and electrical conductivity components. We apply these findings to fit experimental curves of recent Nernst effect measurements in a Weyl semimetal where it could be shown that signatures of Weyl physics are dominating the Nernst signal. From this analysis we determine fundamental properties of the Weyl points, such as their energy and distance in k-space.

MA 25.11 Wed 12:15 H22

Anomaly transport normally explained — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics - UFRN, Campus Universitário Lagoa nova, 59078-970 Natal, Brazil

The anomalous term $\sim \vec{E}\vec{B}$ in the balance of the chiral density can be rewritten as quantum current in the classical balance of density. Therefore it does not violate classical conservation laws as it is claimed to be caused by quantum fluctuations. Moreover this term is derived from the quantum kinetic equations for systems with SU(2) structure within a completely conserving approach. Therefore the origin of this term is not a unique signal of symmetry-breaking terms in the field-theoretical Lagrangian. Regularization-free density and pseudospin currents are calculated in Graphene and Weyl-systems realized as the infinite-mass limit of electrons with quadratic dispersion and a proper spin-orbit coupling. The intraband and interband conductivities are discussed. The optical conductivity agrees well with the experimental values using screened impurity scattering and an effective Zeeman field. The universal value of Hall conductivity is shown to be modified due to the Zeeman field.

[1] arXiv:1809.01547, arXiv:1806.06214, Phys. Rev. B 94 (2016) 165415, Phys. Rev. B 92 (2015) 245425, errata: Phys. Rev. B93 (2016) 239904(E), Phys. Rev. B 92 (2015) 245426

MA 26: Spin dynamics and transport

Time: Wednesday 9:30–13:00 Location: H37

MA 26.1 Wed 9:30 H37

Electric-field control of interfacial spin-orbit fields — •Lin Chen[1], Martin Gmitra[2], Michael Vogel[1], Robert Islinger[1], Matthias Kronseder[1], Dieter Schuh[1], Dominique Bougeard[1], Jaroslav Fabian[2], Dieter Weiss[1], and Christian Back[3] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Germany — [2]Institute of Theoretical Physics, University of Regensburg, Germany — [3]Department of Physics, Technical University Munich, Germany

Electric-field control of current-induced spin-orbit magnetic fields provides a route towards the low-power spin-orbit torque devices. Here, we show that the current-induced spin-orbit magnetic fields at the Fe/GaAs (001) interface [1] can be controlled with an electric field. In particular, by applying a gate-voltage across the Fe/GaAs interface, the interfacial spin-orbit field-vector acting on Fe can be robustly modulated via the change of the magnitude of the interfacial spin-orbit interaction [2]. Our results illustrate that the electric-field in a Schottky barrier is capable of modifying spin-orbit magnetic fields, an effect that could be used to develop spin-orbit torque devices with low-power consumption. [1] L. Chen et al., Nature Commu. 7, 13802 (2016). [2] L. Chen et al., Nature Elect. 1, 350-355 (2018).

MA 26.2 Wed 9:45 H37

Analysis of the spin transfer torques as a function of domain wall length — •Hamidreza Kazemi[1], Bertrand Dupé[2], Nicholas Sedlmayr[3], Imke Schneider[1], Jairo Sinova[2], and Sebastian Eggert[1] — [1]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Mainz, Germany — [3]Department of Physics and Medical Engineering, Rzeszów University of Technology, Rzeszów, Poland

Use of a spin polarized current for the manipulation of magnetic domain walls in ferromagnetic nanowires has been the subject of intensive research for many years. Recently, due to technological advancements creating nano-contact with special characteristics are becoming more and more prevalent. Our goal is to delve into the full quantum investigation of the behavior of the spin transfer torques in a nano-contact of $Ni_{80}Fe_{20}$. According to our DFT calculations the physical behavior of low energies can be described by the s-d model which couples the domain wall and the itinerant electrons. To investigate spin transfer torques, we solve the scattering problem of a noninteracting tight-binding Hamiltonian including an s-d term. Moreover, the resulting magnetoresistance is calculated and compared with experiments.

MA 26.3 Wed 10:00 H37

Hybrid simulation of nonequilibrium spin dynamics — •Johan Briones, Sebastian Weber, Christopher Seibel, Sanjay Ashok, and Baerbel Rethfeld — Department of Physics and Optimas Rearch Center, TU Kaiserslautern, Germany

The complex phenomenon arising after a magnetic film has been excited by a femtosecond laser pulse is studied using a hybrid model (similar to [1]). It consists of a combination of two methods: A Monte Carlo model and the muT model [2]. The former will trace individual high energy nonequilibrium electrons [3], including spin-dependent scattering processes and spin-flip probabilities. The latter, will treat the low energy electrons as an ensemble, tracing their temperature and chemical potential. The magnetization dynamics will be investigated by using a two-band dynamic model which will be first applied to the case of Nickel.

The long-term perspective of this project is to develop a model that can describe the non-equilibrium transport and its effect on magnetization dynamics.

[1]N. Medvedev et al., New J. Phys, 15, 015016 (2013).
[2]B. Y. Mueller and B. Rethfeld, Phys. Rev. B, 90, 144420 (2014).
[3]K. Huthmacher et al., Physica A, 429, 241-251 (2015).

MA 26.4 Wed 10:15 H37

Electric-field control of spin-orbit torques CoFeB thin films — •Mariia Filianina[1,2], Jan-Philipp Hanke[1,3], Kyujoon Lee[1], Dong-Soo Han[1], Yuriy Mokrousov[1,3], and Mathias Kläui[1,2] — [1]Institute of Physics, Johannes Gutenberg University, Mainz, Germany — [2]Graduate School of Excellence Material Science in Mainz, Mainz, Germany — [3]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, Jülich, Germany

Energy-efficient control of magnetization via electric fields has attracted significant interest. These so-called magneto-electric effects have been studied in various systems with the focus put on the manipulations of magnetic anisotropies [1]. However, electric field effects to tune current-induced spin-orbit torques (SOTs) for magnetization switching, which is crucial for spintronics applications, has been little investigated [2].

Here we report on strain-controlled SOTs in perpendicularly magnetized W/CoFeB/MgO multilayers grown on a piezoelectric substrate. The SOTs are evaluated by magnetotransport and second-harmonic methods [3] under different in-plane strains. We find that the strain leads to a non-trivial change in field-like and damping-like torques. We compare our experimental results with theoretical ab initio calculations and uncover the microscopic origin of the observed strain effects on the magneto-electric coupling.

1. S. Finizio et al., Phys. Rev. Appl., Vol. 1, p. 021001 (2014). 2. K. Cai et al., Nat. Mater., Vol. 16, p. 712 (2017). 3. T. Schulz et al., Phys. Rev. B, Vol. 95, p. 224409 (2017).

MA 26.5 Wed 10:30 H37

Scattering of spinon excitations in the 1D Heisenberg model by potentials — •Xenophon Zotos[1,2] and Alexandros Pavlis[1] — [1]Department of Physics, University of Crete,Greece — [2]Leibnitz Institute/IFW Dresden, Germany

By a semi-analytical Bethe ansatz method we study the scattering of a spinon, the elementary quantum many-body topological excitation in the 1D Heisenberg model, by a local and a phonon potential. In particular, we contrast the scattering of a spinon to that of a free spinless fermion in the XY model. This study provides insights in the spin transport by one dimensional quantum magnets with embedded interfaces modeled here as prototype local potentials.

MA 26.6 Wed 10:45 H37

Quantum fluctuations of magnetization via spin shot noise — •Alireza Qaiumzadeh and Arne Brataas — Center for Quantum Spintronics, NTNU, Norway

Recent experiment in current-driven spin valves demonstrate magnetization fluctuations that deviate from semiclassical predictions [1]. We posit that the origin of this deviation is the spin shot noise. On this basis, our theory predicts that the magnetization fluctuations asymmetrically increase in biased junctions irrespective of the current direction. At low temperatures, the fluctuations are proportional to the bias, but at different rates for opposite current directions. Quantum effects control fluctuations even at higher temperatures [2]. Our theory shows the important contribution of so far overlooked spin shot noise on spin transfer torque phenomena.

[1] A. Zholud, R. Freeman, R. Cao, A. Srivastava, S. Urazhdin, Phys. Rev. Lett. 119, 257201 (2017). [2] A. Qaiumzadeh and A. Brataas, arXiv:1808.02907 (2018).

MA 26.7 Wed 11:00 H37

Tracking the order parameter motion during a coherent antiferromagnetic spin precession — •Christian Tzschaschel[1], Takuya Satoh[2], and Manfred Fiebig[1] — [1]Department of Materials, ETH Zurich, Switzerland — [2]Department of Physics, Kyushu University, Japan

Recently, antiferromagnets attract increasing attention for spintronics applications. The high frequency of antiferromagnetic (AFM) resonances suggests the possibility to coherently control AFM order on picosecond time scales. AFM spin dynamics, however, are often obscured by the relative inaccessibility of the AFM order parameter. Here, we directly reveal the dynamics of the AFM order using time-resolved optical second-harmonic generation (SHG). Exploiting the inverse Faraday effect, we optically excite a specific magnon mode in hexagonal $YMnO_3$ and track the ensuing order-parameter dynamics. The coherent Z-mode precession results in a symmetry reduction of the AFM order from $\underline{6}m\underline{m}$ to 3. SHG as a symmetry sensitive technique allows us to separate electron from spin dynamics, which enables a time-resolved quantitative tracking of the AFM order parameter. Specifically, we can estimate the optically induced spin canting angle to be approximately 0.5°. In combination with the simultaneously measured Faraday rotation, we obtain access to both the compensated and uncompensated components of the order parameter, which allows us to track its motion during the AFM spin precession. Probing dynamic symmetry reductions constitutes a general approach, which allows tracking AFM spin dynamics also in anharmonic situations, such as spin reorientations.

15 min. break

MA 26.8 Wed 11:30 H37

Magnetic and transport properties of the transition metal dichalcogenides intercalated by 3d-elements — •S. Polesya[1], S. Mankovsky[1], S. Mangelsen[2], W. Bensch[2], S. Medvedev[3], and Hubert Ebert[1] — [1]Dept. Chemistry, LMU Munich, D-81377 Munich, Germany — [2]Institute of Inorganic Chemistry, 24118 Kiel, Germany — [3]Max Planck Inst. for Chem. Physics of Solids, 01187 Dresden, Germany

The magnetic and transport properties of the $2H{-}NbS_2$ and $2H{-}TaS_2$ compounds intercalated by 3*d*-elements have been investigated by first-principles calculations of the electronic structure using the Korringa-Kohn-Rostoker (KKR) method. We focus on the systems with 33% and 25% of intercalation which allow the formation of ordered phases characterized by $\sqrt{3}\times\sqrt{3}$ and 2×2 in-plane arrangements of the magnetic atoms, respectively. The calculations have been performed both for stoichiometric composition as well as taking into account small deviation from stoichiometry to investigate its impact on the magnetic and transport properties. The ground state magnetic structure as well as finite temperature magnetic properties have been studied via Monte Carlo simulations using the exchange coupling parameters calculated from first principles. The Kubo-Greenwood linear response formalism was used to calculate the temperature dependent electrical resistivities of the systems, both for ambient pressure as well as function of the increasing pressure. The calculated results are in rather good agreement with the available experimental data.

MA 26.9 Wed 11:45 H37

Spin-orbit torque in the surface of the topological insulator Bi_2Te_3 doped with magnetic defects — •Adamantia Kosma[1], Philipp Rüssmann[2], Stefan Blügel[2], and Phivos Mavropoulos[1] — [1]Department of Physics, National and Kapodistrian University of Athens, Panepistimioupolis 15784 Athens, Greece — [2]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We present an *ab initio* investigation of the spin-orbit torque [1,2], exerted on the moments of transition metal impurities at the surface of the topological insulator Bi_2Te_3. We employ the multiple scattering approach as implemented in the full-potential relativistic Korringa-Kohn-Rostoker (KKR) Green function method, combined with the Boltzmann transport equation [3]. We analyze the spin accumulation and the spin flux contribution to the spin-orbit torque on the magnetic defects in response to the electric field, and we discuss the correlation of the spin-orbit torque to the spin current on the Fermi surface. We interpret the results based on the localization and the spin-polarization of the surface states. In addition, we investigate the effect of the concentration of impurities on these quantities by considering multiple random distributions of defects. This work was supported by computational time granted from the Greek Research Technology Network (GRNET) in the National HPC facility–ARIS–under project ID pr00504-TopMag. [1] A. Manchon and S. Zhang, Phys. Rev. B **79**, 094422 (2009). [2] F. Freimuth *et al.*, Phys. Rev. B **92**, 064415 (2015). [3] G. Géranton *et al.*, Phys. Rev. B **93**, 224420 (2016).

MA 26.10 Wed 12:00 H37

Frequency and angular dependencies of spin-orbit-induced magnetic fields and torques — •Filipe Souza Mendes Guimarães, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Magnetization dynamics can be driven by ac electric currents through effective magnetic fields induced by the spin-orbit interaction [1]. In metallic multilayers, the precessing magnetic moment pumps spin currents to the normal metal, which is then converted back to charge currents. We have previously shown how these dynamical processes contribute to the different magnetoresistances and Hall currents of Fe/W(110) and Co/Pt(001) bilayers [2]. In this contribution, we analyze how the effective magnetic fields and the different torques acting on the magnetic moment of these bilayers depend on their rotation angle and on the frequency of the electric field. Even though the effective field acting on the magnetic layer has an ordinary non-resonant behavior, the resulting spin-orbit and external torques present complex responses in all directions. These dynamical results may help to understand switching processes and give guidance for the design of efficient heterostructures.

[1] D. Fang *et al.*, Nat. Nanotechnol. 6, 413 (2011)
[2] F. S. M. Guimarães *et al.*, Sci. Rep. **7**, 3686 (2017)
– Funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator grant 681405 – DYNASORE).

MA 26.11 Wed 12:15 H37

Long-ranged spin transport in magnetism: the role of topology and frustration — •Ricardo Zarzuela[1], Héctor Ochoa[2], Yaroslav Tserkovnyak[3], and Jairo Sinova[1] — [1]Institute of Physics, Johannes Gutenberg-Universität, 55128 Mainz, Germany — [2]Physics Department, Columbia University, New York, NY 10027, USA — [3]Department of Physics and Astronomy, University of California, Los Angeles, California 90095, USA

Spintronics offers new routes towards the design of energy-efficient architectures for the next generation of high-speed electronic devices. However, it also faces the problem of fast degradation of spin signals resulting from decoherence processes. Topological protection of spin textures, rooted in the existence of energy barriers due to topological constraints, seems to play a fundamental role in overcoming this issue and leads to long relaxation lengths (algebraic vs. exponential decay). This robustness usually relies on the existence of an underlying rotational symmetry in spin space (e.g, the U(1) symmetry associated with conventional effective spin superfluids), which breaks down in the presence of parasitic (relativistic) interactions arising during the fabrication process of spintronic devices. In magnetic systems with frustrated interactions dominated by exchange, these symmetry-breaking interactions become "averaged-out" at the macroscopic level and the topological robustness is effectively restored. In this talk I will discuss recent theoretical advances in the long-ranged transport of spin in materials with frustrated (magnetic) interactions, with special attention to that mediated by the spin-superfluid state and skyrmions.

MA 26.12 Wed 12:30 H37

High field magnetoresistivity and spin fluctuation theory in thin film MnSi — •Nico Steinki[1], David Schroeter[1], Niels Wächter[1], Dirk Menzel[1], Hans Werner Schumacher[2], Ilya Sheikin[3], and Stefan Süllow[1] — [1]IPKM, TU Braunschweig, Germany — [2]Physikalisch Technische Bundesanstalt, Braunschweig, Germany — [3]Laboratoire National des Champs Magnétiques Intenses, CNRS, UGA, Grenoble, France

Spin fluctuations in the itinerant helical magnet MnSi have been discussed in terms of the self-consistent renormalization (SCR) theory [1]. Correspondingly, previous high field studies on bulk MnSi have been taken as proof of basic SCR predictions [2]. Here, we present a study of the magnetoresistivity of thin film MnSi in high magnetic fields. We establish that the magnetoresistivity of thin film MnSi can essentially be understood in terms of spin fluctuation theory, allowing us to compare our data to studies of bulk material. However, despite a close qualitative resemblance of bulk and thin film data, there are clear quantitative differences. We propose that these reflect modifications to the spin fluctuation spectra in thin film MnSi, as compared to bulk material.

[1] T. Moriya, Spin Fluctuations in Itinerant Electron Magnetism, (Solid-State Sciences) (Berlin: Springer) (1985).

[2] T. Sakakibara, H. Morimoto, and M. Date: J. Phys. Soc. Jpn. **51**, 2439 (1982).

MA 26.13 Wed 12:45 H37

Boolean and quantum nanologic from first principles — •Wolfgang Hübner, Dibyajyoti Dutta, Stefan Sold, and Georgios Lefkidis — Technische Universität Kaiserslautern and Research Center OPTIMAS, Kaiserslautern, Germany

After having established Ni_4 as a paradigm for the theoretical treatment of ultrafast spin dynamics on highly correlated magnetic nanostructures [1], we apply the state-of-the-art equation-of-motion coupled-cluster with single and double excitations (EOM-CCSD) method for the quantum chemical calculations of both Ni_4 and the synthesized Co_3Ni-EtOH [2]. Thus we can enrich our zoo of laser-triggered magnetic logic functionalities, for which we exploit the spin degree of freedom as the sole information carrier. This zoo includes the ERASE functionality (also necessitating breaking of the time reversal symmetry), as well as the Boolean OR, AND, and the universal CNOT gates.

Due to the high precision of EOM-CCSD, we can go beyond classical logic and consider not only the direction and localization of the spin but also its quantum nature. Thus we additionally find the *which path* interference effect, in which the phase of the spin reveals information about the exact path traveled in a laser-induced spin transfer process [3], and construct the universal $\sqrt{\mathrm{NOT}}$ quantum logic gate (analogue to the Hadamard gate). Last but not least we show that laser-induced spin transfer can also reach the actual CMOS length scale.

[1] W. Hübner *et al.*, Phys. Rev. B **96**, 184432 (2017)
[2] D. Dutta *et al.*, Phys. Rev. B **97**, 224404 (2018)
[3] D. Chaudhuri *et al.*, Phys. Rev. B **96**, 184413 (2017)

MA 27: PhD Focus Session: Biogenic spin phenomena (joint session MA/AKjDPG)

Time: Wednesday 9:30–12:40 Location: H38

5 min opening remarks

Invited Talk MA 27.1 Wed 9:35 H38
Magnetism in biomedicine: basics and applications — •Kannan Krishnan — Departments of Materials Science & Physics, University of Washington, Seattle, WA 98195, USA

Recent developments in synthesis and optimization of magnetite nanoparticles allows for reproducible control of their complex magnetic relaxation behavior even in *extreme* biological environments. This has enabled us to address two of the principal challenges in biomedicine, i.e. detecting disease at the earliest possible time prior to its ability to cause damage (imaging and diagnostics) and delivering treatment at the right place, at the right time whilst minimizing exposure (targeted therapy with a triggered release). Currently, our work is focused on Magnetic Particle Imaging (MPI), a tracer-based, whole-body imaging technology with high contrast (no tissue background) and nanogram sensitivity. MPI is linearly quantitative with tracer concentration, and has zero tissue depth attenuation; it is also safe and uses no ionizing radiation.

In this talk, I will introduce the underlying physics of MPI, and describe results in the development of highly optimized and functionalized nanoparticle tracers for MPI. I will then present state-of-the-art imaging results of preclinical in vivo MPI experiments of cardiovascular (blood-pool) imaging, stroke, GI bleeding, and cancer, all using rodent models. If time permits, I will introduce diagnostic and therapeutic applications of magnetic nanoparticles. Finally, this talk will highlight conceptual ideas that help bridge the gap for physical scientists interested in working on translational problems in biomedicine.

Invited Talk MA 27.2 Wed 10:15 H38
Spin-dynamics of a magnetic nanoparticle chain. — •Michael Winklhofer — Carl von Ossietzky Universitaet Oldenburg, Germany

Magnetic nanoparticle chains occur in nature as magnetosomes in magnetotactic bacteria. A typical magnetosome chain consists of 10-20 magnetite particles (Fe3O4, 35 - 60 nm particle size), whose individual magnetic dipolar moments add up to produce a stable intracellular compass needle that keeps the cell body of the bacterium aligned with the Earth' s magnetic field. The potential of magnetosomes isolated from bacteria for biomedical applications (magnetic hyperthermia and MRI) is due to the relatively large magnetic moment per particle (magnetic single-domains) and the biological membrane that surrounds each particle, thereby preventing phase separation and allowing for functionalization. Since the particles magnetically interact through dipolar coupling only, a magnetosome chain exhibits intriguing spin-wave dynamics. As will be shown here, both experimentally and theoretically, magnonic features such as band gaps depend on the geometric structure of the chain. Magnetic bacteria therefore have promising structures for applications in magnonics at the nanoscale.

Discussion (10:45 - 11:00)

Coffee Break (11:00 - 11:15)

Invited Talk MA 27.3 Wed 11:15 H38
Magnetic materials for biodetection — •Galina V. Kurlyandskaya[1,2] and Alexander P. Safronov[2] — [1]Departamento de Electricidad y Electrónica and BCMaterials, Universidad del País Vasco UPV-EHU, 48080 Bilbao, Spain — [2]Institute of Natural Sciences and Mathematics, Ural Federal University, Ekaterinburg 620002, Russia

Magnetic materials are at the leading edge of the rapidly growing field of biomedical applications. This work summarises recent developments of our groups in the area of magnetic nanomaterials potentially applicable in biomedicine. The main focus of the discussion is the magnetic biodetection. Magnetic biosensor is a compact analytical device incorporating a biological or biologically derived sensitive element, integrated in the physicochemical transducer employing a magnetic field and magnetic materials. Although existing devices allow a quantified evaluation of small changes in the magnetic susceptibility in the living system, or in magnetic field values created by the extracellular electric currents, there is a need to improve their sensitivity and specificity and further develop their design up to miniaturized analytical systems. Fabrication and characterization techniques for following magnetic nanomaterials used in biosensing devices will be discussed and examples of particular detection given: iron oxide nanoparticles obtained by electrophysical techniques and water-based ferrofluids and ferrogels on their basis, amorphous ribbons and thin film multilayered structures with high giant magnetoimpedance responses. This work was supported by the RSF grant 18-19-00090.

Invited Talk MA 27.4 Wed 11:35 H38
From synthetic to biological magnetic microswimmers — •Damien Faivre — Aix Marseille Univ, CEA, CNRS, BIAM, 13108 Saint Paul-Lez-Durance, France — MPI Colloids and Interfaces, 14424 Potsdam, Germany

Microswimmers have numerous applications varying from environmental remediation to medical work. One of the most promising design encompasses the use of magnetic components to obtain sustainable propulsion mechanisms and external controllability. These components can be of biological or synthetic origin. In my group, we have worked with both type: with magnetotactic bacteria on the one hand and with synthetic aggregate of random shape on the other hand. The bacteria typically form magnetic chain inside their body but are motile by means of rotation of their flagellar apparatus. I will show how these bacteria use their chain to orient. I will also show how given bacteria can reach unprecedented speed by a surprising mechanism. In turn, synthetic swimmers are typically inspired from bacterial flagella and therefore are formed via complicated and expensive route to obtained helical shapes. In my group, we went another line and studied random-shape microswimmers. I will show how these shapes can be chosen to obtain swimming behaviors barely possible otherwise, and how studying such microswimmers permit a better understanding of how shape and magnetic properties influence swimming.

Discussion (11:55 - 12:10)

Panel discussion Moderated by Michael Farle (U Duisburg-Essen) (12:10 - 12:40)

MA 28: Bio- and molecular magnetism including biomedical applications

Time: Wednesday 9:30–11:30 Location: H52

MA 28.1 Wed 9:30 H52

Magnetite-gold nanoparticles: from physics to theranostics — •Maria V. Efremova[1,2], Yulia A. Nalench[2], Eirini Myrovali[3], Anastasiia S. Garanina[1,2], Victor A. Naumenko[2], Maxim A. Abakumov[2,4], Marina Spasova[5], Michael Farle[5], Alexander G. Majouga[1,2,6], Natalia L. Klyachko[1,2], and Ulf Wiedwald[2,5] — [1]MSU, Moscow, Russia — [2]NUST MISIS, Moscow, Russia — [3]AUTH, Thessaloniki, Greece — [4]RNRMU, Moscow, Russia — [5]UDE, Duisburg, Germany — [6]MUCTR, Moscow, Russia

In this work, we prepare pairwise connected $Fe_3O_4 - Au$ hybrid nanoparticles (NPs) with diameters of 6-44 nm Fe_3O_4 and 3-11 nm Au aiming for optimized theranostics response in magnetic particle hyperthermia (MPH) and magnetic resonance imaging (MRI).

With increasing NPs diameter from 6 to 25 nm in agarose mimicking tissues, the MPH reveal that the specific loss power increases from 12 to 327 W^*gFe^{-1}, while for the MRI, we observe the growth of the r_2-relaxivity from 118 to 612 $mM^{-1}s^{-1}$. The 25 nm and 44 nm diameter NPs show the similar theranostic performance. These values are significantly enhanced in comparison to other $Fe_3O_4 - Au$ hybrids due to their octahedral shape and large M_s. As a practical application, MRI-controlled drug delivery and dual-mode MRI/fluorescent imaging are presented for the optimized NPs size of 25 nm.

The reported study was funded by the Russian Foundation for Basic Research 18-33-01232 (fluorescent labeling of NPs) and Increase Competitiveness Program of NUST MISIS K3-2017-022 (magnetic measurements).

MA 28.2 Wed 9:45 H52

Superparamagnetic Magnetic Nanoparticle Detection for Early Diagnosis of Neurodegenerative Diseases — •Luca Marnitz, Anastasiia Moskaltsova, Jan Schmalhorst, and Günter Reiss — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Universitätsstraße 25, 33615 Bielefeld

This talk will introduce a new technique for the early detection of neurodegenerative diseases developed within the H2020 project MADIA [1]. It will focus on the development and integration of magnetoresistive sensors which are able to detect small amounts of superparamagnetic magnetic nanoparticles (SMNPs) with diameters of about 50nm inside a microfluidic channel. For this purpose, sensors based on the Giant Magnetoresistance (GMR), Tunneling Magnetoresistance (TMR) and Planar Hall Effect (PHE) were evaluated regarding their suitability for this purpose. The specific challenges of integrating the sensors in microfluidic lab-on-chip systems will be discussed and the realized solutions will be presented. [1]http://www.madia-project.eu/

MA 28.3 Wed 10:00 H52

Time-dependence of fundamental thermodynamic processes investigated in anisotropic magnetic molecules — •Christian Beckmann and Jürgen Schnack — Bielefeld University, Universitätsstr. 25, 33615 Bielefeld

The theoretical understanding of time-dependence in magnetic quantum systems is of great importance in particular for cases where a unitary time evolution is accompanied by relaxation processes. This is of special interest for the realization of fundamental thermodynamic processes.

In this contribution we investigate how a fundamental thermodynamic process, such as the Carnot process, can be performed with finite velocity on an anisotropic magnetic molecule by rotation of the applied magnetic field.

MA 28.4 Wed 10:15 H52

Magnetism of highly-ordered Fe_4 single molecule magnets on a superconductor — •Fabian Paschke[1], Vivien Enenkel[1], Michal Studniarek[2], Jan Dreiser[2], and Mikhail Fonin[1] — [1]Fachbereich Physik, Universitaet Konstanz, 78457 Konstanz, Germany — [2]Swiss Light Source, Paul Scherrer Institute, 5232 Villigen, Switzerland

The controlled deposition, characterization and manipulation of single molecule magnets (SMMs) on surfaces is one of the crucial investigation topics with regard to their possible implementation as units in future electronic and spintronic devices. Fe_4 derivatives are among the most investigated SMMs showing a giant spin and a variety of quantum mechanical phenomena [1]. We recently employed inelastic electron tunneling spectroscopy (IETS) on single molecules to confirm the retained molecular magnetism upon deposition on the isolating graphene surface [2,3].

Here we present the successful deposition and investigation of Fe_4H SMMs on superconducting Pb(111). Using scanning tunneling microscopy (STM) and spectroscopy (STS) we reveal a highly-ordered self assembly of intact Fe_4H molecules and deduce the electronic molecule-substrate interaction by measuring HOMO and LUMO resonances. Magnetic exchange interaction and anisotropy are accessed by IETS and XMCD measurements, revealing the influence of the superconducting Pb surface on the molecular magnetism.

[1] C. Cervetti et al., Nat. Mat. 15, 164 (2015). [2] L. Gragnaniello et al., Nano Lett. 17, 7177 (2017). [3] F. Paschke et al., 2018, submitted.

MA 28.5 Wed 10:30 H52

Four-dimensional inelastic neutron scattering intensity of cluster spin waves in ferromagnetic molecules — •Krunoslav Prsa and Oliver Waldmann — Physikalisches Institut, Universität Freiburg, Germany

The spin-wave approximation of many-body effects in magnetic solids can be adapted to describe excitations from the ferromagnetic ($S = S_{max}$) ground state in molecular nanomagnets. Starting from the Heisenberg Hamiltonian, this method provides exact solutions of the transitions from the ground state into the $M = M_{max} - 1$ sector, which are observed in inelastic neutron scattering (INS) experiments at low temperatures. We provide the analytical results for the INS intensity for isotropic and Ising anisotropic cases in powder and single crystal samples. We find that the complete $\vec{Q}$-dependence of intensity can be expanded in terms of few geometrical basis functions. A key consequence is that one can determine the eigenvectors directly from INS data, without the necessity to solve the magnetic model.

MA 28.6 Wed 10:45 H52

Element specific determination of the magnetic properties of the macrocyclic tetranucluer 3d-4f complexes with Cu3Tb core by means of x-ray magnetic circular dichroism (XMCD) — •K. Kuepper[1], K. Balinski[1], L. Schneider[1], J. Wöllermann[1], A. Buling[1], L. Joly[2], C. Piamonteze[3], H.L.C. Feltham[4], S. Brooker[4], A.K. Powell[5], and B. Delley[3] — [1]Fachbereich Physik , Universität Osnabrück, Barbarastr. 7, Osnabrück D-49069, Germany — [2]Universite de Strasbourg, CNRS, IPCMS, UMR 7504, Strasbourg F-67000, France — [3]Paul Scherrer Institute, Villigen CH-5232, Switzerland — [4]Department of Chemistry and the MacDiarmid Institute, University of Otago, P.O. Box 56, Dunedin 9054, New Zealand — [5]Institut für Anorganische Chemie, Karlsruhe Institute of Technology, Engesserstrasse 15, Karlsruhe D-76131, Germany

Feltham et al. synthesized molecules with Cu3Tb core using organic macrocyclic ligands, i.e. the propylene macrocycle (nickname: Cu3Tb(LPr)), which exhibits slow relaxation of magnetization [1], as well as a larger, butylene linked, macrocycle (nickname: Cu3Tb(LBu)) [2]. We used element specific XMCD to study the magnetic properties of these two molecules in external magnetic fields up to B=13.5 T and at temperatures between T=3K and T=10K [3]. We perform a sum rule analysis abd record element specific magnetization loops indicating a low value for the 3d-4f coupling. [1] H.L.C. Feltham et al., Inorg. Chem. 50, 4232 (2011). [2] H.L.C. Feltham et al., Inorg. Chem. 52, 3236 (2013). [3] K. Balinski et al., PCCP 20, 21286 (2018).

MA 28.7 Wed 11:00 H52

Inelastic Neutron Scattering Studies on a Family of 3*d*-4*f* Heterometallic Mn_2Ln_2 Single-Molecule Magnets — •Julius Mutschler[1], Krunoslav Prša[1], Christopher E. Anson[2], Annie K. Powell[2], and Oliver Waldmann[1] — [1]Physikalisches Institut, Universität Freiburg, Germany — [2]Institut für anorganische Chemie, Universität Karlsruhe, KIT, Germany

The discovery of slow relaxation and quantum tunneling of the magnetization in the now so-called single molecule magnets (SMMs) two decades ago has inspired both physicists and chemists alike. This class of molecules has been expanded to heterometallic clusters incorporating transition metal and rare earth ions. The 4*f* ions were chosen because of their large angular momentum and magnetic anisotropy. Inelastic neutron scattering experiments were performed on the time-of-flight disk-chopper spectrometer IN6 at ILL on the SMM-series Mn_2Ln_2-squares with Ln=Y, Tb, Ho, Dy. Excellent data have been recorded, also for the Dy variety. The analysis of the data using a linked fit approach is presented.

MA 28.8 Wed 11:15 H52

Combining translational and spin-rotational symmetry in exact diagonalization of spin rings — •Tjark Heitmann[1] and Jürgen Schnack[2] — [1]Fachbereich für Physik, Universität Osnabrück, Barbarastr. 7, 49076 Osnabrück — [2]Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, 33615 Bielefeld

Exact diagonalization and other numerical studies of quantum spin systems are notoriously limited by the exponential growth of the Hilbert space dimension with system size. A common and well-known practice to reduce this increasing computational effort is to take advantage of the translational symmetry C_N in periodic systems. This represents a rather simple yet elegant application of the group theoretical symmetry projection operator technique. For isotropic exchange interactions, the spin-rotational symmetry $SU(2)$ can be used, where the Hamiltonian matrix is block-structured according to the total spin and magnetization quantum numbers. Rewriting the Heisenberg Hamiltonian in terms of irreducible tensor operators allows for an efficient and highly parallelizable implementation to calculate its matrix elements recursively in the spin-coupling basis. When combining both C_N and $SU(2)$, mathematically, the symmetry projection technique leads to ready-to-use formulas. However, the evaluation of these formulas is very demanding in both computation time and memory consumption – problems which are said to outweigh the benefits of the symmetry reduced matrix shape. We show a way to minimize the computational effort for selected systems and present the largest numerically accessible cases.

MA 29: Quantum information systems

Time: Wednesday 9:30–10:30 Location: H53

MA 29.1 Wed 9:30 H53

Demonstration of coherent Light-Matter-Spin Interaction — •Marco Pfirrmann[1], Alexey V. Ustinov[1,2], and Martin Weides[1,3] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]National University of Science and Technology MISIS, Moscow, Russia — [3]University of Glasgow, Glasgow, UK

Cavity-magnon-polaritons, hybrid light-spin quasiparticles, are of considerable interest to implement quantum transducers and memories. Formed by two coupled harmonic subsystems, their level structure is harmonic as well. The addition of a non-linearity would increase their functionalities significantly, e.g. by adding an anharmonic component. We demonstrate such a tripartite quantum hybrid system consisting of cavity photons, qubit transitions and spin excitations. A 3D microwave cavity couples strongly to both a superconducting transmon qubit and a ferrimagnetic YIG sphere. Nearly degenerated qubit and cavity frequencies provide dressed states with a level splitting in excess of 100 MHz. The magnon is tuned into and through resonance by an external magnetic field, with an observed coupling larger than 15 MHz. Spectroscopic and time-resolved data of the collective system are demonstrated.

MA 29.2 Wed 9:45 H53

Spin dynamics of Ho single atom magnets — F. Donati[1,2], S. Rusponi[2], L. Persichetti[3], S. Stepanow[3], •A. Singha[1,2], R. Baltic[2], C. Wäckerlin[2], M. Pivetta[1], C. Nistor[3], J. Dreiser[4], K. Kummer[5], E. V.-Fort[5], D. Juraschek[3], N. Spaldin[3], H. Brune[2], and P. Gambardella[3] — [1]IBS Center for Quantum Nanoscience, South Korea — [2]EPFL, Switzerland — [3]ETH Zurich, Switzerland — [4]PSI, Switzerland — [5]ESRF, France

Single atom magnets represent the smallest unit of matter that can be used to store and manipulate information. The strongly localized 4f electrons in rare earth atoms allow only weak interaction with the environment, leading to long magnetic lifetimes as recently discovered for single Ho atoms adsorbed on MgO/Ag(100) [Science 352, 318 (2016)]. Reading and writing their magnetic states at the atomic scale further demonstrated the potential of these atoms as magnetic bits up to 45 K [PRL 121, 027201 (2018)]. Here we investigate the spin reversal mechanism of the Ho atoms by exploring the effects of temperature and external magnetic field on the magnetic lifetime using x-ray magnetic circular dichroism. At 0.01 T, the lifetime of Ho atoms is 1500 s up to 10 K and decreases with temperature following an exponential Arrhenius law with an effective barrier of 4 ± 0.5 meV. However, spin reversal is suppressed in a strong magnetic field of 6.8 T, and the magnetic lifetime remains constant at about 1200 s up to 30 K. Our results suggest that the Ho atoms can mainly exchange energy and angular momentum with the surface via localized vibrational modes of quantized energy, which limits the effectiveness of spin reversal mechanisms.

MA 29.3 Wed 10:00 H53

Investigation of intrinsic decoherence in different closed quantum spin systems — •Patrick Vorndamme and Jürgen Schnack — Universität Bielefeld, PF 100131, D-33501 Bielefeld

Not only in spintronic devices, but also as constituents of quantum simulators or quantum computers, magnetic molecules have many potential applications. At low temperatures the magnetic levels of molecular nanomagnets enable the use as qubits. For such an application the investigation and understanding of decoherence caused by external and internal effects is very important. For now, we work with a pure spin Hamiltonian which contains both, the qubits of interest and bath spins. Both together form our closed system of which we perform time evolutions numerically. We interpret decoherence as entanglement of the qubits with the bath spins, resulting in a mixed reduced density matrix of the qubits. With our spin Hamiltonian we can treat isotropic exchange couplings and anisotropic effects, such as dipolar interactions and easy magnetization axes caused by spin orbit coupling. Our goal is to find qubit states that are insensitive to decoherence. For this purpose we examine clock transitions as well as the stability of ground states with nonzero toroidal moment and zero magnetic moment in different spin constructs, such as spin-frustrated triangular nanomagnets (like Cu_3) with strong antiferromagnetic coupling and weak spin orbit coupling. In fact, there are several ways to realize toroidal moments with both a strong spin orbit coupling and a weak one. In a quantum computer such moments could be conveniently manipulated with a spin-polarized current.

MA 29.4 Wed 10:15 H53

Edge mode locality of symmetry protected topologically ordered spin chains under perturbations — •Marcel Goihl, Christian Krumnow, Marek Gluza, Jens Eisert, and Nicolas Tarantino — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

Spin chains with a symmetry-protected ground state degeneracy are the prototypical systems for exploring topological effects in quantum systems. Recently, various methods of classifying topological order were established and particular representatives, known as fixed-point models, of different classes were constructed. Motivated by on-going experimental developments towards realizing such systems by way of quantum simulation and material engineering, we study how localized edge modes in these systems are deformed by local interactions and disorder. By designing numerical methods for constructing locally conserved operators, we find that interactions of all kinds delocalize the edge modes. The sensitivity of the edge mode operators to disorder is dependent not only on the disorder strength but also the choice and strength of the interaction as well as the edge mode operator being studied. In the many-body interacting regime, we find that one edge mode operator behaves as if subjected to a non-interacting perturbation. This implies that in finite systems edge mode operators effectively delocalize at distinct interaction strengths.

MA 30: Magnetic instrumentation and characterization

Time: Wednesday 10:45–11:45 Location: H53

MA 30.1 Wed 10:45 H53

Bambus: a new inelastic neutron multiplexed analyzer for Panda at MLZ — •A. Bertin[1], P. Cermák[2], J. A. Lim[1], I. Radelytskyi[2], A. Schneidewind[2], and D. S. Inosov[1] — [1]Institut für Festörperphysik, TU Dresden, Dresden, DE — [2]Forschungszentrum Jülich GmbH, Outstation at MLZ, Garching,DE

Cold-neutron triple-axis spectrometers (TAS) are dedicated to the investigation of low-energy excitations in a wide area of condensed matter physics, from quantum magnetism to unconventional superconductors. This technique allows us to measure individual points in the large $(\mathbf{Q}, E)$ space for one instrument setting, in particular at very low temperatures and high magnetic fields. New engineering solutions were recently developed in order to increase the useful signal on TAS. With this purpose, the multianalyser Bambus is being constructed at the cold-neutron triple-axis spectrometer Panda at MLZ, in cooperation with TU Dresden, and financial support from the BMBF project 05K16OD2. Its concept lies in collecting data at a certain energy transfers along a curved path in $\mathbf{Q}$ space, with the aim to construct broad reciprocal space maps at multiple energy transfers in a reliable, easy-to-use setup without movable axes. Hence, experiments will provide an overview in a large $(\mathbf{Q}, E)$ space, in order to get insights of broad features at low energy or study complex dispersion laws. Because this spectrometer is designed as a complementary option to the normal TAS mode, a fast switch between the two setups is foreseen. The general concept will be presented together with the final design, the different key components, and the results obtained with two prototypes.

MA 30.2 Wed 11:00 H53

SQUID Setup for the Measurement of Antiferromagnets and other Magnetically Weak Samples — Michael Paulsen[1], Jörn Beyer[1], Michael Fechner[2], Klaus Kiefer[3], •Bastian Klemke[3], and Dennis Meier[4] — [1]Physikalisch-Technische Bundesanstalt, Berlin, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, CFEL, Hamburg, Germany — [3]Helmholtz-Zentrum Berlin, Berlin, Germany — [4]Norwegian University of Science and Technology, Trondheim, Norway

Antiferromagnets have been studied for several decades in fundamental research and, more recently, as materials of interest in spintronic devices. While these materials typically possess zero net magnetization, predictions of a permanent magnetization of higher order have been made but very few confirmed measurements exist. In this presentation, the development of a SQUID setup for the measurement of antiferromagnets and other weakly magnetic samples is presented. The initial measurements demonstrate that the setup is especially well suited for measuring weak quadrupolar magnetic fields in magnetically shielded rooms.

MA 30.3 Wed 11:15 H53

Quantitative measurements of magnetic states in patterned permalloy disks using off-axis electron holography and model-based reconstruction of magnetisation — •Teresa Wessels[1], Simone Finizio[2], Patrick Diehle[1], Jan Caron[1], Andras Kovacs[1], Vadim Migunov[1,3], Jörg Raabe[2], and Rafal Dunin-Borkowski[1] — [1]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Swiss Light Source, Paul Scherrer Institute, 5232 Villigen, Switzerland — [3]Central Facility for Electron Microscopy (GFE) RWTH Aachen University, 52074 Aachen, Germany

The ability to image magnetic states in sub-micron-sized structures is of increasing importance for new emerging technologies. Here, we investigate intrinsic magnetisation states in permalloy disks using off-axis electron holography in an aberration transmission electron microscope. The disks were deposited onto electron-transparent SiN windows with diameters of 750 to 1500 nm and thicknesses of 50 to 200 nm. Magnetic induction maps were determined from the recorded off-axis electron holograms and used to show that the disks contained magnetic vortices at remanence. The projected in-plane magnetisation in each disk was reconstructed quantitatively using a model-based iterative reconstruction algorithm. A cross-sectional analysis of the disks revealed that they had slightly distorted bowl-like shapes. The relationship between the disk shapes and the three-dimensional nature of the resulting magnetic states will be discussed.

MA 30.4 Wed 11:30 H53

Bringing Neutrons to the User - The Jülich HBS Project for accelerator based neutron sources — •Thomas Gutberlet[1], Ulrich Rücker[1], Paul Zakalek[1], Eric Mauerhofer[1], Tobias Cronert[1], Johannes Baggemann[1], Paul Doege[1], Marius Rimmler[1,3], Sarah Böhm[2], Jingjing Li[1,4], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH, JCNS, Germany — [2]RWTH Aachen, Germany — [3]Forschungszentrum Jülich GmbH, IKP-4, Germany — [4]Forschungszentrum Jülich GmbH, IEK-6, Germany

Neutron scattering has proven to be one of the most powerful methods for studying structure and dynamics of condensed matter on atomic length and time scales. In particular, neutrons are an essential tool to study and understand magnetic phenomena. Accelerator driven neutron sources with high brilliance neutron provision are an attractive option to provide scientist with neutrons for their research. The Jülich Centre for Neutron Science is developing a compact accelerator driven pulsed neutron source to offer access to science and industry to neutrons as medium-flux, but high-brilliance neutron facility. The "High-Brilliance Neutron Source (HBS)" will consist of a high current proton accelerator, compact neutron production and moderator system and optimized neutron transport system for thermal and cold neutrons. The project will allow construction of a scalable neutron source ranging from a university based neutron laboratory to a full user facility with open access and service. We will describe the currents status of the project, the next steps, milestones and the vision for the future use of neutrons at universities and research institutes.

MA 31: Spin dynamics: Magnetic relaxation and Gilbert damping

Time: Wednesday 11:45–12:45 Location: H52

MA 31.1 Wed 11:45 H52

Gilbert damping phenomenology for two-sublattice magnets — •Akashdeep Kamra[1], Roberto Troncoso[1], Wolfgang Belzig[2], and Arne Brataas[1] — [1]Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway — [2]Department of Physics, University of Konstanz, Konstanz, Germany

We present a systematic phenomenological description of Gilbert damping in two-sublattice magnets. Our theory covers the full range of materials from ferro- via ferri- to antiferromagnets. Following a Rayleigh dissipation functional approach within a Lagrangian classical field formulation, the theory captures intra- as well as cross-sublattice terms in the Gilbert damping, parameterized by a 2×2 matrix. When spin-pumping into an adjacent conductor causes dissipation, we obtain the corresponding Gilbert damping matrix in terms of the interfacial spin-mixing conductances. Our model reproduces the experimentally observed enhancement of the ferromagnetic resonance linewidth in a ferrimagnet close to its compensation temperature without requiring an increased Gilbert parameter. It also predicts new contributions to damping in an antiferromagnet and suggests the resonance linewidths as a direct probe of the sublattice asymmetry, which may stem from boundary or bulk.

Reference: Phys. Rev. B 98, 184402 (2018).

MA 31.2 Wed 12:00 H52

Two-magnon scattering contribution to damping and its impact in the determination of the spin mixing conductance — •Andres Conca, Sascha Keller, Matthias R. Schweizer, Evangelos Papaioannou, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Uni-

versität Kaiserslautern, 67663 Kaiserslautern, Germany

We present angle dependent measurements of the damping properties of epitaxial Fe layers with MgO, Al and Pt capping layers. Based on the preferential distribution of lattice defects following the crystal symmetry, we make use of a model of the defect density to separate the contribution of two-magnon scattering to the damping from the isotropic contribution originating in the spin pumping effect, the viscous Gilbert damping and the magnetic proximity effect. Without the contribution of the two-magnon scattering, which depends strongly on the chosen capping layer and defect density, a value of the effective spin mixing conductance $g_{\text{eff}}^{\uparrow\downarrow}$ is obtained which is closer to the $g^{\uparrow\downarrow}$ associated with spin pumping only. The influence of the defect density for bilayers systems due to the different capping layers and to the unavoidable spread in defect density from sample to sample is thus removed. This shows the potential of studying spin pumping phenomena in fully ordered systems in which this separation is possible, contrary to polycrystalline or amorphous metallic thin films.

Financial support by M-era.Net through the HEUMEM project and by the Carl Zeiss Stiftung is gratefully acknowledged.

MA 31.3 Wed 12:15 H52

Magnetization and energy relaxation in the 1D XXZ Heisenberg model — •Xenophon Zotos[1,2] and Alexandros Pavlis[1] — [1]Physics Department, University of Crete, Greece — [2]Leibnitz/IFW Dresden, Germany

We study spin and energy relaxation by the recently proposed Generalized Hydrodynamics approach (GHD) in the linear response regime. We derive a further formulation of the corresponding Drude weights from the finite wave-vector relaxation. Furthermore we analyze the dynamic structure factors in the low temperature regime and compare them to existing results in the literature.

MA 31.4 Wed 12:30 H52

In-situ study of Fe on GaAs (100) and GaAs (110) — •Babli Bhagat, Ralf Meckenstock, and Michael Farle — Center for Nanointegration (CENIDE) and Faculty of Physics, University of Duisburg Essen, Lotharstr. 1, 47057, Duisburg, Germany

Fe films have been intensively studied but there are still some unanswered questions associated to it. We are interested in studying the spin pumping effect in Fe based heterostructures. For that we investigated the growth and stability of 4nm Fe film on GaAs (100) and (110) substrate under ultra high vacuum (UHV) conditions. We have compared the surface reconstruction of Fe film on both substrate orientations in terms of structural and magnetic properties. The films were grown with electron beam evaporation and measured by in-situ Ferromagnetic Resonance (FMR), Low Energy Electron Diffraction (LEED) and Auger Electron Spectroscopy (AES) techniques as a function of time at room temperature. The FMR measurement show island growth in case of Fe\GaAs(110) substrate, which gives two resonance lines with time while on GaAs(100) it formed a flat surface giving a single resonance line with time. The surface roughness was also confirmed by ex-situ Atomic Force Microscopy (AFM) measurements. Thus (100) system has a better surface and interface to study the spin pumping effect in such heterostructures. Further we also did the LEED and AES measurement of Fe\GaAs(100) with time which shows that up-to 8-10 hours the film quality is maintained under the UHV conditions.

MA 32: Magnetic recording, sensors and other devices

Time: Wednesday 12:00–13:00 Location: H53

MA 32.1 Wed 12:00 H53

Properties of Magnetoresistive Sensors in Vortex-Configuration — •Christoph Durner[1,2], Wolfgang Raberg[1], Klemens Pruegl[1], and Jonathan Finley[2] — [1]Infineon Technologies AG, 85579 Neubiberg, Germany — [2]Walter Schottky Institute, E24, Technical University of Munich, 85748 Garching, Germany

Many automotive applications, such as wheel speed, require magnetic sensors with negligible small hysteresis and a wide linear operating range. All these requirements can be met using a Tunneling Magnetoresistance (TMR) spin-valve sensor with the free layer (FL) in the vortex (V) state. The V state is characterized by a closed rotationally symmetric magnetization with a centered z-component, the V core. Usually, the FL exhibits a disk-like shape to enable a V-like magnetization. In reality the FL cannot be processed perfectly cylindrical. The shape alteration leads to a variation of the V behavior upon external magnetic fields and therefore, in a modified electrical signal. Micromagnetic simulation were used to successfully match the magnetization of the FL to the observed electric behavior under the influence of an external magnetic field in dependence of differences in FL structuring. Another focus of the investigations was the improvement of the TMR stack, in particular the layers responsible for the tunneling process, namely free layer, tunnel barrier, and reference layer (RL) system. By optimizing the ferromagnetic material composition and thicknesses of the FL and RL significant improvement of the TMR ratio by a factor of two as well as an improved stability of the entire system with respect to high temperature annealing was achieved.

MA 32.2 Wed 12:15 H53

Mechanically controlled magnetization reversal in single-domain particles — •Thomas Mühl, Stefan Philippi, Heike Schlörb, Dipankar Mukherjee, and Bernd Büchner — IFW Dresden, Dresden, Germany

Magnetization reversal of small ferromagnetic particles requires to overcome an energy barrier which is mainly defined by the magnetic anisotropy. Usual reversal stimuli include the application of static or time-dependent external magnetic fields, thermal activation, spin transfer torque, or combinations thereof. Here, we report on quasi-periodic magnetization reversal in single-domain particles that are exposed to a constant magnetic field perpendicular to the magnet's easy axis. The continuous sequence of reversals is induced by torsional oscillations of the magnet's anisotropy landscape, which are caused by angular oscillations of the magnet's body. In our experiments, a nickel nanowire constitutes both a mechanical resonator and a nanomagnetic sample with uniaxial anisotropy. We measure the transient flexural vibration behavior by electron beam based methods and find strong signatures of periodic magnetization switching between two magnetic states of the nanowire. Furthermore, we extend our approach towards mechanically-controlled single reversals of magnetization that are induced by pulsed mechanical excitation. The latter might be the foundation for a novel ansatz for energy-efficient magnetic data storage.

Ref.: S. Philippi, H. Schlörb, D. Mukherjee, B. Büchner, T. Mühl, Nanotechnology 29, 405503 (2018).

MA 32.3 Wed 12:30 H53

Nano Hall Sensors for Scanning Magnetic Field Microscopy — •Manuela Gerken[1], Davood Momeni Pakdehi[1], Thomas Weimann[1], André Müller[1], Aurélie Solignac[2], Andrin Doll[2], Klaus Pierz[1], Frank Hohls[1], Sibylle Sievers[1], and Hans Werner Schumacher[1] — [1]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [2]SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif sur Yvette Cedex, France

Within the overall miniaturization, also magnetic devices are being scaled down into the micro- and nanometer range. This leads to an increasing demand for high-resolution quantitative metrology to measure the resulting inhomogeneous device stray fields. One promising approach is scanning magnetic field microscopy using nanoscale Hall sensors. Here, we will present our results on the development of gold and graphene Hall sensors with active areas down to 50 nm x 50 nm.

The sensors were fabricated using combinations of electron beam lithography, lift-off process and etching of epitaxially grown graphene. To investigate sensor sensitivity as well as stability they were characterized in homogeneous magnetic fields up to 250 mT. For the sensor calibration we will give an estimation of the uncertainty budget. Finally, we will present a concept how to fabricate gold Hall sensors on cantilevers to integrate them into a metrological AFM for quantitative and high precision scanning Hall magnetometry.

MA 32.4 Wed 12:45 H53

Improvement of band matching by monolayer Ni insertion at the $Co_2FeGa_{0.5}Ge_{0.5}$/Ag interfaces in current-perpendicular-to-plane pseudo spin valves — •Björn Büker[1,2], Jin Won Jung[2], Yuya Sakuraba[2], Yoshio Miura[2], Taisuke Sasaki[2], Andreas Hütten[1], and Kazuhiro Hono[2] — [1]Bielefeld University, Bielefeld, Germany — [2]NIMS, Tsukuba, Japan

All-metallic current-perpendicular-to-plane giant magnetoresistive devices (CPP-GMR) using half-metallic Heusler alloys have gathered a lot of interest lately, e.g. as next generation read heads for high density hard drives. For further enhancement of the MR ratio, interfacial spin-dependent scattering, which is directly related to the electronic band matching of the Heusler and the non-magnetic spacer, is an important factor for optimization. Recently Jung et al. have demonstrated a large enhancement of the MR ratio to more than 80% in $Co_2FeGa_{0.5}Ge_{0.5}$ /Ag/ $Co_2FeGa_{0.5}Ge_{0.5}$ (CFGG) structures by inserting thin layers of NiAl at the CFGG/Ag interface, even though Al showed undesired interdiffusion. Therefore, we have performed a systematic study on thin layers of pure Ni at the CFGG/Ag interface, in order to investigate the mechanism of the enhanced magnetoresistance caused by the inserted layer.
The pseudo spin valve (PSV) films were prepared on a MgO(001) substrate. The MR ratio increased significantly from 27% for $t_{Ni}=0$ nm to 44% for $t_{Ni}=0.21$ nm. HRTEM images of the interface along with atomic resolution EDS elemental mappings confirm a Ni monolayer at the interface.

MA 33: Focus Session: Topology in 3D Reciprocal Space: Beyond Dirac and Weyl Quasiparticles (joint session TT/MA)

Topological Dirac and Weyl semimetals are currently in focus of condensed-matter research. The ultra-relativistic electrons in these systems manifest themselves in experimental probes in many very unusual ways, such as chiral currents, hydrodynamic electron flows, and chiral optical response. Theory and experiment go further and offer even more exotic topological phases, which have no analogies in high-energy physics. Among the recent discoveries are Lorentz-invariance breaking quasiparticles, multi-Weyl semimetals, and topological phases in non-electronic systems.

Organized by: Artem Pronin (Universität Stuttgart), Claudia Felser (MPI-CPfS Dresden), Martin Dressel (Universität Stuttgart)

Time: Wednesday 15:00–18:15 Location: H2

Invited Talk MA 33.1 Wed 15:00 H2
Novel optical and electrical responses in topological semimetals — •Joel Moore — University of California, Berkeley, USA — Lawrence Berkeley National Laboratory, Berkeley, USA

Several new classes of topological materials have been confirmed to exist in experiments over the past decade. Many of these materials support unique electromagnetic properties that affect transport and optical responses in potentially useful ways. For example, topological insulators support a particular electromagnetic coupling known as "axion electrodynamics", and understanding this leads to an improved understanding of magnetoelectricity in all materials. The main focus of this talk is on how topological Weyl and Dirac semimetals can show unique electromagnetic responses; we argue that in linear response the main observable property solves an old problem about optical rotation via the orbital moment of Bloch electrons. Nonlinear responses such as magnetoconductivity can reveal more surprising behavior. Nonlinear optical response (second-harmonic generation) is already known to be remarkably strong in existing Weyl materials, and may show an unexpected strength and quantization in Weyl materials without mirror symmetries.

Talk includes results obtained with Fernando de Juan, Adolfo Grushin, Takahiro Morimoto, Joseph Orenstein, Daniel Parker, Ivo Souza, and Shudan Zhong.

Invited Talk MA 33.2 Wed 15:30 H2
Beyond the elementary particles and the 10-fold classification of non-interacting topological phases — •Alexey Soluyanov — Physics Institute, University of Zurich, Zurich, Switzerland

One of the research directions in string theory is the separation of important theoretical problems into distinct classes based on their similarities. Electronic structure problem is usually not considered to be important in the string theory community. In this talk I will show that the electronic structure theory in fact allows not only for theoretical analysis of problems in quantum field theory and general relativity, but also for their cheap (on the LHC scale) experimental tests, and also provides many hints to other problems in physics, often considered to be of bigger importance than the study of material properties. In particular, I will show that even weakly-interacting crystalline materials realize a collection of topologically-protected quasiparticle excitations that can either be direct analogs of relativistic elementary particles, or due to the absence of Lorentz-symmetry constraint realize completely novel quasiparticles not present in the high-energy standard model. Materials that host such quasiparticles exhibit special transport properties. I will give a detailed description of several families of such materials. Finally, I will show that even the simplest elemental compounds hide physical phenomena that provide very accessible analogies to complicated theoretical physics theories, and illustrate that the current understanding of even the simplest non-correlated crystalline materials is far from complete.

Invited Talk MA 33.3 Wed 16:00 H2
Direct optical detection of Weyl fermion chirality in a topological semimetal — •Nuh Gedik — Department of Physics, Massachusetts Institute of Technology, Cambridge, MA USA

A Weyl semimetal is a novel topological phase of matter, in which Weyl fermions arise as pseudo-magnetic monopoles in its momentum space. The chirality of the Weyl fermions, given by the sign of the monopole charge, is central to the Weyl physics, since it serves as the sign of the topological number and gives rise to exotic properties such as Fermi arcs and the chiral anomaly. In this talk, I will present our recent measurements in which we directly detect the chirality of the Weyl fermions by measuring the photocurrent in response to circularly polarized mid-infrared light. The resulting photocurrent is determined by both the chirality of Weyl fermions and that of the photons. Beyond Weyl semimetals, these experiments establish nonlinear photocurrent spectroscopy as a powerful tool for studying the geometrical properties of the electronic wavefunction in quantum materials. To this end, I will also discuss how we used this method to reveal electrically switchable Berry curvature dipole in the monolayer topological insulator WTe2.

15 min. break.

Invited Talk MA 33.4 Wed 16:45 H2
Evidence for an axionic charge density wave in the Weyl semimetal $(TaSe_4)_2I$ — •Johannes Gooth — Max Planck Institut für Chemische Physik fester Stoffe

An axion insulator is a correlated topological phase, predicted to arise from the formation of a charge density wave in Weyl semimetals. The accompanying sliding mode in the charge density wave phase, the phason, is an axion. It is expected to cause anomalous magneto-electric transport effects. However, this axionic charge density wave has so far eluded experimental detection. In this paper, we report for the first time the observation of a large, positive contribution to the magneto-conductance in the sliding mode of the charge density wave Weyl semimetal $(TaSe_4)_2I$ for collinear electric and magnetic fields (E||B). The positive contribution to the magneto-conductance originates from the anomalous axionic contribution of the chiral anomaly to the phason current, and is locked to the parallel alignment of E and B. By rotating B, we show that the angular dependence of the magneto-conductance is consistent with the anomalous transport of an axionic charge density wave.

Invited Talk MA 33.5 Wed 17:15 H2

Investigations of Dirac/Weyl semimetals under external stimuli — •Ece Uykur — 1. Physikalisches Institut, Universität Stuttgart, Stuttgart, Germany

Dirac/Weyl semimetals acquire 3D linearly dispersive electronic bands, as opposed to the parabolic bands, with band crossings near the Fermi energy, where the low energy excitations are described by the relativistic Weyl or Dirac equations. Optical spectroscopy is one of the strongest methods to probe these low energy responses. Moreover, it can be coupled to an external tuning mechanism such as magnetic fields, pressure, etc. Additional tuning parameters can be used to create a Dirac/Weyl state and/or to provide valuable information about the nature of the observed topological state. A peculiar magnetic field dependence of the Landau-level transitions, for instance, would hint the existence of the massless Dirac/Weyl fermions in the studied system. In this talk, I will summarize our efforts on different Weyl/Dirac semimetals and their optical responses under an external tuning parameter.

MA 33.6 Wed 17:45 H2

Optical conductivity studies of topological nodal semimetals — •Artem V. Pronin[1], David Neubauer[1], Micha B. Schilling[1], Felix Hütt[1], Martin Dressel[1], Alexander Yaresko[2], Leslie M. Schoop[3], Chandra Shekhar[4], and Claudia Felser[4] — [1]1. Physikalisches Institut, Universität, Stuttgart, 70569 Stuttgart, Germany — [2]MPI für Festkörperforschung, 70569 Stuttgart, Germany — [3]Princeton University, Princeton, NJ 08544, USA — [4]MPI für Chemische Physik fester Stoffe, 01187 Dresden, Germany

We have studied a large number of different topological nodal semimetals (TNSMs) by means of optical spectroscopy [1]. Theory predicts that the optical conductivity of TNSMs is not only distinct from the response of "ordinary" semiconductors and metals, but also very sensitive to the TNSM's band structure and band dimensionality [2]. In real TNSMs, free-electron absorption and contributions from topologically trivial parabolic bands are essential. Both effects may mask the predicted behavior. Some of the studied materials are indeed affected by the aforementioned effects quite substantially. In the others, the low-energy optical response, related to the linear electronic bands, is clearly observed. In the course of the presentation, optical conductivity of the studied TNSMs will be discussed alongside the theory predictions.

[1] PRB **93**, 121202 (2016); PRL **119**, 187401 (2017); PRL **121**, 176601 (2018); PRB **98**, 195203 (2018); JPCM **30**, 485403 (2018).
[2] PRL **108**, 046602 (2012).

MA 33.7 Wed 18:00 H2

Thin-film investigations of 3D Dirac fermions in antiperovskite compounds — •Dennis Huang[1], Hiroyuki Nakamura[1], Eslam Khalaf[1,2], Pavel Ostrovsky[1,3], Kathrin Müller[1], Ulrich Starke[1], Alexander Yaresko[1], and Hidenori Takagi[1,4,5] — [1]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany — [2]Department of Physics, Harvard University, Cambridge MA 02138, USA — [3]L. D. Landau Institute for Theoretical Physics RAS, 119334 Moscow, Russia — [4]Department of Physics, University of Tokyo, 113-0033 Tokyo, Japan — [5]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, 70569 Stuttgart, Germany

Topological semimetals hosting Dirac or Weyl fermions lie at the forefront of research in condensed matter physics. Recently, a class of antiperovskite compounds (A_3BO: A = Ca, Sr, Ba; B = Sn, Pb) have been predicted to possess both massive 3D Dirac fermions and topological surface states protected by crystal symmetry. Using molecular beam epitaxy, we grow thin films of the antiperovskite compounds Sr_3PbO and Sr_3SnO. We report ongoing efforts to elucidate the exotic electronic properties of these compounds using transport and spectroscopic probes.

MA 34: Magnetic textures: Transport and dynamics II

Time: Wednesday 15:00–19:00 Location: H37

Invited Talk MA 34.1 Wed 15:00 H37

Reservoir Computing with Random Skyrmion Fabrics — •Daniele Pinna[1], George Bourianoff[2], and Karin Everschor-Sitte[1] — [1]Johannes Gutenberg Universität Mainz Institute of Physics TWIST Group Staudingerweg 7 D 55128 Mainz — [2]Intel Corp., retired

In this talk we will discuss how a random skyrmion "fabric" composed of skyrmion clusters embedded in a magnetic substrate can be effectively employed to implement a functional Reservoir Computing device for recognizing and predicting spatio-temporal events. This is achieved by leveraging the nonlinear resistive response of the individual skyrmions arising from their current dependent anisotropic magnetoresistance effect (AMR). Complex time-varying current signals injected via contacts into the magnetic substrate are shown to be modulated nonlinearly by the fabric's AMR due to the current distribution following paths of least resistance as it traverses the geometry. By tracking resistances across multiple input and output contacts, we show how the instantaneous current distribution effectively carries temporally correlated information about the injected signal. This in turn allows us to numerically demonstrate simple pattern recognition. We argue that the fundamental ingredients for such a device to work are threefold: i) Concurrent probing of the magnetic state; ii) stable ground state when forcings are removed; iii) nonlinear response to input forcing. Whereas we demonstrate this by employing skyrmion fabrics, the basic ingredients should be general enough to spur the interest of the greater magnetism and magnetic materials community to explore novel reservoir computing systems.

MA 34.2 Wed 15:30 H37

Insight into enhanced stability of nanoscale magnetic skyrmions — •Anastasiya S. Varentsova[1], Stephan von Malottki[3], Grzegorz Kwiatkowski[2], Stefan Heinze[3], and Pavel F. Bessarab[1,2] — [1]ITMO University, St. Petersburg, Russia — [2]University of Iceland, Reykjavík, Iceland — [3]University of Kiel, Kiel, Germany

Experimental data [1,2] demonstrates that nanoscale magnetic skyrmions are only stable at low temperature, but room temperature stability is required for future applications. Here it is demonstrated by means of transition state theory [3] and atomistic spin Hamiltonian that the stability of nanoscale skyrmions can be enhanced to the desired level by a concerted adjustment of material parameters preserving the skyrmion size [4]. Both increase in the energy barrier and the entropy barrier for the skyrmion collapse contribute to the stabilization, but it is the entropic effect that plays a dominant role, leading to the variation of skyrmion lifetime by more than ten orders of magnitude within the chosen parameter range. The pronounced enhancement of the entropy barrier is explained in terms of magnon-skyrmion bound states.

[1] N. Romming *et al.*, Phys. Rev. Lett. **114,** 177203 (2015).
[2] K. Litzius *et al.*, Nat. Phys., **13**. 170–175, (2017).
[3] P.F. Bessarab *et al.*, Sci. Rep., **8**, 3433, (2018).
[4] A.S. Varentsova *et al.*, Nanosyst.:Phys.Chem.Math., **9**, 356, (2018).

MA 34.3 Wed 15:45 H37

Approaching the Skyrmion shift register — •Christian Denker[1], Sören Nielsen[2], Malte Römer-Stumm[2], Nina Meyer[1], Neha Jha[1], Enno Lage[2], Markus Münzenberg[1], and Jeffrey McCord[2] — [1]Institut für Physik, Universität Greifswald, Germany — [2]Nanoscale Magnetic Materials - Magnetic Domains, Institute for Materials Science, Universität Kiel, Germany

The experimental realization of Skyrmion race track memories or shift registers requires a material system able to host Skyrmions with reasonable lifetime and allowing control of skyrmion motion and pinning, preferably by electric currents or fields. Ta/CoFeB/MgO fulfills these requirements and shows the highest reported TMR ratios for magnetic tunnel junctions (MTJ) and is, therefore, an ideal candidate for all electrical generation and detection by MTJs which is desirable but to our knowledge still lacking. We will show our results on current induced Skyrmion motion in Ta/CoFeB/MgO trilayers, as well as our experiments on Skyrmions in MTJ layer stacks.

MA 34.4 Wed 16:00 H37

Impact of transition metals clusters on the stability and dy-

namics of skyrmions — Jonathan Chico, •Imara Lima Fernandes, I Gede Arjana, Stefan Blügel, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, D-52425 Jülich, Germany

Magnetic skyrmions are prime candidates for future spintronic devices. However, incorporating them as possible information carriers hinges on their interaction with inhomogenities present in any device. Recently, it was shown that $3d$ and $4d$ single-atomic defects can either repel or pin skyrmions [1]. Using first-principles calculations in conjunction with atomistic spin dynamics, we investigate the complex motion of technologically relevant small skyrmions in Pd/Fe/Ir(111) with $3d$ and $4d$ transition metal single-atomic defects and clusters. The obtained dynamical behaviour is richer and goes beyond the expected from the Thiele equation. This allows us to study the impact of different types of defects on the skyrmions dynamics and the complexity of different motion regimes is revealed and compared with what is known for larger skyrmions. The present study may give guidance on how such defects can be used to engineer tracks for controlled skyrmion motion which is of great importance for the design of future spintronic devices. – Funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator grant 681405 - DYNASORE).

[1] I. Lima Fernandes. et al., Nat. Commun. **9**, 4395 (2018).

MA 34.5 Wed 16:15 H37

Dynamics in confined skyrmion ensembles on different time scales — •Alexander F. Schäffer[1], Levente Rózsa[2], Jamal Berakdar[1], and Elena Y. Vedmedenko[2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany — [2]Institut für Nanostruktur- und Festkörperphysik, Universität Hamburg, D-20355 Hamburg, Germany

In this study, ensembles of magnetic skyrmions on confined geometries are shown to exhibit characteristic temperature driven motion on two different time-scales. The intrinsic fluctuating dynamics ($t \sim 1$ ns) is governed by short-ranged symmetric and antisymmetric exchange interaction, whereas the long-time limit ($t \gtrsim 10$ ns) is determined by the coaction of skyrmion-skyrmion-repulsion and the system's geometry.

Full micromagnetic simulations along with quasiparticle model Monte Carlo calculations for realistic island shapes and sizes are performed and analyzed, indicating the special importance of skyrmion dynamics at finite temperatures including skyrmion-skyrmion and skyrmion-boundary repulsion effects.

Our results highlight the conflict between skyrmion-mobility and finite observation times, directly affecting the addressability of skyrmionic bits, which is a key challenge on the path of developing skyrmion-based room-temperature applications.

The presented quasiparticle Monte Carlo approach bears great potential for a computationally effective description of the diffusive motion of skyrmion ensembles on finite geometries like racetrack memory setups.

MA 34.6 Wed 16:30 H37

Skyrmions for non-conventional computing — •Klaus Raab[1], Nico Kerber[1,4], Jakub Zázvorka[1], Florian Jakobs[2], Daniel Heinze[1], Niklas Keil[1], Sascha Kromin[1], Samridh Jaiswal[1,3], Kai Litzius[1,4], Gerhard Jakob[1], Peter Virnau[1], Daniele Pinna[1], Karin Everschor-Sitte[1], Andreas Donges[2], Ulrich Novak[2], and Mathias Kläui[1,4] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, DE-55099 Mainz, Germany — [2]Fachbereich Physik, Universität Konstanz, Universitätsstraße 10, DE-78457 Konstanz, Germany — [3]Singulus Technologies AG, DE-63796 Kahl, Germany — [4]Graduate School of Excellence Materials Science in Mainz, DE-55128 Mainz, Germany

In cascading logic gates for probabilistic computing [1], undesired correlations can occur that thus impede the functionality as a logic device. To decorrelate an information stream, a reshuffler device based on skyrmoins has been proposed [1], that we realize using skyrmions in a multilayer stack [2-3] : In a Ta-based material we are able to not only stabilize and controllably nucleate the skyrmions, but also displace them by current injection due to spin-orbit torques [4]. To eliminate correlations in a skyrmion data stream, we show that we can decorrelate the signals using a device with leads for skyrmion transport and a chamber where this reshuffling occurs [4]. We study the different skyrmion transport possibilities and properties to gauge the device performance. The low reshuffler footprint and low power usage compared to e.g. CMOS [3,4] might enable more energy efficient computing.

MA 34.7 Wed 16:45 H37

Role of damping and continuity in the stability of skyrmions and antiskyrmions — •Martin Stier[1], Wolfgang Häusler[2], and Michael Thorwart[1] — [1]Universität Hamburg, Jungiusstr. 9, 20355 Hamburg — [2]Universität Augsburg, Universitätsstr. 1, 86135 Augsburg

Magnetic skyrmions are magnetic vortices with non-vanishing topological charge Q. This topological charge can not be changed by means of a continuous transformation of the magnetic texture $\mathbf{n}(x, y, t)$. This topologically protects skyrmions as well as antiskyrmions and the transition to topologically different phases is forbidden. On lattices, however, this topological protection does not hold in a strict sense and skyrmions can be created or destroyed as it is confirmed by experiment and theory. Nevertheless, on discrete lattices the topological protection is still taken as a justification for the comparably strong stability of skyrmions even without a strict theoretical support. To establish ties between the discrete and continuous limit we study the decay of skyrmions and antiskyrmions. By increasing the number lattice sites we approach the continuous limit. We discuss the according decay times with a distinct focus on the role of the damping on the decay.

15 min. break

MA 34.8 Wed 17:15 H37

Spin eigen-excitations of the antiferromagnetic skyrmion — •Volodymyr Kravchuk[1,4], Helen Gomonay[2], Denis Sheka[3], Karin Everschor-Sitte[2], Davi Rodrigues[2], Jeroen van den Brink[1], and Yuri Gaididei[4] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany — [3]Taras Shevchenko National University of Kyiv, Ukraine — [4]Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine

The spectrum of eigen-excitations of a skyrmion in a uniaxial collinear antiferromagnet with the easy-axis perpendicular to the film plane is analyzed. Two branches of the bounded eigenstates are found in the gap: the low-frequency modes demonstrate significant dependence of the eigenfrequencies on the skyrmion radius R with the characteristic asymptotic behavior $\omega \propto R^{-2}$ for large R. While the high-frequency modes are close to the magnon continuum and weakly depend on the skyrmion radius. In the absence of an external magnetic field all modes, except the radially symmetrical one, are doubly degenerate with respect to the sense of rotation, clockwise or counterclockwise. The perpendicular magnetic field results in a splitting of the degenerate modes. A general approach for describing the dynamics of the antiferromagnetic domain wall string is developed, it is utilized for estimation of eigenfrequencies of the low-frequency modes.

MA 34.9 Wed 17:30 H37

Magnetic behaviour investigation using simulations, conventional and space-time-resolved x-ray detected FMR — •Santa Pile[1], Taddäus Schaffers[1], Thomas Feggeler[2], Ralf Meckenstock[2], Detlef Spoddig[2], Katharina Ollefs[2], Verena Ney[1], Hendrik Ohldag[3], Rysard Narkowicz[4], Kilian Lenz[4], Jürgen Lindner[4], Michael Farle[2], Heiko Wende[2], and Andreas Ney[1] — [1]Johannes Kepler University Linz, 4040 Linz, Austria — [2]University of Duisburg-Essen, 47057 Duisburg, Germany — [3]SSRL, SLAC National Accelerator Laboratory, Menlo Park, CA — [4]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden, Germany

STXM, XMCD spectroscopy and FMR were combined using a synchronization scheme between the x-ray pulses of the synchrotron and the microwave excitation (STXM-FMR). This STXM-FMR setup enables the visualization of the high frequency magnetization dynamics in the GHz regime with a spatial resolution of 35 nm and a time resolution of 17.4 ps [1]. Lithographically grown combinations of magnetic micro-stripes 5x1x0.03 *m3 were investigated. The samples were precharacterised using conventional FMR [2] and micro magnetic simulations. For STXM-FMR measurements a static magnetic field was applied in the plane of the stripes. As a result several uniform and transitional spin-wave FMR modes were visualised and agree with the simulations.

[1] S. Bonetti, et. al., Rev. Sci. Instrum. 86, 093703 (2015)
[2] R. Narkowicz, et. al., Reson.175, 275 (2005)

MA 34.10 Wed 17:45 H37

Skyrmion diffusion in thin film multilayers — •Markus Weissenhofer, Andreas Donges, and Ulrich Nowak — Fachbereich Physik, Universität Konstanz, Universitätsstraße 10, DE-78457 Konstanz, Germany

While being of fundamental interest as the type of diffusion yields information on transport and dissipation processes, thermally activated diffusion processes can also serve as a sensitive tool to analyze system properties. We use the stochastic Landau-Lifshitz-Gilbert equation to simulate diffusive motion of Skyrmions in a (Pt0.95Ir0.05)/Fe-bilayer on a Pd(111) surface. Here, the frustration of the isotropic exchange interactions in connection with the Dzyaloshinskii-Moriya interaction is responsible for the creation of skyrmionic structures [1]. We demonstrate the validity of the existing analytical theory for diffusive motion in flat energy landscapes [2] by calculating the diffusion coefficient for Skyrmions with different topological charges finding a linear temperature dependence as analytically expected [3]. Simulations at low temperatures reveal that in this system skyrmionic structures which are deformed by the Dzyaloshinskii-Moriya interaction show anisotropic diffusive behaviour in combination with rotational brownian motion in a weak periodic potential. Furthermore we quantitatively investigate this rotational energy landscape for deformed skyrmions and determine the mean rotation time for different temperatures [1].

[1] Rózsa et al., Phys. Rev. B 95, 094423 (2017). [2] Schütte et al., Phys. Rev. B 90, 174434 (2014). [3] Zázvorka et al., arXiv:1805.05924 [cond-mat.mtrl-sci]

MA 34.11 Wed 18:00 H37

Deformations of magnetic skyrmions — •Davi Rohe Rodrigues[1], Artem Abanov[2], and Karin Everschor-Sitte[1] — [1]Institute of Physics, Johannes Gutenberg-University, 55128 Mainz, Germany — [2]Department of Physics & Astronomy, Texas A&M University, College Station, TX 77843-4242, USA

Dynamical deformations of skyrmions have several implications on their transport properties, like a modified skyrmion Hall angle and a maximum skyrmion velocity.[1,2,3] Furthermore, the gigahertz dynamics of skyrmion excitation modes might be exploited for non-conventional computation.[4] In this work, we derive a general framework to describe the dynamics of deformations in isolated magnetic skyrmions. This effective profile ansatz- and microscopic detail-independent theory can be applied to current and field driven dynamics of skyrmions.[5] We analyse the change in the skyrmion Hall angle due to deformation of skyrmions and derive a current-induced bimeron instability. This powerful formalism provides an efficient tool to understand the experimentally observed low-energy skyrmion dynamics as well as suggests new applications of magnetic skyrmions.

[1]Litzius et al., to be published; [2] Leliaert et al., Jour. Phys. D 52 024003 (2019); [3]Tomasello et al., arXiv:1808.01476; [4] Bourianoff et al., AIP Advances 8 (2018); [5] Rodrigues et al., Phys. Rev. B 97 134414 (2018).

MA 34.12 Wed 18:15 H37

Maximizing Skyrmion Device Efficiency by Engineering the Drive and Temperature Dependence of Skyrmion Dynamics and the Resulting Skyrmion Hall Effect — Kai Litzius[1,2,3], Jonathan Leliaert[4], Pedram Bassirian[1], Davi Rodrigues[1], Sascha Kromin[1], Ivan Lemesh[5], Jakub Zazvorka[1], Kyu-Joon Lee[1], Jeroen Mulkers[4,6], •Nico Kerber[1,2], Daniel Heinze[1], Niklas Keil[1], Robert M. Reeve[1,2], Markus Weigand[3], Bartel Van Waeyenberge[4], Gisela Schütz[3], Karin Everschor-Sitte[1,2], Geoffrey S. D. Beach[5], and Mathias Kläui[1,2] — [1]Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [2]Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany — [3]Max Planck Institute for Intelligent Systems, 70569 Stuttgart, Germany — [4]Ghent University, B-9000 Ghent, Belgium — [5]Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA — [6]University of Antwerp, B-2020 Antwerp, Belgium

To reveal the origin of the Skyrmion Hall Angle (SkHA) and the temperature-dependence of the skyrmion dynamics, we investigate skyrmion trajectories at different temperatures and drive-amplitudes. We find the velocities to be strongly temperature-dependent, whereas the mechanism of the SkHA is independent of temperature, with different slopes in the depinning and viscous flow regimes. We explain these slopes by revealing the different underlying mechanisms including skyrmion surface tension and -deformation that sets the limit of the maximum velocity in ferromagnetic devices unless counteracted.

MA 34.13 Wed 18:30 H37

Overcoming the speed limit in skyrmion racetrack devices by suppressing the skyrmion Hall effect — •Börge Göbel[1], Alexander Mook[2], Jürgen Henk[2], and Ingrid Mertig[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle (Saale), Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle (Saale), Germany

Magnetic skyrmions are envisioned as carriers of information in racetrack storage devices. Unfavorably, the skyrmion Hall effect hinders the fast propagation of skyrmions along an applied electric current and limits the device's maximum operation speed. We show that the maximum skyrmion velocity increases by a factor of 10 when the skyrmion Hall effect is suppressed, since the straight-line motion of the skyrmion allows for the application of larger driving currents. We consider a ferromagnet on a heavy metal layer, which converts the applied charge current into a spin current by the spin Hall effect. The spin current drives the skyrmions in the ferromagnet via spin-orbit torque. We show by analytical considerations and simulations that the deflection angle decreases, when the spin current is polarized partially along the applied current direction and derive the condition for complete suppression of the skyrmion Hall effect.

[1] B. Göbel, A. Mook, J. Henk, and I. Mertig, arXiv:1808.06391 (2018)

MA 34.14 Wed 18:45 H37

Magnetotransport Fingerprints of Bloch Points in Thin Films — •Matthias Redies[1], Fabian Lux[1], Jan-Philipp Hanke[2], Patrick Buhl[1], Gideon Müller[1,3], Nikolai Kiselev[1], Stefan Blügel[1], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany — [3]Science Institute of the University of Iceland, VR-III, 107 Reykjavik, Iceland

While chiral magnetic skyrmions have attracted much attention in recent years, a new type of thin-film chiral particle – of a chiral bobber – has recently been theoretically predicted and experimentally observed [1]. On the basis of theoretical arguments, here we present a clear way to use chiral bobbers for the purposes of future spintronics by revealing that these novel chiral states have inherent transport fingerprints that allow their unique electrical detection in systems of different types of chiral states [2]. We show that bobbers' unique transport and orbital features are rooted in the non-trivial magnetization distribution near the Bloch points, and show that the fine-tuning of the Bloch point topology can be used to drastically increase the emergent response properties of chiral bobbers to external fields, which holds great potential for the development of chiral dynamics and cognitive computing.

[1] Filipp N Rybakov et al, 2016 New J. Phys. 18 045002

[2] Matthias Redies et al, arXiv:1811.01584

MA 35: Caloric effects in ferromagnetic materials

Time: Wednesday 15:00–17:00 Location: H52

MA 35.1 Wed 15:00 H52

A multicaloric cooling cycle that exploits hysteresis — •Tino Gottschall[1,2], Adrià Gràcia-Condal[3], Maximilian Fries[2], Andreas Taubel[2], Lukas Pfeuffer[2], Lluís Mañosa[3], Antoni Planes[3], Konstantin P. Skokov[2], and Oliver Gutfleisch[2] — [1]Dresden High Magnetic Field Laboratory, HZDR, Germany — [2]Faculty of Materials Science, TU Darmstadt, Germany — [3]Facultat de Física, Universitat de Barcelona, Barcelona, Spain

The giant magnetocaloric effect, in which large thermal changes are induced in a material on the application of a magnetic field, can be used for refrigeration applications, such as the cooling of systems from a small to a relatively large scale. However, commercial uptake is limited. We propose an approach to magnetic cooling that rejects the conventional idea that the hysteresis inherent in magnetostructural phase-change materials must be minimized to maximize the reversible magnetocaloric effect. Instead, we introduce a second stimulus, uniaxial stress, so that we can exploit the hysteresis [1]. This allows us to lock-in the ferromagnetic phase as the magnetizing field is removed, which drastically reduces the volume of the magnetic field source and so reduces the amount of expensive Nd-Fe-B permanent magnets needed for a magnetic refrigerator. The technical feasibility of this hysteresis-positive approach is demonstrated using Ni-Mn-In Heusler alloys. Our study could lead to an enhanced usage of the giant magnetocaloric effect in commercial applications.

[1] T. Gottschall et al., Nat. Mater. **17**, 929 (2018).

MA 35.2 Wed 15:15 H52

Unraveling the role of hydrogen on the vibrational and magnetic properties of $LaFe_{13-x}Si_xH_y$ — •Markus E. Gruner[1], Alexandra Terwey[1], Joachim Landers[1], Soma Salamon[1], Werner Keune[1], Katharina Ollefs[1], Valentin Brabänder[2], Iliya Radulov[2], Konstantin Skokov[2], Jiyong Zhao[3], Michael Y. Hu[3], Thomas S. Toellner[3], Ercan E. Alp[3], Oliver Gutfleisch[2], and Heiko Wende[1] — [1]Universität Duisburg-Essen — [2]TU Darmstadt — [3]Argonne National Laboratory

$LaFe_{13-x}Si_x$ is one of the most promising candidates for magnetic refrigeration applications. Its favorable first-order magnetic transition is connected to the itinerant electron metamagnetism of Fe, while loading with hydrogen allows to shift T_C to ambient conditions. To avoid decomposition into low- and high-T_C regions, full loading is mandatory, which occupies only a part of the (24d) interstitial sites. Our density functional theory (DFT) calculations reveal that hydrogen strongly disfavors the presence of Si close to the interstitial sites. By combining DFT and nuclear resonant inelastic X-ray scattering (NRIXS), we identify adiabatic electron-phonon coupling as the microscopic mechanism causing the beneficial cooperative interplay between electronic, magnetic and vibrational degrees of freedom in $LaFe_{13-x}Si_xH_y$. In addition, we discuss the impact of interstitial hydrogen on the magnetic interactions between the different Fe sites and give an oulook on the impact of a partial substitution of Fe with other transition metals on the vibrational properties.

Funding by the DFG within SPP 1599 is gratefully acknowledged.

MA 35.3 Wed 15:30 H52

Local structural analysis of $La(Fe, Si)_{13}$-compounds — •Cynthia Pillich[1], Alexandra Terwey[1], Katharina Ollefs[1], Benedikt Eggert[1], Daniela Trienes[1], Markus E. Gruner[1], Werner Keune[1], Valentin Brabänder[2], Iliya Radulov[2], Konstantin Skokov[2], Oliver Gutfleisch[2], Mauro Rovezzi[3,4], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47057 Duisburg, Germany — [2]Materials Science, Technical University Darmstadt, 64287 Darmstadt, Germany — [3]Observatoire des Sciences de l'Univers de Grenoble (OSUG), UMS 832 CNRS, Univ. Grenoble Alpes, F-38041 Grenoble, France — [4]3BM30B/CRG-FAME, ESRF, Polygone Scientifique Louis Nèel, 71 avenue des Martyrs, 38000 Grenoble, France

$La(Fe, Si)_{13}$-compounds show excellent magnetocaloric properties due to an isostructural volume decrease upon increasing temperature, accompanying a first-order magnetostructural transition, and therefore is used in solid state refrigeration. By analyzing the Extended X-Ray Absorption Fine Structure (EXAFS) at the Fe K- and La L_3-edge we can observe the influence of Mn-doping on the local surrounding of the atoms in $La(Fe, Si)_{13}$. The measurements were performed for different Mn-concentrations in the 1:13 system as well as varying temperatures. A lattice contraction at the phase transition from the FM to the PM state was observed. Comparing the experimental data with a theoretically modeled EXAFS signal gives insight into the local lattice configuration. Funding by the DFG (SPP1599) is acknowledged.

MA 35.4 Wed 15:45 H52

Element-specific view on $La(FeSi)_{13}$ — •Katharina Ollefs[1], Markus E. Gruner[1], Alexandra Terwey[1], Benedikt Eggert[1], Iliya Radulov[2], Konstantin Skokov[2], Werner Keune[1], Fabrice Wilhelm[3], Andrei Rogalev[3], Oliver Gutfleisch[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg- Essen, Germany — [2]Functional Materials, Technical University Darmstadt, Darmstadt, Germany — [3]Synchrotron Radiation Facility, Grenoble, France

Due to its large magneto-caloric effect, the itinerant electron metamagnet $La(FeSi)_{13}$ is of great interest for its potential use in solid state refrigeration. In order to better understand the magnetic interactions in this material and how they change at the transition, we have performed x-ray absorption measurements. X-ray magnetic circular dichroism measurements in the low temperature phase at the Fe K-edge and La $L_{2,3}$-edges reveal not only a magnetic moment on Fe but also a sizable magnetic moment in the 5d states of La. Magneto-optical sum-rule analysis and DFT calculations indicate an anti-parallel alignement of the Fe and La spin moment and a small orbital moment on La also anti-parallel to spin moment. Disentangling the different magnetic moment contributions in $La(FeSi)_{13}$ may reveal additional sources for hysteresis and might shed light on the thermodynamic role of the particular magnetic degrees of freedom. Funding by the DFG (SPP1599) is acknowledged.

MA 35.5 Wed 16:00 H52

Spin Seebeck effect and ballistic transport of quasi-acoustic magnons in room-temperature yttrium iron garnet films — •Timo B. Noack[1], Halyna Yu. Musiienko-Shmarova[1], Thomas Langner[1], Frank Heussner[1], Viktor Lauer[1], Björn Heinz[1], Dmytro A. Bozhko[1], Vitaliy I. Vasyuchka[1], Anna Pomyalov[2], Victor L'vov[2], Burkard Hillebrands[1], and Alexander A. Serga[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Kaiserslautern, Germany — [2]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot, Israel

We study the transient behavior of the spin current generated by the Longitudinal Spin Seebeck Effect (LSSE) in a set of platinum-coated Yttrium Iron Garnet (YIG) films of different thicknesses. The LSSE is induced by means of pulsed microwave heating of the Pt layer and the spin currents are measured electrically using the inverse spin Hall effect. We demonstrate that the time evolution of the LSSE is determined by the evolution of the thermal gradient triggering the flux of thermal magnons in the vicinity of the YIG/Pt interface. These magnons move ballistically within the YIG film with constant group velocity. The ballistic flight of the magnons with energies above 20 K is a result of their almost linear dispersion law, similar to that of acoustic phonons. By fitting the time-dependent LSSE signal for different film thicknesses varying by almost an order of magnitude, we found that the effective propagation length is practically independent of the YIG film thickness.

MA 35.6 Wed 16:15 H52

Millisecond Dynamics of the Magnetocaloric Effect in a First- and Second-Order Phase Transition Material — •Jago Döntgen, Jörg Rudolph, and Daniel Hägele — AG Spektroskopie d. kond. Materie, Ruhr-Universität Bochum

One of the key challenges of the research in magnetocaloric materials is a reliable determination of the adiabatic temperature change ΔT. We have developed a novel method for direct measurements of ΔT that allows for the investigation of the magnetocaloric effect on length- and time-scales inaccessibly by traditional calorimetry. Our technique is based on the application of temporally oscillating magnetic fields and detection of the resulting change of the thermal radiation emitted by the sample. We achieve a unique combination of a sensitivity of better than 1 mK, a time-resolution of 10 μs, and magnetic field modulation frequencies exceeding 1 kHz [1]. We present dynamic measurements of the magnetocaloric effect, that allow for a direct distinction between reversible and irreversible sample behavior. The ΔT dynamics of the first-order phase transition material $La_{1.2}Fe_{11.4}Si_{1.4}Mn_{0.2}H_y$ show a peculiar self-quenching at temperatures slightly below the peak maximum.[2] This behavior can be attributed to the first-order nature of the phase transition, which takes place at the phase boundary between the paramagnetic and ferromagnetic sample regions.

[1] Döntgen et al., Rev. Sci. Instrum. **89**, 033909 (2018)
[2] Döntgen et al., Energy Technol. **6**, 1470-1477 (2018)

MA 35.7 Wed 16:30 H52

Magnetocaloric potential of Ni-Mn-(In,Sn,Al) Heusler alloys in case of complete martensite-to-austenite transformation in high magnetic fields — •Franziska Scheibel[1], Andreas Taubel[1], Lukas Pfeuffer[1], Tino Gottschall[2], and Oliver Gutfleisch[1] — [1]Funktionale Materialien, Technische Universität Darmstadt, Germany — [2]Hochfeld- Magnetlabor Dresden, Helmholtz-Zentrum Dresden-Rossendorf, Germany

Ni-Mn-based Heusler are known as potential materials for magnetic refrigeration, due to their large magnetocaloric effect during first-order magnetostructural transformation (FOMST). The challenge of the thermal hysteresis of the FOMST becomes an advantage by using a new cooling cycle concept, which introduces a second stimulus (uniaxial stress) besides the magnetic field[1]. The new concept enables the reduction of the permanent magnet volume and the duration of the magnetic field application which allows an increase in the field.
We show the magnetocaloric potential of Ni-Mn-(In, Sn, Al) Heusler alloys by direct adiabatic temperature change ΔT_{ad} measurements in pulsed magnetic fields up to 30 T inducing a complete martensite-to-austenite transformation. Thereby, the MCE of different Heusler alloys can be compared by considering the max. ΔT_{ad} for a complete transformation rather than comparing minor-loop transformation in 1 or 2 T. As an example, a ΔT_{ad} of -17 K is measured in $Ni_{46}Mn_{38}Sn_{11}Co_5$ for a 20 T field pulse.
The work is supported by the ERC advanced grand *Cool Innov*.
[1] T. Gottschall et al., Nature Materials 17, 929-934 (2018)

MA 35.8 Wed 16:45 H52

Investigation of microstructure and magnetocaloric properties of Ni-Co-Mn-Ti Heusler alloys — •Andreas Taubel, Benedikt Beckmann, Lukas Pfeuffer, Franziska Scheibel, Maximilian Fries, Tino Gottschall, Konstantin P. Skokov, and Oliver Gutfleisch — TU Darmstadt, Alarich-Weiss-Straße 16, 64287 Darmstadt

Ni-Mn-X(-Co) Heusler alloys show a martensitic transformation that can be coupled to a magnetic phase change resulting in promising properties for magnetocaloric applications [1,2]. Recently, the principle of all-d metal Heusler alloys has been introduced by placing d-metal elements on the X site for those alloys. Especially the systems with X=Ti have been studied as promising materials due to a large magnetization change, good tunability of the phase transition and enhanced mechanical properties.

In this work, we report on the microstructural properties of Ni-rich $Ni_{50-x}Co_xMn_{50-y}Ti_y$ and Mn-rich $Mn_{50}Ni_{50-x-y}Co_xTi_y$ alloys. By optimizing the processing route of the novel Ni-Mn-Ti system, we could improve the inverse magnetostructural phase transition in terms of sharpness and magnetization change. A large isothermal entropy change of up to 38 $Jkg^{-1}K^{-1}$ has been measured for a magnetic field change of 2T by isofield protocol.

This work was supported by DFG (Grant No. SPP1599) and ERC (Advanced Grant "cool innov").

[1] A. Taubel et al., physica status solidi (b) 255 (2), 1700331 (2018)
[2] T Gottschall et al., Nature materials 17 (10), 929 (2018)

MA 36: Spin transport

Time: Wednesday 15:00–18:15 Location: H53

MA 36.1 Wed 15:00 H53

Electrical control of antiferromagnetic domain walls — •Sonka Reimers[1,2], Peter Wadley[1], Richard P. Campion[1], Francesco Maccherozzi[2], Sarnjeet S. Dhesi[2], and Kevin W. Edmonds[1] — [1]University of Nottingham, United Kingdom — [2]Diamond Light Source, United Kingdom

Antiferromagnets have a number of favourable properties as active elements including ultra-fast dynamics, zero stray fields and insensitivity to external magnetic fields[1]. Tetragonal CuMnAs is a testbed system in which the antiferromagnetic order parameter can be switched reversibly at ambient conditions using electrical currents[2]. Previous experiments used orthogonal in-plane current pulses to induce 90° rotations of antiferromagnetic domains and terahertz electrical writing speeds have been demonstrated[3].

Here[4], we demonstrate that antiferromagnetic domain walls can be manipulated to realize stable and reproducible domain changes by reversing the polarity of the current only. The resulting Néel spin orbit torque acts primarily on the domain wall. The reversible domain and domain wall reconfigurations are imaged using x-ray magnetic linear dichroism microscopy, and can also be detected electrically. The switching by domain wall motion can occur at much lower current densities than those needed for coherent domain switching.

References: [1] Jungwirth, T. et al., Nat. Nanotechnol. 11 (2016). [2] Wadley, P. et al., Science 351 (2016). [3] Olejník, K. et al., Science Advances 4(3), (2018). [4] Wadley, P., Reimers, S. et al., Nat. Nanotechnol. 13(5), (2018).

MA 36.2 Wed 15:15 H53

Tetragonal CuMnAs alloy: role of defects — •Frantisek Maca[1], Josef Kudrnovsky[1], Pavel Balaz[2], Vaclav Drchal[1], Karel Carva[2], and Ilja Turek[2] — [1]Institute of Physics ASCR, Praha, Czech Republic — [2]Charles University, Faculty of Mathematics and Physics, Praha, Czech Republic

The antiferromagnetic CuMnAs alloy with tetragonal structure is a promising material for the AFM spintronics. The resistivity measurements indicate the presence of defects about whose types and concentrations is more speculated as known. We confirmed vacancies on Mn or Cu sublattices and Mn on Cu and Cu on Mn antisites as most probable defects in CuMnAs by ab-initio total energy calculations.

We have estimated resistivities of possible defect types as well as resistivities of samples for which the X-ray structural analysis is available. In the latter case we have found that samples with Cu- and Mn-vacancies with low formation energies have also resistivities which agree well with the experiment.

Finally, we have also calculated exchange interactions and estimated the Neel temperatures by using the Monte Carlo approach. A good agreement with experiment was obtained.

[1] F. Maca, J. Kudrnovsky, V. Drchal, K. Carva, P. Balaz, and I. Turek, J. Magn. Magn. Mater. 474 (2019) 467.

MA 36.3 Wed 15:30 H53

Limits of collective spin transport in easy-plane magnets — •Martin Evers and Ulrich Nowak — University of Konstanz, D-78457 Konstanz

Within certain limits, magnetism can be described by continuous field-theory, i.e. by the micromagnetic framework. The magnetic equations are rather complex since these comprise all non-linearities of the Landau-Lifshitz-Gilbert equation; but for special systems, e.g. easy-plane magnets with small out-of-plane component the equations reduce to something showing almost the same mathematical structure as the Gross-Pitaevski equation describing the time evolution of a Bose condensate—and therefore superfluidity. Because of this very resemblance, transport in such magnets is called “spin superfluidity” [1,2], although there is one mayor difference: a damping term resulting from Gilbert damping, unavoidably leading to dissipation in the spin superfluid. However, this damping can be quite small.

Our work rests on atomistic spin simulations of easy-plane ferro-and antiferromagnets, carried out within the limits of the analytical theory of the field equations and beyond. This approach allows especially to test limits of this kind of transport—e.g. with respect to a finite temperature, high driving strengths, or disorder—presented in this talk.

[1] S. Takei et al., Phys. Rev. Lett. **112**, 227201 (2014)

[2] B. Flebus et al., Phys. Rev. Lett. **116**, 117201 (2016)

MA 36.4 Wed 15:45 H53

First principles studies of XAS/XMCD experiments in 2D heterostructures under steady-state non-equilibrium conditions — •Alberto Marmodoro, Masako Ogura, Sebastian Wimmer, and Hubert Ebert — Ludwig-Maximilians-Universität, München, Germany

We report on progress in the field of ab initio theoretical spectroscopy for out-of-equilibrium scenarios. This regime can be approached through either pump-probe experiments, or the application of a steady-state, time independent but finite external perturbation.

We consider here the case of XAS/XMCD investigations in multilayer compounds subjected to a finite electric field [1]. These techniques allow for high selectivity in the chemical element and even local environment being targeted. In combination with various kinds of theoretical sum rules, this can lead to fundamental insight on basic electronic structure features of a material.

Our computational framework is based on a fully relativistic multiple scattering / KKR Green function solution scheme for the basic SCF-DFT problem, and the simulation of various kind of spectroscopy and transport experiments. We put to the test a combination of recent developments for the non-equilibrium extension of this basic formalism [2] with established procedures for the study of x-ray absorption in bulks or 2D heterostructures.

[1] R. Kukreja et al., PRL 115, 096601 (2015); G. van der Laan, Physics 8, 83 (2015). [2] S. Achilles et al., PRB 88, 125411 (2013); M. Ogura, H. Akai, JPSJ 85, 104715 (2016)

MA 36.5 Wed 16:00 H53

Non-local magnetotransport in ferromagnetic insulator/Pt heterostructures — •Richard Schlitz[1,2], Toni Helm[3,4], Michaela Lammel[5], Kornelius Nielsch[5,6], Artur Erbe[4], and Sebastian T.B. Goennenwein[1,2] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, Germany — [2]Center for Transport and Devices of Emergent Materials, Technische Universität Dresden, Germany — [3]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [4]Helmholtz-Zentrum Dresden-Rossendorf e.V., Germany — [5]Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Institute for Metallic Materials, Dresden, Germany — [6]Technische Universität Dresden, Institute of Materials Science, Germany

Non-local long range spin transport phenomena in yttrium iron garnet/Pt heterostructures recently attracted a lot of interest. The experiments are commonly interpreted in terms of magnon diffusion in combination with spin Hall physics[1]. In this study, we first reproduce the fingerprint of the non-local magnetoresistance reported in literature by rotations of the magnetic field in three mutually orthogonal planes and current dependent experiments. After characterization we use a focused ion beam (FIB) to alter the shape of the yttrium iron garnet film in between the Pt contacts and study the ensuing changes in the non-local transport properties. Our results corroborate that magnon transport indeed is the main mechanism for the non-local transport.

[1] L. J. Cornelissen *et al.*, Nature Physics **11**, 1022-1026 (2015)

MA 36.6 Wed 16:15 H53

Atomic Layer Deposition of spin Hall active platinum thin films — •Michaela Lammel[2], Richard Schlitz[1], Akinwumi A. Amusan[2], Stefanie Schlicht[3], Tommi Tynell[2], Julien Bachmann[3], Georg Woltersdorf[4], Kornelius Nielsch[3], Sebastian T.B. Goennenwein[1], and Andy Thomas[3] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden — [2]Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Institute for Metallic Materials — [3]Friedrich-Alexander University Erlangen-Nürnberg, Inorganic Chemistry — [4]Institute of Physics, Martin Luther University Halle-Wittenberg

Due to its strong spin orbit coupling, platinum (Pt) is often used as a spin injector/detector in spintronics. We used atomic layer deposition (ALD) to fabricate Pt thin films in various thicknesses on $Y_3Fe_5O_{12}$(YIG)/$Gd_3Ga_5O_{12}$ substrates. Magnetotransport experiments were performed on the YIG/Pt heterostructures in three mutually orthogonal rotation planes, revealing the fingerprint of spin Hall magnetoresistance (SMR). Hereby the SMR ratio in our YIG/Pt bilayers is smaller by approximatley a factor of 20 in comparison to results reported for high-quality sputtered Pt. Clearly, further experiments will be required to optimize the interface quality in such ALD-based heterostructures. Nevertheless, our results show that spin Hall active Pt thin films can be fabricated by ALD. Our results pave the way for establishing conformal coating of non-planar surface geometries with spin Hall active metals via ALD [1].

[1] Schlitz *et al.*, Appl. Phys. Lett. **112**, 242403 (2018)

MA 36.7 Wed 16:30 H53

Spin Fano factor for spin pumping, spin Seebeck effect and spin transfer torque — •yuichi ohnuma — Kavli Institute for Theoretical Sciences, University of Chinese Academy of Sciences, Beijing, China

Noise measurements on nonequilibrium electric currents are known as effective probes of the electron transport in mesoscopic systems. While the equilibrium noise is related to the linear response conductance through the fluctuation-dissipation theorem, nonequilibrium shot noise contains unique information on the effective charge and statistics of a quasiparticle, which cannot be obtained from the resistance measurement.

Recently, it has been proposed that the fluctuation of spin current provide the effective spin of spin transport. In this talk, we show the effective spin carried by magnons in the spin pumping (SP), spin Seebeck effect (SSE) and spin transfer torque (STT) at the interface of a bilayer of a paramagnetic metal and a ferromagnetic insulator. Using the method of non-equilibrium Green's function, we have derived the expressions of the spin current and spin current noise. Combing these two results, we find the conditions for the spin shot noise and obtain the spin Fano factor which describes the effective spin for SP, SSE, and STT.

MA 36.8 Wed 16:45 H53

Topological magnetotransport in antiferromagnetic spintronics — •Libor Šmejkal[1,2], Rafael González-Hernández[1], Tomáš Jungwirth[2], and Jairo Sinova[1,2] — [1]INSPIRE group, Uni Mainz, Germany — [2]Institute of Physics, Czech Academy of Sciences, Prague, Czech Rep.

Merging topological quasiparticles with magnetism became a new direction in the field of topological quantum materials and topological spintronics [1]. Based on ab initio theory, we have predicted a large anisotropic magnetoresistance reaching 6% in Mn_2Au antiferromagnet which was recently observed in current-induced torques experiments [2]. Here, we will catalogue antiferromagnetic systems based on their symmetry and topology [3]. We will show how the presence and breaking of time-reversal symmetry in our antiferromagnetic models open the avenues for relativistic metal-insulator transition and giant anisotropic magnetoresistance [4], and topological anomalous Hall effect in complex magnetic systems [5]. Finally, we will identify a broad list of real material candidates by our first-principle calculations and band-structure engineering.

[1] L. Šmejkal, Y. Mokrousov, B. Yan, and A. H. MacDonald, Nat. Phys. (2018) [2] S. Yu. Bodnar, L. Šmejkal, et al. Nat. Comm. (2018) [3] L. Šmejkal, and T. Jungwirth, book chapter in Topology in Magnetism, Springer (2018) [4] L. Šmejkal, J. Železný, J. Sinova, and T. Jungwirth, Phys. Rev. Lett. (2017) [5] L. Šmejkal, R. González-Hernandez, T. Jungwirth, and J. Sinova, arXiv (2018)

15 min. break

MA 36.9 Wed 17:15 H53

Organic spin valves based on spin-coated P(VDF-TrFE) films on $La_{0.7}Sr_{0.3}MnO_3$ — •Camillo Ballani[1] and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle(Saale) — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, Nanotechnikum Weinberg, 06120 Halle(Saale)

Organic spin valves (OSV) are well known for the occurrence of magnetoresistive effects and resistive switching and, therefore, have a huge potential for applications. However, the exact mechanism of transport through the organic interlayer often remains unclear [1]. Furthermore it has been demonstrated that the ferroelectric copolymer P(VDF-TrFE) in combination with a ferromagnetic $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) bottom layer exhibits large resistive switching (RS) effects [2]. The functionality of OSV devices for studying TAMR and RS requires smooth and continuous ultra-thin organic interlayers with clean interfaces. An easy way to deposit such films is spin-coating of dissolved organic polymer powder and subsequent thermal annealing. This study reports on properties like morphology and thickness dependence of spin-coated P(VDF-TrFE) copolymer thin films on the deposition parameters. The films are deposited on epitaxial ferromagnetic LSMO layers grown by pulsed laser deposition on $SrTiO_3$ (001) substrates. Furthermore, we present a patterning process for OSV based on P(VDF-TrFE) and LSMO, and a characterization of their magnetotransport properties.

[1] M. Grünewald *et al.*, Phys.Rev. B, **84**, 125208 (2011)
[2] S. Majumdar *et al.*, Adv.Funct.Mater. **28**, 1703273 (2018)

MA 36.10 Wed 17:30 H53

Lateral spin transport in chemically doped organic semiconductors — •Janis Siebrecht[1,2], Shu-Jen Wang[1], Deepak Venkateshvaran[1], and Henning Sirringhaus[1] — [1]Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom — [2]present address: Max Planck Institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart, Germany

A central goal in the field of spintronics is the development of materials with high spin diffusion lengths. Their low cost and long spin lifetimes make organic semiconductors a potential candidate for technological applications. Here, we test the spin transport in the conjugated polymers IDTBT, N2200, P3HT and CDT-BTZ at different levels of chemical doping. Our devices generate a pure spin current using ferromagnetic resonance (FMR) and exploit the inverse spin Hall effect (ISHE) to convert the spin current into a voltage. By varying the channel width of the organic between source and detector, we find a spin diffusion length of several hundred nanometers for P3HT doped with F4TCNQ. We use the dependence of the ISHE signal on thermal de-doping to test a theoretical model [1] that describes spin diffusion based on hopping and exchange coupling.

1. Yu. Z.G., Nanoelectron. Spintron. 1:1-18 (2015)

MA 36.11 Wed 17:45 H53

Accurate and generalized formalism for spin-admixture parameter calculations — •Uday Chopra[1,2], Shambhawi Shambhawi[3], Sergei Egorov[1,4], Jairo Sinova[1], and Erik R. McNellis[1] — [1]Johannes Gutenberg University, Staudingerweg 7, Mainz, 55128 — [2]Graduate School Material Science in Mainz, Staudingerweg 9, Mainz, 55128 Germany — [3]Dept. of Chemical Engineering and Biotechnology, University of Cambridge, Philippa Fawcett Dr, Cambridge CB30AS — [4]University of Virginia, Chemistry Department, McCormick Rd, Charlottesville, VA 22901 USA

The spin-admixture parameter, γ [1,2], is key to understanding spin-dynamics in molecules. It characterizes the influence of spin-orbit coupling (SOC) on spin-dynamics in virtually all models for molecular materials with the spin- up/down mixing in a SOC perturbed wave-function. The parameter governs the probability of spin-flip as the charge hops in a network of sites in an organic semiconductor. However, the quality of its current first-principles electronic structure theory formulation is severely limited by multiple approximations. We generalize this formulation to remove all of these flaws and demonstrate its accurate predicability of spin-relaxation in organic semiconductors. The resulting γ is straightforwardly computed, valid for vastly greater variations in target molecules and chemical composition, and more sensitive to aspects of geometric and electronic structure. We discuss this by highlighting trends in spin-admixture influenced by molecular design. [1] Z. G. Yu, Phys. Rev. B, 85, 115201 (2012). [2] Z. G. Yu, Phys. Rev. Lett, 106, 106602 (2011).

MA 36.12 Wed 18:00 H53

Proximity induced anisotropic magnetoresistance in graphene with broken sublattice symmetry — •Jeongsu Lee and Jaroslav Fabian — Universität Regensburg, 93047 Regensburg, Germany

Proximity induced anisotropic magnetoresistance (PAMR) is present when spin-orbit coupling and proximity-induced exchange fields coexist and the PAMR response could also provide means to observe ferromagnetic order in the tunnel barrier. Recent, experimentally demonstrated 2D ferromagnets made a breakthrough in ferromagnetic van der Waals heterostructures. Employing realistic parameters extracted from the first principles calculations, we theoretically investigate the proximity-induced anisotropic magnetoresistance in spin-orbit coupled systems with exchange field in consideration of broken sublattice symmetry. This work is supported by SFB 1277 (project A09).

MA 37: Focus Session: Insulator Spintronics

New building blocks for magnonics

Time: Wednesday 15:45–19:15 Location: H38

Invited Talk MA 37.1 Wed 15:45 H38

Magnon Transport and Magnonic Topological Insulators — •Daniel Loss — University of Basel, Switzerland

The physics of spin and magnon transport in magnetic insulating systems has attracted a lot of attention in recent years due to fundamental reasons but also due to promising applications such as low-dissipation devices. In my talk I will focus on the magnon counterparts of electron transport such as the Wiedemann-Franz law, the Josephson effect in magnon BECs, persistent magnon currents, magnon quantum Hall conductance, and magnon topological edge states in Skyrmion lattices.

Invited Talk MA 37.2 Wed 16:15 H38

Implementation of the Stimulated-Raman-Adiabatic-Passage mechanism in magnonics — •Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Magnonics is the field of spin waves. Being wave-based, magnonics bears the advantage of the ease of implementation of computation schemes developed in other areas of wave-based phenomena. One example is the concept of "quantum- classical analogy", which was created in the field of waveguide optics. It was shown, that the use of classical light in optical waveguides allows for the physical realization of quantum phenomena in atom physics, such as the population transfer between two states via a third, intermediate, dark state, where direct transitions between the two states are dipole forbidden. This process is referred to as STImulated Raman Adiabatic Passage (STIRAP) and has found various applications in many fields of physics.

We present first results of the magnonic realization of such a STIRAP process (m-STIRAP). Using micromagnetic simulations, we show that the population of magnons can be transferred between two waveguides via an intermediate waveguide. If the "counterintuitive" coupling scheme is used, the intermediate waveguide is not excited during the transfer, thus resembling the quantum-classical analogy of a dark state.

Our results bear high potential for future magnonic device functionalities and designs by bringing together the wealth of quantum-classical analogy phenomena with the wealth of means to control wave propagation in magnonic systems.

MA 37.3 Wed 16:45 H38

Hybridization of Ferro- and Antiferromagnetic Magnon Modes in GdIG — •Lukas Liensberger[1,2], Akashdeep Kamra[3], Hannes Maier-Flaig[1,2], Stephan Geprägs[1,2], Andreas Erb[1], Sebastian T. B. Goennenwein[4], Rudolf Gross[1,2,5], Wolfgang Belzig[6], Hans Huebl[1,2,5], and Mathias Weiler[1,2] — [1]Walther-Meißner-Institut — [2]Physik-Department, Technische Universität München — [3]Center for Quantum Spintronics, Norwegian University of Science and Technology — [4]Institut für Festkörper- und Materialphysik, Technische Universität Dresden — [5]Nanosystems Initiative Munich — [6]Department of Physics, University of Konstanz

The ability to tailor the static and dynamic magnetic properties of rare-earth iron garnets has stimulated a multitude of research studies and resulted in numerous applications. One prime example of this material class is the compensated ferrimagnet gadolinium iron garnet (GdIG). We investigate the magnetization dynamics of a single crystal GdIG disk using broadband magnetic resonance and study in particular the dispersion relation of the ferro- and the antiferromagnetic modes. Close to the magnetization compensation temperature T_c we observe a strong and tunable interaction of these two modes. We explain our observations by employing a two-sublattice model for the ferrimagnet and find good agreement with theory. A weak, anisotropy-induced coupling is exchange enhanced close to T_c and yields strong coupling. The clock- and counterclockwise precessing modes thereby

hybridize into linearly oscillating modes.

We acknowledge financial support by the DFG via project WE5386/4.

15 min. break

Invited Talk MA 37.4 Wed 17:15 H38

Spintronics at interfaces of insulators and non-magnetic metals - magnon Bose-Einstein condensation and induced superconductivity — •Niklas Rohling, Eirik Løhaugen Fjaerbu, and Arne Brataas — Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491, Trondheim, Norway

The coupling between a normal metal (NM) on one side and an antiferromagnetic (AFI) or ferromagnetic insulator (FI) on the other side allows for spin transport through the interface via spin pumping and spin transfer torque (STT). We describe this coupling by a Heisenberg exchange Hamiltonian and perfectly matching lattices. The coupling of the electronic and magnonic states then depends crucially on their amplitude at the interface. We discuss briefly the possibility of generating a magnon Bose-Einstein condensate via STT [1,2]. Then we focus on a model describing superconductivity induced by interfacial coupling to magnons in a FI-NM-FI trilayer [3]. The electron-magnon interaction at the interfaces induces electron-electron interactions, which in turn can result in p-wave superconductivity. We solve the gap equation numerically, estimate the interface coupling strength for yttrium iron garnet (YIG)-Au-YIG and EuO-Au-EuO trilayers, and find critical temperatures in an experimentally accessible range.

[1] Bender et al., Phys. Rev. Lett. **108**, 246601 (2012); Phys. Rev. B **90**, 094409 (2014).

[2] Fjærbu, Rohling, Brataas, Phys. Rev. B **95**, 144408 (2017).

[3] Rohling, Fjærbu, Brataas, Phys. Rev. B **97**, 115401 (2018).

Invited Talk MA 37.5 Wed 17:45 H38

Magnon Transport and Dynamics in Magnetic Insulator — •Jing Liu — University of Groningen

I will give an overview of our recent results of the transport of thermal magnons in a magnetic insulator, yttrium iron garnet. We have shown that these can be generated electrically and by Joule heating, and can propagate with a typical relaxation length of 10 micrometers[1]. We have developed a theoretical description, where the magnon transport is driven by (a combination of) a gradient of the temperature (magnon spin Seebeck effect) or by the gradient of the magnon chemical potential[2].

Recently, we demonstrated that the magnon transport can be modulated by the injection of magnons by an intermediate electrode, which acts analogously to a gate electrode in electrical field effect transistor[3]. Besides, we investigated the interaction between (nonlocal) magnon transport of thermal magnons and GHz magnetization dynamics. We observe both enhancement and suppression of the magnon transport, and I will discuss the possible origins[4]. Finally, we discovered a new way to inject and detect magnon by using the anomalous spin Hall effect of permalloy. This also provides a possibility of injecting magnon spins with an out-of-plane component[5,6].

[1] L.C. Cornelissen, J. Liu et al. Nature Phys. 11, 1022 (2015) [2] L.C. Cornelissen et al. Phys. Rev. B94, 014412 (2016) [3] L.C. Cornelissen, J. Liu et al. Phys. Rev. Lett. 120, 097702 (2018) [4] J. Liu et al. Arxiv 1810.11667 (2017) [5] K.S. Das et al. Phys. Rev. B96, 220408(R) (2017) [6] K.S. Das, J. Liu et al. Nano Lett. 18. 5633 (2018)

MA 37.6 Wed 18:15 H38

Enhanced magnon spin transport in $NiFe_2O_4$ thin films on the lattice-matched substrate $MgGa_2O_4$ — Juan Shan[1], Amit V. Singh[2], Lei Liang[1], Ludo C. Cornelissen[1], Zbigniew Galazka[3], Arunava Gupta[2], Bart J. van Wees[1], and •Timo Kuschel[1,4] — [1]Zernike Institute for Advanced Materials, University of Groningen, The Netherlands — [2]MINT Center, University of Alabama, USA — [3]Leibniz-Institut für Kristallzüchtung, Berlin, Germany — [4]Center for Spinelectronic Materials and Devices, Bielefeld University, Germany

We report on enhanced magnon spin transport properties in epitaxial $NiFe_2O_4$ (NFO) films grown on $MgGa_2O_4$ substrates [1] compared to NFO films deposited on standard $MgAl_2O_4$ [2]. The reduction of the lattice mismatch from 3.2% to 0.8% decreases the number of antiphase boundary defects in the NFO films and, thus, improves structural and magnetic properties. Further, spin transport is strongly improved as we have studied by nonlocal magnon spin transport experiments with Pt injector and detector strips. While the magnon spin diffusion length in the NFO films of around 3 μm is not changed drastically, the nonlocal spin transport signal is enhanced by two orders of magnitude. This increase is detectable for both electrically and thermally excited magnons. In addition, we observe spin transport signals in NFO that point to magnetoelastic coupling identified as magnon polarons [1]. These findings make lattice-matched NFO being an important alternative to $Y_3Fe_5O_{12}$ (YIG) in terms of spin transport properties.

[1] J. Shan et al., Appl. Phys. Lett. 113, 162403 (2018)

[2] J. Shan et al., Appl. Phys. Lett. 110, 132406 (2017)

Invited Talk MA 37.7 Wed 18:30 H38

Tunable long distance spin transport in antiferromagnetic insulators — •Mathias Kläui — Institute of Physics, Johannes Gutenberg-University Mainz

We probe spin transport in insulating antiferromagnets, such as NiO [1,2], CoO [3] and hematite [4]. Spin currents are generated by heating as resulting from the spin Seebeck effect and by spin pumping measurements and we find in vertical transport short (few nm) spin diffusion lengths [2,3].

For hematite, however, we find in a non-local geometry that spin transport of tens of micrometers is possible. We detect a first harmonic signal, related to the spin conductance, that exhibits a maximum at the spin-flop reorientation, while the second harmonic signal, related to the Spin Seebeck conductance, is linear in the amplitude of the applied magnetic field [4]. The first signal is dependent on the direction of the Neel vector of the antiferromagnet and the second one depends on the induced magnetic moment due to the field. From the power and distance dependence, we unambiguously distinguish long-distance transport based on diffusion [4] from predicted spin superfluidity that can potentially be used for logic [5].

References: [1] L. Baldrati et al., PRB 98, 024422 (2018) [2] L. Baldrati et al. PRB 98, 014409 (2018) [3] J. Cramer et al., Nature Comm. 9, 1089 (2018) [4] R. Lebrun et al., Nature 561, 222 (2018). [5] Y. Tserkovnyak et al., PRL 119, 187705 (2017).

MA 37.8 Wed 19:00 H38

All-electrical control of spin transport in a three-terminal yttrium iron garnet/platinum nanostructure — •T. Wimmer[1,2], M. Althammer[1,2], L. Liensberger[1,2], N. Vlietstra[1], S. Geprägs[1], M. Weiler[1,2], R. Gross[1,2,3], and H. Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, Technische Universität München, Garching, Germany — [3]Nanosystems Initiative Munich (NIM), München, Germany

The transport of information via spin waves (magnons) in ferromagnetic materials provides novel, intriguing pathways towards information processing and manipulation beyond charge-based semiconductor technology. Here, the investigation of the transport of magnons in transistor like structures is of key importance.

In this study, we investigate the transport and control of magnon spin currents using an all-electrical detection and manipulation scheme. To this end, we utilize three parallelly aligned, electrically isolated platinum (Pt) electrodes deposited on a 13 nm thin yttrium iron garnet (YIG) film. The outer Pt contacts act as spin current injector and detector while the center one realizes the control of the magnon conductance. All electrodes use the (inverse) spin Hall effect to act on the magnon system. We are able to control the magnon spin conductance by up to 60 %/mA. Most interestingly, in addition to the linear control of the magnon transport, we find a highly non-linear regime to the spin conductance modulation.

Financial support by the DFG is gratefully acknowledged.

MA 38: Spin hall effects

Time: Wednesday 17:15–19:00 Location: H52

MA 38.1 Wed 17:15 H52

Spin-Charge Conversion in NiMnSb Alloy Films — Zhenchao Wen[1,2], Zhiyong Qiu[2,3], •Sebastian Tölle[4], Cosimo Gorini[5], Takeshi Seki[2], Dazhi Hou[2], Takahide Kubota[2], Ulrich Eckern[4], Eiji Saitoh[2], and Koki Takanashi[2] — [1]NIMS, Tsukuba, Japan — [2]Tohoku University, Sendai, Japan — [3]Dalian University of Technology, Dalian, China — [4]University of Augsburg, Germany — [5]University of Regensburg, Germany

Heterostructures with half-metallic ferromagnets (HMF) such as NiMnSb represent an interesting platform for various spin-charge conversion processes since (1) perfect HMFs have the unique property that their conduction electrons are fully spin-polarized at zero temperature, and (2) the interface can exhibit spin-orbit effects, e.g., Rashba spin-orbit coupling. In this work, we study the spin to charge conversion in NiMnSb/YIG bilayers, with YIG serving as a spin pump. Due to spin-orbit coupling, the injected spin current results in a transverse voltage which shows an unusual temperature dependence with a thickness-dependent sign change. We explain this behaviour by two competing contributions, a temperature independent one due to the interface and a bulk contribution, different in sign, which originates from minority-spin electrons due to thermally excited magnons.

MA 38.2 Wed 17:30 H52

Ab initio theory of the spin Hall effect and its application to random Pt-based alloys — •Ilja Turek[1], Josef Kudrnovsky[2], and Vaclav Drchal[2] — [1]Institute of Physics of Materials, Czech Acad. Sci., Brno, Czech Republic — [2]Institute of Physics, Czech Acad. Sci., Prague, Czech Republic

In this contribution, we present our approach to the spin-dependent conductivity tensor in substitutionally disordered alloys based on the concept of intersite electron transport within the relativistic tight-binding linear muffin-tin orbital (TB-LMTO) method. This approach leads to non-random and spin-independent effective current (velocity) operators, which enables one to define easily the corresponding effective spin-current operators that are non-random as well. The configuration averaging of the Fermi-surface and Fermi-sea terms of the spin-dependent conductivity tensor is performed by means of the coherent potential approximation (CPA) in analogy with that formulated recently for the standard conductivity tensor. The developed theory will be illustrated by studies of the spin Hall effect in selected Pt-based alloys (Pt-Au, Pt-Re, Pt-Ta) focused on the values and concentration trends of the spin Hall conductivity and the spin Hall angle.

MA 38.3 Wed 17:45 H52

High-speed domain-wall motion driven by spin-orbit torques and Dzyaloshinskii-Moriya interaction in a magnetic insulator — •Saül Vélez[1,2], Jakob Schaab[1,2], Marvin Müller[1], Elzbieta Gradauskaite[1], Morgan Trassin[1], Manfred Fiebig[1], and Pietro Gambardella[1] — [1]ETH Zürich — [2]Equally contributing

Electrical manipulation of magnetic domains and domain walls (DWs) in magnetic films is an essential ingredient for the development of novel functional devices. Current-induced spin-orbit torques (SOTs) can deterministically switch thin magnetic films and drive Néel chiral DWs at high speeds. The recent addition of magnetic insulators (MIs) as SOT-switchable magnetic layers have prospects for the development of novel non-volatile magnonic logic circuits and memories. However, key aspects such as the dynamics of DWs induced by SOTs in MIs remain so far unexplored. Here, by implementing magneto-optical Kerr effect microscopy, we demonstrate efficient SOT-manipulation of chiral DWs in Tm3Fe5O12(TmIG)/Pt -stabilized by a small in-plane field-, with measured velocities of up to 400 m/s at current densities $\sim 1.5\times 10^8$ A/cm^2. The high quality of the TmIG crystals leads to a very low current subthreshold for DW flow $\sim 5\times 10^6$ A/cm^2, extremely small depinning fields (∼1-2 Oe) and to extraordinarily large DW displacements upon domain contraction. We also identify Dzyaloshinskii-Moriya interaction (DMI) in TmIG/Pt, with slightly favored left-handed Néel chiral DWs. All these findings point MIs as strong candidates to compete with metallic ferromagnets for spintronic applications, yet enabling the implementation of complementary functionalities.

MA 38.4 Wed 18:00 H52

Spin and anomalous Hall effect induced charge and spin currents in ferromagnetic/nonmagnetic heterostructures — •Albert Hönemann[1], Christian Herschbach[1], Dmitry V. Fedorov[2], Martin Gradhand[3], and Ingrid Mertig[1,4] — [1]Martin Luther University Halle-Wittenberg, Halle, Germany — [2]University of Luxembourg, Luxembourg, Luxembourg — [3]University of Bristol, Bristol, United Kingdom — [4]Max Planck Institute of Microstructure Physics, Halle, Germany

Transport phenomena caused by spin-orbit coupling such as spin Hall effect (SHE) and anomalous Hall effect (AHE) are highly relevant topics of current research. In ferromagnetic/nonmagnetic heterostructures, the interplay of spin-orbit and exchange interaction causes new phenomena like spin-orbit torques [1].

We use an *ab initio* approach based on a relativistic Korringa-Kohn-Rostoker method to determine the electronic structure [2] and solve the linearized Boltzmann equation to describe the electronic transport [3]. We apply these methods to a Co/Cu superlattice with different substitutional impurities delta-distributed within the individual atomic layers [4]. We investigate the AHE-induced charge current as well as the SHE-induced spin current perpendicular and parallel to the interface and report on the spatial distribution of charge and spin current with respect to the interface.

[1] Gambardella *et al.*, Phil. Trans. R. Soc. A **369**, 3175 (2011); [2] Gradhand *et al.*, PRB **80**, 224413 (2009); [3] Gradhand *et al.*, PRL **104**, 186403 (2010); [4] Hönemann *et al.*, arXiv 1807.06404 (2018);

MA 38.5 Wed 18:15 H52

Ultra-low switching current density in all-amorphous W-Hf/CoFeB/TaOx films — •Katharina Fritz and Markus Meinert — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Germany

In our previous work [1], we investigated the spin Hall effect of W-Hf thin films, which exhibit a phase transition from a segregated phase mixture to an amorphous alloy below 70% W. Accompanied by a jump in resistivity, the spin Hall angle shows a pronounced maximum at the composition of the phase transition. A maximum spin Hall angle of θ_{SH}=0.20 was obtained for amorphous W0.7Hf0.3. Due to their amorphous character, the films are expected to contain few pinning centers and, therefore, to show fast domain wall motion, making them interesting in the context of current induced SOT switching.

Using Kerr microscopy, we study the domain wall structure and magnetization switching of amorphous W-Hf/CoFeB/TaOx stacks with perpendicular magnetic anisotropy and large spin Hall angle. We observe current induced domain wall motion without an in-plane assist field, indicating Néel-type domain walls. Investigations of magnetization switching as a function of in-plane assist-field and current pulse-widths reveal switching current densities as low as 3×10^9 A/m^2 in the dc limit.

[1] K. Fritz, S. Wimmer, H. Ebert, and M. Meinert, Phys. Rev. B 98, 094433 (2018)

MA 38.6 Wed 18:30 H52

Impurity induced Spin-Dependent Transport in Uranium Thin Films — •Ming-Hung Wu and Martin Gradhand — H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom

Uranium, a light actinide with itinerant 5f-electrons has been investigated for decades due to its complex properties [1]. It crystallizes in a large variety of structures such as α (orthorhombic), β (bct), γ (bcc) and hcp phase, it shows superconductivity and is close to a ferromagnetic transition [2]. Furthermore, its strong spin-orbital coupling makes uranium a promising material for spintronics applications. Especially in magnetic multilayer systems the proximity of heavy, large spin-orbit coupling, and ferromagnetic materials promises interesting emergent behavior [3]. In order to shed light on the complex physics in multilayer systems, we focus on the spin-dependent transport of uranium thin film. In our ab initio calculations we analyze the spin Hall effect and anomalous Hall effect in bulk uranium incorporating Fe impurities. We extend this work to free standing uranium thin film and discuss the implications of magnetic as well as non-magnetic impurities on the spin-dependent transport in multilayers including ferromagnetic materials.

Reference

[1] S. Adak et al., Phys. B 406, 3342 (2011).
[2] J.-C. Griveau et al., C. R. Phys. 15, 599 (2014).
[3] R. Springell et al., Phys. Rev. B 77, 064423 (2008).

MA 38.7 Wed 18:45 H52

Transverse spin Hall magnetoresistance in Au/YIG — •Tobias Kosub[1], Saül Vélez[2], Juan M. Gomez-Perez[2], Luis E. Hueso[2,3], Jürgen Fassbender[1], Fèlix Casanova[2,3], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [2]CIC nanoGUNE, Donostia-San Sebastian, Spain — [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

Magnetic insulators and nonmagnetic metals are both large classes of materials, but their combined application for insulator spintronics hinges on peculiar interface effects, such as spin Hall magnetoresistance (SMR). This effect is usually exploited for metals like Pt or Ta [1], which offer good chemical properties and large spin Hall angles.

However, many more metals can be employed in SMR applications when longitudinal and transverse resistances are properly separated [2] to routinely access smaller magnetoresistance effects.

We demonstrate this approach through a thorough study [3] of a Au thin film on the magnetic insulator $Y_3Fe_5O_{12}$ revealing both longitudinal and transverse magnetotransport signatures of the spin Hall magnetoresistance. An anomalous Hall effect due to proximity magnetization is not evident. We calculate spintronic quantities like spin mixing conductivities based only on static magnetotransport results using a meta-analysis.

[1] T. Kosub et al., *Nat. Commun.* **8**, 13985 (2017).
[2] T. Kosub et al., *Phys. Rev. Lett.* **115**, 097201 (2015).
[3] T. Kosub et al., *Appl. Phys. Lett.*, (2018), doi: 10.1063/1.5053902.

MA 39: Overview Talk: Christopher Lutz (joint session O/MA)

Time: Thursday 9:30–10:15 Location: H15

Invited Talk MA 39.1 Thu 9:30 H15

Magnetic sensing by single-atom spin resonance in an STM — •Christopher Lutz — IBM Almaden Research Center, San Jose California, USA

Electron spin resonance (ESR) is widely used to obtain high energy resolution of magnetic properties in bulk samples. We use a low-temperature STM to perform ESR of individual magnetic atoms on a surface, and employ these atoms as atomic-scale magnetic sensors. This technique combines the high energy resolution of spin resonance with the single-atom control of STM. We drive spin resonance by using the large electric field available in the tunnel junction, and sense the spin by means of magnetoresistance, using a spin-polarized STM tip. Magnetic coupling between two iron atoms placed a few nanometers apart shows inverse-cube dependence on distance, which indicates dipole-dipole interaction. This yields a precise measure of the magnetic moment, which is then used to probe other atoms, such as the magnetic bits formed by individual holmium atoms. The STM can also drive spin resonance of titanium and copper atoms, which show free spin-1/2 behavior, in contrast to the large moment and easy-axis anisotropy of iron. Assembled arrays of low-spin atoms show exchange coupling that results in highly entangled magnetic states. Some isotopes exhibit hyperfine coupling, the interaction between the nucleus and the electrons of an atom, and the ESR spectrum reveals properties of the nucleus and the influence of the local atomic environment. The combination of STM with ESR thus provides a flexible tool for exploring nano-scale magnetism.

MA 40: Frustrated Magnets - Strong Spin-Orbit Coupling (joint session TT/MA)

Time: Thursday 9:30–13:00 Location: Theater

MA 40.1 Thu 9:30 Theater

Dimerization of the honeycomb iridate α-Li_2IrO_3 under pressure — •Jihaan Ebad-Allah[1,2], V. Hermann[1], M. Altmeyer[3], F. Freund[1], A. Jesche[1], A. A. Tsirlin[1], M. Hanfland[4], P. Gegenwart[1], I. I. Mazin[5], D. I. Khomskii[6], R. Valenti[3], and C. A. Kuntscher[1] — [1]Universität Augsburg, 86159 Augsburg, Germany — [2]University of Tanta, 31527 Tanta, Egypt — [3]Goethe- Universität Frankfurt, 60438 Frankfurt am Main, Germany — [4]European Synchrotron Radiation Facility, BP 220, 38043 Grenoble, France — [5]Code 6393, Naval Research Laboratory, Washington DC 20375, USA — [6]Universität zu Köln, 50937 Köln, Germany

The honeycomb iridates A_2IrO_3 (A= Na, Li) show novel behavior and phases arising from the competition between spin-orbit coupling, magnetization, and dimerization. Here, we show the results of x-ray diffraction and optical spectroscopy measurements under pressure on α-Li_2IrO_3 and Na_2IrO_3 single crystals. In α-Li_2IrO_3, a pressure-induced dimerization of Ir-Ir bonds is observed at P_c=3.8 GPa, concomitant with anomalies in the optical response, while in Na_2IrO_3 this transition is expected at a much higher pressure [1]. The results are discussed in terms of the effect of Ir-Ir bonds on the magnetic and electronic properties and compared to other honeycomb materials.

[1] V. Hermann et al., Phys. Rev. B **97**, 020104(R) (2018)

MA 40.2 Thu 9:45 Theater

Fingerprints of Kitaev physics in RIXS on Na_2IrO_3 and α-Li_2IrO_3 — •Alessandro Revelli[1], Marco Moretti Sala[2], Giulio Monaco[3], Maria Hermanns[4], Petra Becker[5], Ladislav Bohatý[5], Friedrich Freund[6], Anton Jesche[6], Philipp Gegenwart[6], Paul van Loosdrecht[1], Jeroen van den Brink[7], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]ESRF, Grenoble, France — [3]Universitá di Trento, Italy — [4]Stockholm University, Sweden — [5]Abt. Kristallographie, Institut fur Geologie und Mineralogie, Universität zu Köln, Germany — [6]Experimentalphysik VI, Universität Augsburg, Germany — [7]IFW Dresden, Germany

The honeycomb iridates Na_2IrO_3 and α-Li_2IrO_3 are discussed as candidate materials for hosting Kitaev physics. We study the magnetic excitations in these compounds by resonant inelastic x-ray scattering (RIXS) at the Ir L_3 edge, searching for experimental fingerprints of Kitaev physics. In both compounds, we find a broad continuum of excitations centered at q=0. This continuum survives up to 300 K, roughly 20 times the magnetic ordering temperature. The dynamical structure factor shows that spin-spin correlations are restricted to nearest neighbors, a characteristic property of the Kitaev model. Also the polarisation dependence agrees with an interpretation in terms of bond-directional Kitaev exchange interactions.

MA 40.3 Thu 10:00 Theater

Thermodynamic evidence for proximity to the Kitaev QSL in A_2IrO_3 (A = Na, Li) — •Kavita Mehlawat[1,2], A Thamizhavel[3], and Yogesh Singh[1] — [1]Department of Physical Sciences, Indian Institute of Science Education and Research (IISER) Mohali, Knowledge City, Sector 81, Mohali 140306, India. — [2]Leibniz Institute for Solid State and Materials Research IFW Dresden, 01069 Dresden, Germany — [3]Department of Condensed Matter Physics and Material Sciences, Tata Institute of Fundamental Research, Mumbai 400005, India

The honeycomb lattice iridates A_2IrO_3 (A = Na, Li) are candidates for the realization of the Kitaev-Heisenberg model although their proximity to Kitaev's quantum Spin-Liquid (QSL) is still debated. We report on heat capacity C and entropy S_{mag} for A_2IrO_3 (A = Na, Li) in the temperature range $0.075\ K \leq T \leq 155\ K$ [1]. We find a two-peak structure for the magnetic heat capacity C_{mag} for both materials and S_{mag} shows a plateau between the peaks with a value close to $\frac{1}{2}$Rln2. These features signal the fractionalization of spins into Majorana Fermions close to Kitaev's QSL as predicted recently [2, 3]. These results provide the first thermodynamic evidence for the proximity of A_2IrO_3 to the Kitaev QSL [1].

Financial support: Hallwachs-Röntgen Postdoc Program, UGC-CSIR India.

[1] K. Mehlawat, A. Thamizhavel, and Y. Singh, Phy. Rev. B 95, 144406 (2017)
[2] J. Nasu, M. Udagawa, and Y. Motome, Phys. Rev. B 92 115122 (2015)
[3] Y. Yamaji, T. Suzuki, T. Yamada, S. I. Suga, N. Kawashima, and M. Imada, Phys. Rev. B 93, 174425 (2016)

MA 40.4 Thu 10:15 Theater

Copper and zinc iridates - new derivatives of the β-Li_2IrO_3 structure — •Alexander O. Zubtsovskii and Alexander A. Tsirlin — EP VI, EKM, University of Augsburg, Germany

Lithium and sodium iridates (A_2IrO_3 where A = Li, Na) form a narrow group of real-world material prototypes of the Kitaev model on the honeycomb and 3D honeycomb-like lattices. Tuning their properties by suitable chemical substituions remains a challenging problem, because only a few A_2IrO_3 iridates can be obtained by high-temperature solid synthesis. Here, we report two new compounds based on the β-Li_2IrO_3 structure and obtained by low-temperature ionic exchange of the Li^+-ions for the nonmagnetic (Zn^{2+}) and magnetic (Cu^{2+}) ions. Crystal structures refined using synchrotron X-ray diffraction data suggest the same motif of IrO_6 octaedra as in the parent compound, but with different positions of Cu^{2+} and Zn^{2+} compared to Li^+. We further report magnetic susceptibility data and discuss the nature of magnetism in these new compounds.

MA 40.5 Thu 10:30 Theater

Microscopic study of the Kitaev material β-Li_2IrO_3 under pressure and magnetic field — •Mayukh Majumder[1], Markus Pritz-Zwick[2], Tushar Kanti Dey[1], Rudra Sekhar Manna[1], Gediminas Simutis[3], Jean-Christophe Orain[3], Friedrich Freund[1], Rustem Khasanov[3], Pabitra Kumar Biswas[4], Norbert Büttgen[2], Aleaxander Tsirlin[1], and Philipp Gegenwart[1] — [1]EP VI, University of Augsburg — [2]EP V, University of Augsburg — [3]PSI, Switzerland — [4]ISIS Pulsed Neutron and Muon Source, UK

β-Li_2IrO_3 with Ir^{4+} moments on a three-dimensional hyperhoneycomb lattice belongs to the class of much-discussed Kitaev materials [1]. At zero-field and ambient pressure, it displays a phase transition at 38 K to an incommensurate non-coplanar and counter-rotating spiral magnetic state [2]. Application of magnetic fields exceeding 2.8 T along the easy b-axis transforms the ground state into a partially polarized quantum paramagnet, which we characterize by thermodynamic as well as ^{7}Li NMR experiments. Furthermore, long-range order (at zero-field) can also be suppressed by the application of hydrostatic pressure. We also discuss our comparative study of bulk and μSR experiments under pressure, which reveal a first-order transition at 1.4 GPa giving way to a new ground state with the coexistence of dynamically correlated and frozen spins [3]. No accompanying structural transition was found and further characterization by ^{7}Li NMR experiments under pressure is intended.

Work supported by DFG through TRR 80.

[1] Phys. Rev. Lett. 114, 077202 (2015)
[2] Phys. Rev. B 90, 205116 (2014)
[3] Phys. Rev. Lett. 120 237202 (2018)

MA 40.6 Thu 10:45 Theater

Structural and magnetic properties of antifluorite $(NH_4)_2IrCl_6$: Candidate $J_{\rm eff}$=1/2 Mott insulator — •Nazir Khan, Anton Jesche, and Alexander A. Tsirlin — EP VI, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

Ammonium hexachloroiridate, $(NH_4)_2IrCl_6$, possesses a face centered cubic (fcc) lattice of the antifluorite K_2PtCl_6-type with isolated and regular $IrCl_6$ octahedra at high temperatures. The lattice symmetry and the 5d magnetic ion (Ir^{4+}) render realization of ideal $J_{\rm eff}$=1/2 moment on the frustrated fcc lattice that has been predicted to host rich magnetic phases driven by Heisenberg and Kitaev exchanges. Using synchrotron X-ray powder diffraction and dilatometry, we investigate structural effects in $(NH_4)_2IrCl_6$ at low temperatures and in applied magnetic fields. Magnetization measurements indicate long-range antiferromagnetic ordering sets in below T_N=2.2 K. The field dependence of magnetization suggests a field induced magnetic phase transition at a critical field which depends on the crystallographic directions. The estimated effective magnetic moment seems consistent with the $J_{\rm eff}$=1/2 picture. However, dilatometry shows a sharp drop in the length change along the <111> direction just below T_N. This indicates a possible lattice distortion at low temperature which may result in a deviation from the ideal $J_{\rm eff}$=1/2 ground state. Magnetostriction measurements show that the field induced magnetization in the compound is strongly coupled to its lattice.

MA 40.7 Thu 11:00 Theater

Syntheses and magnetic properties of two sodium ruthenates: Na_3RuO_4 and Na_2RuO_3 — •Vera P. Bader, Alexander Tsirlin, Anton Jesche, and Philipp Gegenwart — EP VI, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany

Ruthenates show a diversity of magnetic phenomena, e.g. due to strong Ru-O covalency in the case of Ru^{5+} [1] and due to the non-magnetic $J = 0$ state potentially leading to Van Vleck excitons in Ru^{4+} [2]. Additionally, geometrical frustration may affect the magnetic properties. We focus on two ruthenates with the Ru-ions in the oxidation state 5+ and 4+, respectively. In Na_3RuO_4 the $Ru^{5+}O_6$ octahedra condense into tetramers which are composed of two equilateral triangles. In Na_2RuO_3 the Ru^{4+} ions form honeycomb layers. We prepare powder samples of Na_3RuO_4 via solid state reaction in a controlled atmosphere. The measurement of the magnetic susceptibility shows an antiferromagnetic transition at 30 K and suggests suppression of the magnetic order. Specific heat measurements reveal two consecutive phase transitions at 25 K and 28 K. Na_2RuO_3 powder is synthesized by thermal decomposition of a precursor in argon. Due to the layered structure the compound is prone to stacking faults. To improve the quality of the sample different synthesis routes have been compared.

[1] A. Hariki *et al.*, PRB 96, 155135 (2017)
[2] G. Khaliullin, PRL 111, 197201 (2013)

15 min. break.

MA 40.8 Thu 11:30 Theater

Bilayer Kitaev models: Phase diagrams and novel phases — •Urban F. P. Seifert[1], Julian Gritsch[2], Erik Wagner[3], Darshan G. Joshi[4], Wolfram Brenig[3,1], Matthias Vojta[1], and Kai P. Schmidt[2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, Germany — [2]Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Germany — [3]Institut für Theoretische Physik, Technische Universität Braunschweig, Germany — [4]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

We study the fate of $\mathbb{Z}_2$ spin liquid phases in differently stacked bilayer versions of Kitaev's honeycomb model. Increasing the inter-layer Heisenberg coupling $J_\perp$ (at fixed Kitaev couplings $K^{x,y,z}$) eventually destroys the topological spin liquid in favor of a paramagnetic dimer phase. We establish phase diagrams as a function of $J_\perp/K$ and Kitaev coupling anisotropies using Majorana-fermion mean-field theory, and employ different expansion techniques in the limits of small and large $J_\perp/K$. For strong anisotropies, we use effective models for the different layer stackings to discuss the quantum phase transition out of the Kitaev phase. The phase diagrams depend sensitively on the nature of the stacking and anisotropy strength. In some stackings and at strong anisotropies we find a single transition between the Kitaev and dimer phases. Importantly, for other stackings we prove the existence of two novel macro-spin phases which can be understood in terms of Ising chains which can be either coupled ferromagnetically, or remain degenerate, thus realizing a classical spin liquid. We also suggest the existence of a flux phase with spontaneous inter-layer coherence.

MA 40.9 Thu 11:45 Theater

Magnetic Frustration in Cd-substituted $HoInCu_4$ — Maximilian Wolf[1], Christina Baumeister[1], Sebastian Bachus[1], Jens-Uwe Hoffmann[2], Oliver Stockert[3], and •Veronika Fritsch[1] — [1]EP 6, Electronic Correlations and Magnetism, Augsburg University, Germany — [2]Helmholtz-Zentrum Berlin, Berlin, Germany — [3]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

$HoInCu_4$ is one of the rare examples of a partially frustrated magnetic metal [1, 2], due to the Ho ions forming an fcc lattice, with alternating antiferromagnetic planes along [100], which are separated by frustrated planes. The substitution of In with Cd in $HoInCu_4$ yields a breakdown of magnetic frustration, resulting for $HoCdCu_4$ in a fully ordered magnetic structure of ferromagnetic planes, stacked antiferromagnetically along the [111] direction [3, 4]. We have investigated the evolution of magnetic order and magnetic frustration in

$HoIn_{1-x}Cd_xCu_4$ with thermodynamic and transport measurements at low temperatures. Our data indicate the presence of a bicritical point between the frustrated and the unfrustrated phase. Furthermore we present neutron-diffraction data on single crystals of $HoInCu_4$ showing enhanced diffuse scattering as a consequence of magnetic frustration.

[1] V. Fritsch *et al.* PRB **71**, 132401 (2005)
[2] O. Stockert *et al.* unpublished
[3] V. Fritsch *et al.* PRB **73**, 094413 (2006)
[4] O. Stockert *et al.*, Experimental Report, MLZ Garching (2017)

MA 40.10 Thu 12:00 Theater

Discovery of kagome spin ice with crystallized magnetic monopoles in intermetallic compound HoAgGe — •Kan Zhao and Philipp Gegenwart — Experimentalphysik VI, Center for Electronic Correlations and Magnetism, Augsburg University, 86159 Augsburg, Germany

Spin ices are exotic phases of matter characterized by frustrated spins obeying local ice rules that minimize the number of spatially isolated magnetic monopoles, in analogy with the electric dipoles in water ice. In two dimension (2D), one can similarly define ice rules for in-plane Ising-like spins arranged on a kagome lattice, which require each triangle plaquette to have a single monopole, and can lead to a variety of unique orders and excitations at different temperatures.

By integral experimental and theoretical approaches including single crystal synthesis, magnetometry, thermodynamic measurements, neutron scattering and Monte Carlo simulations, we establish the intermetallic compound HoAgGe as the first example of crystalline (i.e. non-artificial) kagome spin ice[1]. It features a variety of partial and fully ordered states and sequence of field-induced phases at low temperatures, all consistent with the kagome ice rule. The multi-stage ordering behavior characteristic of kagome ice are further confirmed by specific heat and magnetic entropy data. Our discovery provides unique possibilities for the study of two-dimensional spin-ice physics.

[1] Zhao, K. et al. submitted (2018)

MA 40.11 Thu 12:15 Theater

Field-induced phases in extended Kitaev models: Insights from hidden symmetries and relevance for real materials — •David Kaib, Stephen Winter, and Roser Valenti — Institut für Theoretische Physik, Goethe-Universität Frankfurt

At zero magnetic field, Kitaev's honeycomb model hosts a Z_2 spin liquid with itinerant Majorana fermions. We study a field-induced intermediate phase (IP) in the antiferromagnetic (AFM) Kitaev model, which has been discussed in terms of a gapless $U(1)$ spin liquid [1-3].

In order to characterize the IP, we consider various dynamical correlations, calculated via exact diagonalization (ED). By analyzing hidden symmetries of the model, we discuss which general nonuniform fields retain the IP, and introduce nonuniform fields that relate the field-response of the AFM model to the FM model. Within ED resolution, we find that the IP could represent a line of critical points within the parameter space of such fields.

At last, we turn to models with extended interactions, in order to relate to real materials. Since the candidate materials are thought to realize ferromagnetic (FM) coupling, we identify an extended model with FM Kitaev coupling, that is dual to the pure AFM Kitaev model, and study its vicinity to Hamiltonians of real materials.

[1] C. Hickey et al., arXiv:1805.05953
[2] H.-C. Jiang et al., arXiv:1809.08247
[3] L. Zou et al., arXiv:1809.09091

MA 40.12 Thu 12:30 Theater

Excitations in the high magnetic field phase of the putative Kitaev material $RuCl_3$ — •Anuja Sahasrabudhe[1], Raphael German[1], Thomas C. Keothe[1], Jonathan Buhot[2], Vladimir Tsurkan[3], Alois Loidl[3], Petra Becker[1], Markus Grüninger[1], and Paul H.M. van Loosdrecht[1] — [1]Universität zu Köln, II. Physikalisches Institut. — [2]Radboud University Nijmegen, HMFL. — [3]Universität Augsburg, Institut für Physik.

$RuCl_3$ is discussed as one of the closest realizations of a J=1/2 Kitaev system on a hexagonal lattice. Yet it shows antiferromagnetic (AF) ordering at low temperature signaling the presence of important interactions in addition to the anisotropic Kitaev interactions. AF order can be suppressed by an external magnetic field. The phase diagram and the behavior in high fields are vividly discussed. Here, we probe the magnetic excitation spectrum of $RuCl_3$ with Raman spectroscopy in high magnetic fields. The observed high field excitation spectra yield a detailed insight into the nature of the high field phase.

MA 40.13 Thu 12:45 Theater

Heat transport in the putative Kitaev-Heisenberg spin liquid α-$RuCl_3$ under high magnetic fields — •Matthias Gillig[1], Xiaochen Hong[1], Richard Hentrich[1], Federico Caglieris[1], Maryam Shahrokhvand[2], Uli Zeitler[2], Maria Roslova[3], Anna Isaeva[3], Thomas Doert[3], Bernd Büchner[1], and Christian Hess[1] — [1]Leibniz Institute for Solid State and Material Research Dresden, Germany — [2]HFML, Radboud University, Nijmegen, Netherlands — [3]Faculty of Chemistry and Food Chemistry, TU Dresden, Germany

α-$RuCl_3$ is due to the honeycomb structure of its Ru-sites and the exchange frustration a prime candidate to realize the Kitaev model in a material. The model bears interesting physics with a quantum spin liquid (QSL) ground state and exotic excitations. Although α-$RuCl_3$ orders antiferromagnetically (AFM) below 7 K, indications of a QSL were found experimentally.

We have performed heat transport measurements on α-$RuCl_3$ down to $T = 0.4$ K and up to $B = 33$ T. Below $T = 4$ K thermal conductivity κ is raised in low magnetic fields up to 5 T before it decreases again to a minimum at 8 T. This decline coincides with the suppression of the AFM phase. For $B > 8$ T, κ is strongly enhanced for all temperatures and no sign of saturation is observed. The increase of thermal conductivity can be assigned to a field-induced phase featuring a field-dependent excitation spectrum. More specifically the data suggest the opening of a spin excitation gap which reduces the phononic scattering rate. For the whole T- and B-range investigated the data are consistent with a pure phononic heat transport mechanism.

MA 41: Magnetic Textures: Statics and Imaging II

Time: Thursday 9:30–13:15 Location: H37

MA 41.1 Thu 9:30 H37

Tunig the chiral orbital magnetization of single magnetic skyrmions with atomic defects — •Imara Lima Fernandes and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, D-52425 Jülich, Germany

Magnetic skyrmions are localized topologically protected non-collinear spin textures with particle-like properties. Recently, an optical experimental was proposed to access the topological nature of skyrmions by measuring the orbital magnetic moment generated by the non-collinearity of the spin magnetic moments [1]. Such a chiral orbital moment is independent of the strength of spin-orbit interaction and acquires a topological nature for large skyrmions [1,2]. Following our previous work [3], we explore from a full *ab initio* approach the effect of *3d* and *4d* transition metal defects interacting with realistic single magnetic skyrmions generated in PdFe bilayer deposited on Ir(111). We investigated the two main factors contributing to the chiral/topological orbital magnetization of skyrmions, namely the intertwining of the electronic structure properties with the three spin scalar chirality and possibly higher order chiralities.

[1] M. dos Santos Dias et al., Nat. Comm. **7**, 13613 (2016); [2] M. dos Santos Dias, S. Lounis, SPIE 10357, 103572A (2017); [3] I. Lima Fernandes et al., Nat. Comm. **9**, 4395 (2018).

– Funding from the ERC under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator grant 681405 - DYNASORE).

MA 41.2 Thu 9:45 H37

Thermal stability of skyrmions in chiral magnets and frustrated magnets — Benjamin Heil, Achim Rosch, and •Jan Masell — Institut für Theoretische Physik, Universität zu Köln, Köln, Deutschland

Magnetic skyrmions are particle-like textures in the magnetization which are characterized by a topological winding number. Skyrmions have been observed on scales ranging from nano- to micrometers and from cryogenic temperatures up to room temperature. The combination of properties like small size, topological quantization, and efficient manipulation makes them interesting candidates for applications in future information technology devices.

The topological winding number implies that - in a continuous model for the magnetization - a skyrmion can not be erased smoothly. This property is often argued to provide them with an extraordinary stability against thermal fluctuations. We calculate the minimal energy barrier for the destruction/creation of two species of skyrmions which are stabilized by (i) Dzyaloshinskii-Moriya or (ii) frustrated exchange interactions. We show that the energy barriers remain finite even in the continuous limit and provide an expression for the saddle point configuration. In particular we show that, in the absence of frustration, the micromagnetic saddle point is independent of the external magnetic field.

MA 41.3 Thu 10:00 H37

Modulated Magnetic Structures in GaV_4S_8 and GaV_4Se_8 as Seen by Lorentz Transmission Electron Microscopy — •László Balogh[1], Markus Preissinger[2], Vladimir Tsurkan[2], István Kézsmárki[2], Sándor Bordács[1], Ádám Butykai[1], Franziska Harder[3], Felix Börrnert[3], Daniel Wolf[3], and Axel Lubk[3] — [1]Department of Physics, Budapest University of Technology and Economics — [2]Zentrum für Elektronsiche Korrelation und Magnetismus, Institut für Physik, Universität Augsburg — [3]Institute for Solid State Research, Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

Among bulk materials the lacunar spinel GaV_4S_8 was the first compound in which Néel-type skyrmions were observed. Although Lorentz transmission electron microscopy (L-TEM) is found to be an excellent probe to study the structure and dynamics of Bloch skyrmions, the L-TEM imaging of the Néel-type modulations in lacunar spinels has so far been elusive. Here, we present a L-TEM study of the magnetic textures in GaV_4S_8 and GaV_4Se_8. On thin platelet samples we found that a modulated magnetic order developes below 40 K, which is two times higher compared to bulk crystals. By probing both the local magnetic and crystal structures the coupling between the spin and lattice degrees of freedom was studied in these multiferroic compounds.

MA 41.4 Thu 10:15 H37

Ordering Temperature and Skyrmions in Thin Lamellas of $GaMo_4S_8$ — •Markus Preissinger[1], Vladimir Tsurkan[1], István Kézsmárki[1], László Balogh[3], Sándor Bordács[3], Hiroyuki Nakamuro[4], Franziska Harder[2], Felix Börrnert[2], and Axel Lubk[2] — [1]Zentrum für Elektronsiche Korrelation und Magnetismus, Institut für Physik, Universität Augsburg — [2]Institute for Solid State Research, Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden — [3]Department of Physics, BME Faculty of Natural Science, Budapest University of Technology and Economics — [4]Department of Materials Science and Engineering, Kyoto University

Lacunar spinels are the first compounds found to host Néel-type skyrmions in their bulk forms. The Néel-type character of the skyrmions is a consequence of the polar rhombohedral distortion of their high-temperature cubic structure. Using Lorentz transmission electron microscopy, in thin lamellas of $GaMo_4S_8$ we found that the magnetic ordering temperature is 3 times higher compared to bulk crystals. Moreover, instead of Néel-type skyrmion lattices observed in bulk crystals with a typical periodicity of 10-20nm we found Bloch-type skyrmion crystals with lattice constants about 200nm. The change in the character of the skyrmions implies a chiral crystal structure realized in thin lamellas.

MA 41.5 Thu 10:30 H37

Zero-field magnetic skyrmions in RhCo films on Ir(111) — Marco Perini[1], André Kubetzka[1], Sebastian Meyer[2], Stephan von Malottki[2], Stefan Heinze[2], Roland Wiesendanger[1], and •Kirsten von Bergmann[1] — [1]Department of Physics, University of Hamburg, Germany — [2]Institut für Theoretische Physik und Astrophysik, University of Kiel, Germany

Magnetic skyrmions can be stablized in thin films by interface-induced Dzyaloshinskii-Moriya interactions that compete with exchange interactions. Such skyrmions can become lowest energy states in applied magnetic fields but are only metastable configurations in zero magnetic field.

We have studied the magnetic properties of a RhCo atomic bilayer on Ir(111) using spin-resolved scanning tunneling microscopy. Depending on the stacking of the Rh monolayer we observe a significant number of domain walls with unique rotational sense in the otherwise out-of-plane magnetized film. The path of these domain walls is typically not straight. We also observe small circular magnetic objects in the virgin state. They coexist in both oppositely magnetized ferromagnetic domains and resemble zero-field magnetic skyrmions with up- or down-pointing core. Ab-inito calculations in combination with spin dynamics simulations shed light on the origin of these unusual properties.

MA 41.6 Thu 10:45 H37

New findings in the magnetic phase diagram of GaV_4Se_8 — •Bertalan György Szigeti[1], Sándor Bordács[2], Ádám Butykai[2], Korbinian Geirhos[1], Jonathan Stuart White[3], Peter Lunkenheimer[1], Vladimir Tsurkan[1], Martino Poggio[4], and István Kézsmárki[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135, Ausgburg, Germany — [2]Department of Physics, Budapest University of Technology and Economics, 1111, Budapest, Hungary — [3]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, CH-5232, Villigen, Switzerland — [4]Department of Physics, University of Basel, 4056, Basel, Switzerland

GaV_4Se_8 is a member of the lacunar spinel family, which was found to host a robust Néel-type skyrmion lattice (SkL) on the full temperature range below the paramagnetic state down to zero kelvin and on a wide field range, even in oblique field directions[1]. This wide stability range is due to the polar, easy-plane anisotropic nature of GaV_4Se_8. In oblique magnetic fields we observed an additional modulated phase besides the cycloidal and the SkL states, using small-angle neutron scattering, magnetic torque, magnetization and magnetocurrent measurements. The formation of this novel modulated phase shows strong connection with the reorientation process of the modulation vectors.

[1] Bordács, S., et al., Sci. Rep. 7.1, 7584 (2017)

MA 41.7 Thu 11:00 H37

Observation of Skyrmion nucleation and manipulation by Ultrafast laser pulse — •Mohamad-Assaad Mawass[1], Nina Novakovic[1], Alexander Steigert[1], Oleksii Volkov[2], Denys Makarov[2], and Florian Kronast[1] — [1]Helmholtz-Zentrum Berlin für Materialen und Energie, Berlin, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany

Skyrmions are topologically protected magnetic entities, particle-like magnetization structures. They are considered as potential candidates for spintronic devices e.g. racetrack memories. While the controlled formation and motion of skyrmions is a key issue for the functionality of such devices, the conventional approach to generate and stabilize skyrmions in thin magnetic materials mostly leads to multiple and randomly distributed skyrmions (skyrmions cluster) without control on the formation or annihilation of individual entities. Here we provide a direct experimental visualization of ultrafast nucleation of individual Skyrmions by local laser heating at room temperature (RT) using a tunable fs-Laser beam in ultrathin ferromagnetic system employing X-ray Photoemission Electron Microscope (XPEEM). Furthermore, using the advantage of the all-optical helicity-dependent switching (AO-HDS) in which a circularly polarized femtosecond laser pulse switches the magnetization of a ferromagnetic thin film as function of laser helicity, we show for the first time writing and erasing one single Skyrmionic bubble domain controlled by the laser chirality at a specific laser condition at RT.

15 min. break

MA 41.8 Thu 11:30 H37

Skyrmion meets magnetic tunnel junction: an efficient way for electrical skyrmion detection investigated by ab initio theory — •Jonas F. Schäfer, Philipp Risius, Michael Czerner, and Christian Heiliger — Institut für Theoretische Physik, JLU Giessen

Building devices based on skyrmions requires a sufficiently sensitive detection method. The most straightforward way would be a device based on tunnel magnetoresistance, where a second magnetic electrode has to be used. However this approach is not practical since the magnetic counter electrode is most likely going to interfere with the skyrmion. This issue can be overcome by nonmagnetic counter-electrodes, which detect skyrmions from their non-collinear magnetization. Up to now, skyrmion induced non-collinear effects on transport were only investigated for STM tips based on the Tersoff and Hamann model, reaching about 20% for specific energies. In our work we examine the effects of skyrmions on electronic transport in Cu/Fe/MgO/Cu, Cu/Fe/MgO/V and V/Fe/MgO/Cu tunnel junctions, incorporating the influence of the barrier and the non-magnetic reference electrode material. Using our KKR based NEGF code, we show that non-collinear effects on transport strongly depend on the material of the leads, beyond energy dependent variations in the density of states. While for the copper electrodes only a variation in conductivity of a few percent can be reached, for vanadium the effect reaches up to 125% and is large over a wide energy range. The calculated large effect for vanadium is quite surprising and motivates further investigation.

MA 41.9 Thu 11:45 H37

High-resolution tunneling electron charge and spin transport theory of various skyrmions — •Krisztián Palotás — Wigner Research Center for Physics, Hungarian Academy of Sciences, Budapest, Hungary — Budapest University of Technology and Economics, Budapest, Hungary — University of Szeged, Szeged, Hungary

Based on a combined charge and vector spin transport theory [1] capable of imaging noncollinear magnetic textures on surfaces with spin-polarized scanning tunneling microscopy (SP-STM) [2], the high-resolution tunneling electron charge and coupled spin transport properties [3] of a variety of Néel- and Bloch-type skyrmions are investigated [4]. The chosen axially symmetric skyrmions belong to the same topology class, having a vorticity value of 1. It is demonstrated that the SP-STM images can be used to determine the helicity of the skyrmions. Moreover, the modified spin polarization vectors of the conduction electrons due to the local chirality of the complex spin texture are incorporated into the tunneling model. It is found that this effect modifies the apparent size of the skyrmions. These results contribute to the proper identification of topological surface magnetic objects imaged by SP-STM, and deliver important spin transfer torque vector parameters for current-induced spin dynamics.

References: [1] K. Palotás et al., Phys. Rev. B 94, 064434 (2016). [2] K. Palotás et al., Phys. Rev. B 96, 024410 (2017). [3] K. Palotás et al., Phys. Rev. B 97, 174402 (2018). [4] K. Palotás, Phys. Rev. B 98, 094409 (2018).

MA 41.10 Thu 12:00 H37

Skyrmions in 2D chiral magnets stabilized by tilted magnetic field — •Vladyslav Kuchkin[1], Filipp Rybakov[2], Stefan Blügel[1], and Nikolai Kiselev[1] — [1]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics, KTH-Royal Institute of Technology, SE-10691 Stockholm, Sweden

Chiral magnets are known to host a variety of different nontrivial localized magnetization configurations possessing particle-like properties, which can be effectively manipulated by various external stimuli. The corresponding model Hamiltonian contains contributions of Heisenberg exchange, Dzyaloshinskii-Moriya interaction and Zeeman energy. In the current work, we consider 2D chiral magnets in the presence of tilted magnetic fields. Using the micromagnetic approximation allows reducing the problem to the system of partial differential equations, which can be analyzed with accurate analytical methods. This approach allowed us to study the long-range interaction between the skyrmions of different types and their stability as a function of the angle and strength of the tilted magnetic field. The combination of the analytical approach with numerical simulations allowed us to obtain the phase diagrams, the coexisting regions of magnetic skyrmions with different topological charges, as well as to describe the interaction potential between them. The presented results are important for both fundamental research as well as practical applications of magnetic skyrmions.

MA 41.11 Thu 12:15 H37

Small Skyrmions at room temperature: Realistic skyrmion lifetimes from the atomistic model — •Markus Hoffmann[1], Gideon P. Müller[1,2], and Stefan Blügel[1] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Science Institute of the University of Iceland, VR-III, 107 Reykjavík, Iceland

Chiral magnetic skyrmions are of great scientific interest but also of potential relevance in information technology, data storage, processing, and neuromorphic computing. To compete with existing technology, those skyrmions have to fulfill stringent requirements: Long lifetimes at room temperature at sizes smaller than 10 nm. Therefore, a significant effort of the magnetism community lies on the analysis of the stability of such small skyrmions. So far [1,2], mainly the micromagnetic model was employed. Here, we go beyond the micromagnetic limit, using the atomistic Heisenberg-type spin-lattice Hamiltonian. We show that the range and the frustration of magnetic interactions as well as structural aspects provide a bright outlook for lifetime dependence on the materials properties. For this, we perform LLG, GNEB and HTST calculations within our Spirit code [3].

We acknowledge funding from the DARPA TEE program through grant MIPR (#HR0011831554) from DOI.

[1] F. Büttner *et al.*, Sci. Rep. **8**, 4464 (2018)
[2] A. Bernand-Mantel *et al.*, SciPost Phys. **4**, 27 (2018)
[3] Spirit spin simulation framework, spirit-code.github.io

MA 41.12 Thu 12:30 H37

Co/Pt/W and Co/Pt/Ir multilayers as host materials for potential Skyrmion devices — •Valentin Ahrens, Simon Mendisch, Martina Kiechle, Ádám Papp, and Markus Becherer — Technische Universität München(TUM), Chair of Nanoelectronics, Arcisstr. 21, 80333 Munich, Germany

Perpendicular magnetized, room temperature sputtered, Co/Pt/Ir and Co/Pt/W multilayers are investigated as a potential host for skyrmions. Basic investigations on the magnetic properties (H_c, K_{eff} and IEC), of single and bilayer stacks were performedin order to promote a better understanding of those multilayer systems. These properties are assessed by means of magneto-optical Kerr effect(MOKE) measurements and K_{eff} is fitted from anomalous hall effect (AHE) measurements. Furthermore the hysteretic behaviour of nanostructured films is investigated using a laser-MOKE. By means of FIB irradiation (Ga^+), the anisotropy of the nanostructures is locally decreased to form artificial nucleation centers. This allows to explicitly tune the interlayer exchange coupling (IEC) from FM to AF by means of Ga^+ radiation. This tunability is highly sensitive to the Ga^+ ion dose. Different multilayer stacks are evaluated according to their ability to host skyrmions. To reach certain domain states the samples are demagnetized by a linearly decreasing oscillatory magnetic field. By application of field pulses of different length t_{pulse} and strength B_{pulse} the domains are transformed into skyrmions. The skyrmion behaviour in 3D magnetic fields is investigated by means of MOKE and magnetic force microscopy (MFM) imaging.

MA 41.13 Thu 12:45 H37

Nucleation process of the low-temperature skyrmion phase in Cu_2OSeO_3. — •Denis Mettus, Marco Halder, Alfonso Chacon, Andreas Bauer, and Christian Pfleiderer — Physik Department, Technische Universität München, Garching, Germany

Magnetic materials can host topologically non-trivial spin textures called skyrmions, which are an object of interest in recent years. For bulk chiral magnets with cubic lattice symmetry, it was believed that a skyrmion phase exists near the helimagnetic to paramagnetic transition, which is stabilized by thermal fluctuations.

Recently, a second skyrmion phase in Cu_2OSeO_3 has been identified at low temperatures (LTS), accompanied by a tilted conical phase. The new skyrmion phase is thermodynamically disconnected from the well-known high-temperature phase (HTS) and has a different stabilization mechanism given by cubic magnetocrystalline anisotropy terms.

We report a study of the nucleation process of the LTS. We present first order reversal magnetization data revealing that the nucleation of the LTS occurs by virtue of the tilted conical phase. We consider in addition the effects of magnetic field cycling on the magnetization and ac susceptibility for single crystal Cu_2OSeO_3 sample. The analysis of the susceptibility data allows us to identify the changes in the different phases concentrations with the varying parameters of a magnetic field cycling, which helps to understand the process of the phase nucleation.

MA 41.14 Thu 13:00 H37

Nanoscale magnetic structure dependence on plate thickness in $Mn_{1,4}PtSn$ single crystals — •Belen Zuniga[1,2], Peter Milde[1], Praveen Vir[2], Markus König[2], Lukas Eng[1], Claudia Felser[2], and Andy Mackenzie[2] — [1]Institute of Applied Physics, TU Dresden, Dresden, Germany. — [2]Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany.

Materials with D_{2d} crystal symmetry may theoretically host a variety of different magnetic textures such as spirals or antiskyrmions [1,2]. $Mn_{1,4}PtSn$ is an acentric tetragonal Heusler compound that possesses such a D_{2d} symmetry and furthermore, a helical ground state and an antiskyrmion lattice under the application of a small magnetic field at room temperature [3].

Here we show that the *ab*-plane of bulk $Mn_{1,4}PtSn$ exhibits ferromagnetic order, with high anisotropy and self-organization of the magnetic domains, hosting magnetic structures over a broad range of sizes, ranging from ∼ 10 μm down to ∼ 100 nm. Moreover, when preparing ultra-thin single-crystalline $Mn_{1,4}PtSn$ samples, we find a critical sample thickness of 4.5 μm below which the fractal-like magnetic domain patterns abruptly change into magnetic lamellar structures with sub-micrometer periodicity. When applying a magnetic field, a regular lattice of bubble-like domains is induced into these crystalline thin-plate $Mn_{1,4}PtSn$ samples.

References: [1] A.N. Bogdanov and D.A. Yablonskii, Sov. Phys. JETP 68 (1989) 101. [2] W. Koshibae and N. Nagaosa, Nat. Commun. 7 (2016) 10542. [3] A.K. Nayak et al., Nature 548 (2017) 561.

MA 42: Focus Session: Curvilinear magnetism

Time: Thursday 9:30–12:30 Location: H38

Invited Talk MA 42.1 Thu 9:30 H38
Magnetic nanomembranes: From flexible magnetoelectronics to remotely controlled microrobotics — •Oliver G. Schmidt — Institute for Integrative Nanosciences, Leibniz IFW Dresden, Germany

Magnetic nanomembranes are thin, flexible, transferable and can be shaped into unique 3D microobjects. This allows us to explore technology platforms based on shapeable, imperceptible and printable magnetoelectronics for new application scenarios; especially those where magnetic field sensing plays an essential role, such as position tracking in automotive systems, wearable electronics and human-machine interfaces.

If magnetic nanomembranes are self-assembled and integrated into 3D micro-objects they serve as unique device architectures for on-chip electronic applications as well as off-chip deployment of remotely controlled micro-robotic systems. In the latter case, the magnetic material is an essential part in constructing cellular cyborg machinery for alternative approaches in targeted drug delivery and reproduction technologies.

Invited Talk MA 42.2 Thu 10:00 H38
Curvature-induced chiral effects in nanomagnets — •Oleksandr Pylypovskyi — Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

Demand in scalable and energy saving devices for memory, computing and sensoric applications excites research in development of materials whose properties provide novel and more efficient ways for manipulation of spins and electrons. One of the perspective directions is the extension of planar films into the third dimension. The shape and topology of magnetic shell couples with a magnetic texture either via short- and long-range parts of magnetostatics or geometrically defined anisotropy axes in specifically prepared shells.

In this talk, we consider chiral effects in quasi-one dimensional magnets and curvilinear thin shells. The local curvature appears as an effective inhomogeneous antisymmetric exchange of the interfacial Dzyaloshinskii-Moriya interaction type and nonlocal magnetostatics-driven chiral interaction. In combination with geometry-induced anisotropy, it modifies ground state as well as statics and dynamics of topological solitons (domain walls and skyrmions).

Invited Talk MA 42.3 Thu 10:30 H38
Chiral magnetoresistance in curved and noncurved geometries — •Pietro Gambardella — Department of Materials, ETH Zurich, Switzerland

Magnetoresistive phenomena occupy a prominent place in current developments of spintronics and spin-orbitronics. This talk will focus on the emergence of chiral electron transport in magnetic conductors due to geometrical effects and spin-orbit coupling. As a first system of interest, we will discuss CoNi microhelices fabricated by electrodeposition. The magnetoresistance of such structures presents a specific angular and field dependence as well as a chiral unidirectional component, which set it apart from the magnetoresistance of thin films and tubular structures. As a second example, we will discuss nanometer-thick layered conductors lacking inversion symmetry. In these systems, charge-spin conversion phenomena due to the spin Hall and Rashba-Edelstein effects also result in a chiral unidirectional magnetoresistance, which scales with the current and changes sign for either current or magnetization reversal. We will describe the different mechanisms that compete to determine the unidirectional resistance in helical and layered conductors, as well as their current, field, and material dependence. These results provide an overview of the magnetoresistance in chiral conductors as well as practical insight on how to design structures that display nonreciprocal electron transport.

Invited Talk MA 42.4 Thu 11:00 H38
Domain Wall Dynamics in Curved Geometries — •Robert M. Reeve[1], Mohamad-Assaad Mawass[1,2,3], Kornel Richter[1], Andre Bisig[1,2], Benjamin Krüger[1], Markus Weigand[2], Hermann Stoll[1,2], Andrea Krone[1], Florian Kronast[3], Gisela Schütz[2], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg-University Mainz — [2]Max Plank Institute for Intelligent Systems, Stuttgart — [3]Helmholtz-Zentum Berlin für Materialien und Energie

Curved geometries have recently raised significant interest due to novel effects occurring when the curvature of the geometry influences the spin dynamics which is highly relevant for shapeable spintronics applications [1]. One of the first curved geometries that has been intensively investigated is the ring geometry since it exhibits special switching properties and also it is an ideal playground to study confined spin structures such as domain walls [2] and it may be appropriate for technological applications such as MRAM. The special curved geometry of a ring allows one to use a fully flux-closure vortex state to store bits and to switch between states of opposite circulation using uniaxial fields [3], the concept of automation is used [4]. Automotion relies on energy gradients generated by geometrical gradients as implemented in varying curvature rings [5] where one can tailor the dynamics and in particular the domain wall velocities. [1] D. Makarov et al., Appl. Phys. Rev. 3, 011101 (2016) [2] M. Kläui et al., Reviews in J. Phys. Cond. Mat. 15, R985 (2003) & 20, 313001 (2008) [3] K. Richter et al., Phys. Rev. B 94, 024435 (2016) [4] M. Mawass et al., Phys. Rev. Appl. 7, 044009 (2017) [5] K. Richter et al., Phys. Rev. Appl. 5, 024007 (2016)

15 min. break

MA 42.5 Thu 11:45 H38
Curvature induced asymmetric dispersion in nanotubes: the full story — •Attila Kákay — Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany

Spin-wave propagation in ferromagnetic nanotubes is fundamentally different than in flat thin films as shown recently[1]. The dispersion relation is asymmetric regarding the sign of the wave vector. As a consequence, spin waves traveling in opposite directions have different wavelength. This purely curvature induced effect originates from the dipole-dipole interaction, namely from the dynamics dipolar volume charges. Such non-reciprocal spin-wave propagation [2] is known for flat thin films with interfacial Dzyalonshiinsky-Moriya interaction. Here, we will discuss in a nanotube with circular cross section the effect of the divergence terms, one by one, on the spin-wave dispersion. The divergence terms in the cylindrical coordinate system together with the term depending on the mean curvature lead to different asymmetries of the dispersion. Moreover, we emphasise the importance of the mean curvature and show that by tailoring it the asymmetry of the dispersion relation can be suppressed with the modulation of the nanotube diameter. As a consequence, we can conclude that the curvature induced magnetochiral effect with magnetostatic origin can be switched on and off by the manipulation of the surface curvature. [1] J.A. Otálora, et. al., Phys. Rev. Lett. 117, 227203 (2016). [2] K. Zakeri, et. al., Phys. Rev. Lett. 104, 137203 (2010).

MA 42.6 Thu 12:00 H38
Experimental confirmation of exchange-driven DMI — •Oleksii Volkov[1], Florian Kronast[2], Ingolf Mönch[1], Mohamad-Assaad Mawass[2], Attila Kákay[1], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany — [2]Helmholtz-Zentrum Berlin für Materialen und Energie, Berlin, Germany

Dzyaloshinskii-Moriya interaction (DMI) is a key ingredient which allows to obtain chiral non-collinear magnetic textures, e.g. chiral domain walls and skyrmions. The conventional spin-orbit induced DMI emerges in gyrotropic crystals or at the interfaces. Therefore, tailoring of DMI is done by optimizing materials. A viable alternative to the material screening approach relies on the use of geometrically broken symmetries of conventional materials, where local geometrical curvatures generate effective exchange-induced DMI.

Here, we provide the very first experimental confirmation of the existence of the curvature-induced DMI in a Permalloy parabolic nanostripe. By analyzing the evolution of transversal domain wall (DW) [1] under the influence of external field we correlate the depinning field of the DW with the curvature-induced DMI field. We put forth a framework to analyze this field and assess the strength of the effective DMI.

[1] O. Volkov et. al, Physica Status Solidi – Rapid Research Letters, 1800309 (2018).

MA 42.7 Thu 12:15 H38

Experimental and theoretical study of curvature effects in parabolic nanostripes — •Oleksii Volkov[1], Florian Kronast[2], Ingolf Mönch[1], Mohamad-Assaad Mawass[2], Attila Kákay[1], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany — [2]Helmholtz-Zentrum Berlin für Materialen und Energie, Berlin, Germany

Curvilinear magnetic objects are in the focus of intensive research due to the possibility to obtain new fundamental effects and stabilize topologically non-trivial magnetic textures at the nanoscale [1]. The physics in these systems is driven by the interplay between exchange and magnetostatic interactions, which contain spatial derivatives in their energy functionals. This makes both interactions sensitive to the appearance of bends and twists in the physical space.

Here, we address experimentally and theoretically curvature-induced effects in parabolic nanostripes with different geometrical parameters [2]. We show that two different magnetic states can appear: the homogeneous magnetic distribution along the parabolic stripe and a state with a transversal domain wall pinned at the vertex of the parabola. The analytical calculation, based on local magnetostatic model, showed its validity and applicability in a wide range of geometrical parameters.

[1] R. Streubel et al., J. Phys. D: Applied Physics 49, 363001 (2016).

[2] O. Volkov et al., Physica Status Solidi – Rapid Research Letters, 1800309 (2018).

MA 43: Micro- and nanostructured magnetic materials

Time: Thursday 9:30–11:15 Location: H52

MA 43.1 Thu 9:30 H52

Accelerated magnetic re-ordering in Ne^+ irradiated FeAl thin film — •Maciej Oskar Liedke[1], Jonathan Ehrler[2], Rantej Bali[2], Jakub Cizek[3], Maik Butterling[1], Eric Hirschmann[1], and Andreas Wagner[1] — [1]Institute of Radiation Physics, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — [2]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — [3]Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic

Thermally activated (re)ordering processes in ferromagnetic $Fe_{60}Al_{40}$ thin films during in-situ annealing have been investigated by magnetometry and positron annihilation spectroscopy supported with atomic superposition calculations. A ferromagnetic A2-disordered phase coexists with a paramagnetic B2-ordered phase in the as-grown sputter deposited films. Due to thermal treatment at elevated temperature of 773K the B2-phase can be fully established. However, employing Ne^+ irradiation as a tool to generate a pure A2-phase and subsequent mild temperature annealing the activation temperature for (re)ordering can be decreased to only 400K. It will be shown that due to immobile large vacancy clusters, which are dominant in the as-grown films and possess a high thermal activation barrier the ordering is strongly hindered. Ion irradiation breaks down these pinning defects strongly accelerating thermal diffusion and reordering. These results provide insights into thermal reordering processes in binary alloys, and the consequent effect on magnetic behavior.

MA 43.2 Thu 9:45 H52

Self-assembly of magnetic nanoparticles investigated using advanced scattering techniques — •Nileena Nandakumaran[1], Mikhail Feygenson[1], Lester Barnsley[2], Artem Feoktystov[2], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science, 52425 Jülich, Germany — [2]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science JCNS at Heinz Maier-Leibnitz Zentrum MLZ, Lichtenbergstraβe 1,85748 Garching, Germany

Superparamagnetic iron oxide nanoparticles (NPs) of 20nm and 27nm were investigated using small angle neutron scattering (SANS, revealing a profound size effect of self-assembly in the larger sized nanoparticles. The particle size distribution and the core diameter were determined with Transmission electron microscopy and small angle x-ray scattering (SAXS). Magnetization measurements reveal a blocking temperature above the room temperature. SANS with polarized neutrons was used to separate the nuclear and magnetic scattering contributions for both NP sizes. The 27nm NPs form linear chains even in the zero field; SAXS and SANS data were best described by a linear pearl model. The self-assembly of 27nm NPs could be manipulated by an applied magnetic field, as clearly shown by the 2-D SANS and SAXS data. This analysis opens new perspectives and understanding of the control and manipulation of NPs to benefit a wide range of applications, including catalysis and biomedicine.

MA 43.3 Thu 10:00 H52

Field-induced deformation of nanorod-hydrogel composites — •Kerstin Birster, Rouven Schweitzer, Christoph Schophoven, and Andreas Tschöpe — Universität des Saarlandes, Experimentalphysik, Campus D2.2, 66123 Saarbrücken

Shape-changing smart materials are able to reversibly deform in response to an external stimulus such as temperature, pressure, or electric and magnetic fields. An evident application is their use as active components in soft microactuators.

In the present study, we used ferromagnetic single domain nanorods as magnetic phase in cylindrical shaped polyacrylamide hydrogel composites. During polymerisation a magnetic texture was imprinted by alignment of the anisotropy axes in magnetic fields of predefined geometry. If the nanorods are directed perpendicular to the long cylinder axis, the composite is forced to a torsional deformation. A more complex spatially modulated alignment of the anisotropy axis into one half-space caused a sinusoidal bending of the composite filament. The specific deformation patterns were measured by video microscopy and data were analyzed assuming a continuum model with volume-distributed torques. Both examples demonstrate the potential of tuning the field induced deformation of magnetic composites which will be extended to a combined torsional bending motion. An alternative approach is the use of a magnetic gradient field to collect core-shell nanorods with adsorbed gelatin in a thin 2D multilayer.

MA 43.4 Thu 10:15 H52

Voltage control of magnetism in Iron oxide/Iron nanostripes and electrodeposition of epitaxial Fe nanocuboids — •Martin Nichterwitz[1,2], Shashank Honnali Sudheendra[1], Jonas Zehner[1], Mara Henschel[1], Kornelius Nielsch[1], and Karin Leistner[1] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Physical Chemistry, Technische Universität Dresden, 01062 Dresden, Germany

Voltage control of magnetism by ionic approaches, such as the transformation between metal oxide and metal in gated architectures, presents a promising pathway to low-power magnetic devices. Up to now, magneto-ionic manipulation has been reported mainly for ultrathin films.[1,2] We investigate the transfer of magneto-ionic effects from extended thin film to nanostripe geometry. We present initial results on voltage-controlled magnetoresistance in sputtered Fe stripes on Au probed via in situ magneto-transport measurements. The magnetoresistance behavior is found to be strongly dependent on the FeOx/Fe thickness. A voltage-induced change of resistance and magnetoresistance is achieved and discussed with regard to the electrochemical manipulation of the grain boundaries. Further, electrochemical control of shape and magnetism of FeOx/Fe nanoislands is presented by epitaxial electrodeposition on GaAs. A stable Fe core with crystalline oxide shell and strong in-plane magnetic anisotropy is achieved.[3]

[1] Gilbert et al., Nature Comm. 7, (2016) 12264 [2] Duschek et al., APL Mater. 4 (2016) 032301 [3] Leistner et al. Nanoscale 9 (2017) 5315

MA 43.5 Thu 10:30 H52

Domain engineering in ferroic systems with a compensated magnetic order — •Amadé Bortis[1], Jannis Lehmann[1], Claire Donnelly[1,2], Naëmi R. Leo[1,2], Peter M. Derlet[1,2], Laura J. Heyderman[1,2], and Manfred Fiebig[1] — [1]Departement of Materials, ETH Zurich, 8093 Zurich, Switzerland — [2]Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

The configuration of domains in ferromagnetic materials is determined by the interplay of competing energy terms. In systems with zero net magnetisation, it is much less understood how microscopic coupling mechanisms affect the size and morphology of domains and domain walls. In order to access all relevant magnetic degrees of freedom, we investigate the formation of domains in a ferroic model system consisting of planar dipolar-coupled Ising-like ferromagnetic building blocks. These nanomagnets are arranged on a square lattice such that a unit cell yields a vortex-like compensated magnetisation and the as-grown state consists of domains with uniform magnetic handedness. By varying the distances between nanomagnets, we can independently tune the interaction strengths for the inter- and intra-vortex coupling. Using magnetic force microscopy and Monte-Carlo simulations, we examine a general phase diagram and link the average domain size to the ratio of inter- and intra-vortex coupling strength. We observe transitions to short-range order above the critical temperature that determine the resulting substructure of a domain wall. Our work reveals an approach to model and tailor ferroic order and provides insight into the formation of domains in materials with zero net magnetisation.

MA 43.6 Thu 10:45 H52

Origin and Manipulation of Stable Vortex Ground States in Permalloy Nanotubes — Michael Zimmermann[1], •Thomas Meier[1], Florian Dirnberger[1], Attila Kákay[2], Martin Decker[1], Sebastian Wintz[2,3], Simone Finizio[3], Elisabeth Josten[2], Jörg Raabe[3], Matthias Kronseder[1], Dominique Bougeard[1], Jürgen Lindner[2], and Christian Back[4,1] — [1]Institut für experimentelle und angewandte Physik, Universität Regensburg — [2]Helmholtz-Zentrum, Dresden Rossendorf, Institute of Ion Beam Physics and Material Science — [3]Paul Scherrer Institut, Villigen, Schweiz — [4]Physik-Department, Technische Universität München

We present a detailed study on the static magnetic properties of individual permalloy nanotubes (NTs) with hexagonal cross-sections. Anisotropic magnetoresistance (AMR) measurements and scanning transmission X-ray microscopy (STXM) are used to investigate their magnetic ground states and its stability. We find that the magnetization in zero applied magnetic field is in a very stable vortex state. Its origin is attributed to a strong growth-induced anisotropy with easy axis perpendicular to the long axis of the tubes. AMR measurements of individual NTs in combination with micromagnetic simulations allow the determination of the magnitude of the growth-induced anisotropy for different types of NT coatings. We show that the strength of the anisotropy can be controlled by introducing a buffer layer underneath the magnetic layer. The magnetic ground states depend on the external magnetic field history and are directly imaged using STXM.

MA 43.7 Thu 11:00 H52

Dynamical magnetic properties of individual permalloy nanotubes — Michael Zimmermann[1], Thomas Meier[1], Elisabeth Josten[2], Kilian Lenz[3], Rysard Narkovic[3], Jürgen Lindner[3], Christian Horst Back[4], and •Attila Kakay[3] — [1]Physics Department, Universität Regensburg, Universitätsstr. 31, D-93040 Regensburg, Germany — [2]Forschungszentrum Jülich, Ernst Ruska-Center, Jülich, Germany — [3]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [4]Technical University Munich, Physics Department, München, Germany

Magnetic nanostructures extending into the third dimension are intensively studied nowadays due to their possible use as building blocks for future applications as dense magnetic memories, logical devices or magnetic sensors. Recently we have shown that the ground states of the individual nanotubes with hexagonal cross section can be manipulated with static and rf magnetic fields[1]. Here, we present a detailed study on the ferromagnetic response of such individual nanotubes. Finite element micromagnetic simulations are used to interpret the measurement data. We show that the main FMR mode excited in the axially magnetised case for the modes counter-propagating around the circumference is not degenerate. The lifting of the degeneracy is due to the hexagonal shape. Moreover, the presence of the curvature induced magnetochiral effect strongly suppresses one of the modes. [1] M. Zimmermann et. al, Nano Letters 18, 2828 (2018)

MA 44: Magnetic imaging (Experimental techniques)

Time: Thursday 9:30–11:00 Location: H53

MA 44.1 Thu 9:30 H53

Towards determining the spin axis of individual CoO nanoparticles — •David Bracher[1], Tatiana M. Savchenko[1], Martin Testa Anta[2], Veronica Salgueiriño[2], Frithjof Nolting[1], Martino Poggio[3], and Armin Kleibert[1] — [1]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland — [2]Departamento de Física Aplicada, Universidade de Vigo, 36310, Vigo, Spain — [3]Department of Physics and Astronomy, University of Basel, CH-4056 Basel, Klingelberstrasse 82, Switzerland

Antiferromagnetic materials at the nanoscale are of profound interest for spintronics devices, e.g. spin valves and magnetic random access memories etc. However, the absence of a stray field makes exploring nano-sized antiferromagnetically ordered system very challenging. Here, we use x-ray magnetic linear dichroism (XMLD) spectromicroscopy to investigate the chemical and magnetic properties of individual CoO/Co3O4 core- shell nanoparticles with a diameter of about 100 nm. Complementary high resolution scanning electron microscopy is used to correlate the morphology and the magnetic properties of individual nanoparticles. Temperature-dependent XMLD spectra of single nanoparticles indicate a reversible magnetic phase transition of the CoO core close to Néel temperature of bulk CoO. In addition we observe a pronounced orientation dependent XMLD signal of the nanoparticles. These observations reveal that nano-sized CoO/Co3O4 structures exhibit stable antiferromagnetic order with a preferred spin axis. Our approach paves the way towards characterization of nanoscaled antiferromagnetic spintronics devices.

MA 44.2 Thu 9:45 H53

Nanoscale imaging of ultrafast spin dynamics using high-harmonic radiation — •Sergey Zayko[1], Ofer Kfir[1], Michael Heigl[2], Michael Lohmann[1], Murat Sivis[1], Manfred Albrecht[2], and Claus Ropers[1] — [1]IV Physical Institute, University of Göttingen — [2]Institute of Physics, University of Augsburg

Sources of ultrashort pulses at the extreme-UV and soft-X-rays provide for an ultrafast probe of magnetic textures and topological spin arrangements, such as domain patterns and skyrmions. However, despite a widespread application of high harmonic spectroscopy over the past decade, magnetic imaging using high harmonics has only recently been demonstrated [1]. Here, we report the first demonstration of nanoscale real-space imaging of ultrafast spin dynamics using circularly-polarized high-harmonic radiation. By measuring transient x-ray magnetic circular dichroism (XMCD), femtosecond demagnetization in nanoscale networks of magnetic domains is captured with sub-40-fs temporal and down to 19 nm spatial resolution [2]. This versatile ultrafast magneto-optical microscope will allow for comprehensive studies of ultrafast magnetism in space and time, compatible with applied external magnetic fields, currents, optical excitation and other in-situ capabilities. Furthermore, we believe that polarization-dependent ultrafast high harmonic imaging can be extended to other ultrafast phenomena, including structural dynamics and femtochemistry [3]. [1] Kfir, Zayko et al., Science Advances 3, no. 12, eaao4641(2017) [2] Zayko et al., Th1B.4. 10.1364/CLEOPR (2018) [3] Kraus et al., Nat. Rev. Chemistry 2, 82-94 (2018)

MA 44.3 Thu 10:00 H53

A Concept for a Magnetic Particle Imaging Scanner with Halbach-Arrays — •Anna C. Bakenecker[1], Jonas Beuke[1], Peter Blümler[2], Anselm von Gladiss[1], Thomas Friedrich[1], and Thorsten M. Buzug[1] — [1]Institute of Medical Engineering, University of Lübeck, Germany — [2]Insititute of Physics, University of Mainz, Germany

Magnetic particle imaging (MPI) is a new medical imaging technique that enables three-dimensional real-time imaging of magnetic nanoparticles used as tracer material. Although it is not in clinical use yet, it is highly promising, since no ionizing radiation is necessary. Therefore, MPI is suitable as an interventional imaging technique. The upscaling of MPI is a major challenge as even preclinical scanners featuring a small bore have an immense power consumption for the electromagnetical generation of the desired magnetic field geometries. A concept is proposed, which consists of mechanically rotatable Halbach-Arrays in dipole and quadrupole configurations. Even though permanent magnets are used, this concept features a high flexibility in terms of adjusting the magnetic field geometries. It is possible to adjust the field gradient, the field of view as well as the sampling rate. Therefore, it is possible to choose between overview scanning, real-time imaging and detailed visualization of a chosen region of interest. A short introduction into MPI will be given and the concept of the proposed scanner will be explained.

MA 44.4 Thu 10:15 H53

Quantitative nanoscale magnetic imaging with a cryogenic single spin magnetometer — •Qi-Chao Sun[1], Andreas Brunner[1], Tetyana Shalomayeva[1], Marc Scheffler[2], Rainer Stöhr[1], and Jörg Wrachtrup[1,3] — [1]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]Max Planck Institute for Solid State Research,Heisenbergstraße 1, 70569 Stuttgart, Germany

The electron spin of nitrogen-vacancy (NV) defects in diamond offer a promising platform for probing condensed matter systems by measuring the surface magnet field quantitatively with an operating temperature range from cryogenic temperature to above room temperature and a dynamic range spanning from DC to GHz. Here, we report our operation of cryogenic scanning nano magnetometer with single NV defect in diamond. To demonstrate the performance of our system, we measure the magnetic field on the surface of bulk Cu2OSeO3. With an NV defect about 10 nm from the sample surface, we directly measure the magnetic field component along the NV axis which shows a clear stripe structure with a period of 80 nm, attributed to the helical spin order. Thanks to the quantitative magnetic imaging, we reconstruct the vector field from the measurement result and obtain an image of the helical magnetic field. The development of NV-based magnetic imaging will enable more previously inaccessible studies of physics of spins and currents in correlated electron materials and devices.

MA 44.5 Thu 10:30 H53

A new scanning reflection x-ray microscope for magnetic imaging in the EUV range — •Andreas Schümmer[1], Hans-Christoph Mertins[1], Claus Michael Schneider[2], Roman Adam[2], Daniel Bürgler[2], Larissa Juschkin[3], and Ulf Berges[4] — [1]University of Applied Sciences, Münster Stegerwaldstraße 39, 48565 Steinfurt, Germany — [2]Forschungszentrum Jülich, Wilhelm-Johnen-Straße, 52428 Jülich, Germany — [3]Rhein Westfälische Technische Hochschule Aachen, Templergraben 55, 52062 Aachen, Germany — [4]TU Dortmund, Zentrum für Synchrotronstrahlung, Maria-Goeppert-Mayer-Str. 2, 44227 Dortmund, Germany

The advancing miniaturization in magnetic data storage and spintronics requires imaging characterization methods that can also investigate buried layers with element-selectivity and high sensitivity. Here, first magnetic domain images obtained with a new scanning reflection x-ray microscope (SRXM) are presented. Free standing zone plates and a scanning device were developed for the extreme ultra violet (EUV) range available at the beamline 12 at the DELTA synchrotron facility. The transversal magneto optical Kerr effect (T-MOKE) at the Fe 3p edge under 30° grazing incidence was applied to imaging the magnetic domain structure of buried Fe layers in Au/Fe/Cr-wedge/Fe/Ag samples, where the Cr thickness varies between 0.3 and 0.7 nm and thus gives rise to a transition between antiferromagnetic and ferromagnetic magnetic interlayer coupling between the Fe layers. The advantage of working in the EUV range is an increased intensity of the reflected light, which is about 2 orders of magnitude larger than at the 2p edges.

MA 44.6 Thu 10:45 H53

Soft X ray magnetic tomography — Aurelio Hierro-Rodriguez[1], Carlos Quiros[2], Andrea Sorrentino[3], Ricardo Valcarcel[3], Luis M Alvarez Prado[2], Jose Ignacio Martin[2], Jose M Alameda[2], Stephen McVitie[1], Eva Pereiro[3], Maria Velez[2], and •Salvador Ferrer[3] — [1]School of Physics and Astronomy University of Glasgow G12 8QQ, Glasgow (UK) — [2]Departamento de Fisica, Universidad de Oviedo, 33007 Oviedo, Spain — [3]ALBA Synchrotron, 08290 Cerdanyola del Valles, Spain

Soft X ray transmission microscopy with circularly polarized photons tuned at specific resonant energies allows to image magnetic textures by exploiting the dichroic absorption contrast which depends on the angle of the magnetization and X ray beam. Changing their relative orientations allows determining the orientation of the magnetization of the sample [1]. We have recently developed 3D magnetic reconstruction tomography [2] which allows to reconstruct the magnetization at ~ 30 nm resolution and to localize magnetic singularities in thin films (thickness up to ~300 nm) . These results will be illustrated in a permalloy/NdCo/permalloy trilayer where magnetic bifurcations at the top and bottom permalloy layers are clearly separated. Our method is well suited for identifiying buried magnetic features in multilayers.

1.- C. Blanco-Roldan et al.,Nat Comm. (2015) DOI: 10.1038/ncomms9196 2.- A. Hierro-Rodriguez, J. Synchrotron Rad.(2018)24, 1144

MA 45: Focus Session: Spins on Surfaces I (joint session O/MA)

Organizer: Andreas Heinrich (Center for Quantum Nanoscience, IBS, Seoul, South Korea)

Time: Thursday 10:30–13:00 Location: H15

Invited Talk MA 45.1 Thu 10:30 H15

Enhancing quantum coherence of magnetic atoms on a surface — •Yujeong Bae[1,2,3], Kai Yang[2], Philip Willke[1,3], Taeyoung Choi[1,3], Andreas J. Heinrich[1,3], and Christopher P. Lutz[2] — [1]Center for Quantum Nanoscience, Institute for Basic Science, Seoul 03760, Republic of Korea — [2]650 Harry Rd — [3]Department of Physics, Ewha Womans University, Seoul 03760, Republic of Korea

Coherent control of spin states is of central importance in spin-based information processing and spintronic devices. However, the spin coherence of individual atoms on a surface is easily disrupted by interaction with environment such as electric or magnetic field noise as well as unwanted coupling with neighboring spins. Here we demonstrate that a singlet-triplet transition in a pair of antiferromagnetically coupled spin-1/2 atoms yields enhanced spin coherence compared to individual atoms. We used scanning tunneling microscope to assemble two hydrogenated titanuim atoms on MgO(001). At a precisely selected spacing that gives a large interaction energy between two atoms, we obtain spin states having a high degree of protection from disrupting fields, and also provides thermal initialization into the singlet state. We show that a two level system composed of these singlet and triplet states is insensitive to global and local magnetic field variation, resulting in longer spin coherence times compared to individual atoms.

MA 45.2 Thu 11:00 H15

Quantum Nanoscience: Atoms on Surfaces as Quantum Spins — •Andreas Heinrich — IBS Center for Quantum Nanoscience at Ewha Womans University, Seoul, Korea

Quantum Nanoscience is a discipline that combines quantum science with nanoscience. It aims to utilize quantum coherence in solid-state and molecular systems. Among the many basic science questions in this field are open versus closed quantum systems and the controlled interaction of the quantum systems with the host materials. Getting control of those methods and concepts will enable engineered quantum systems with controllable quantum coherence. Possible applications range from quantum sensing to quantum computation. Scanning Tunneling Microscopy is a unique tool in that it allows to image surface with atomic resolution, build structures one atom at a time and measure the structures with high energy and spin resolution - all in one machine. We will outline relevant experiments that enable the STM to become a potent tool of quantum nanoscience.

MA 45.3 Thu 11:15 H15

Sensing the spin of a spectroscopically dark Ce adatom with an STM — •Markus Ternes[1,2], Chris Lutz[3], Andreas Heinrich[4,5], and Wolf-Dieter Schneider[6,7] — [1]RWTH Aachen University, Germany — [2]Peter Grünberg Institute PGI-3, Forschungszentrum Jülich, Germany — [3]IBM Almaden Research Center, San Jose, CA, USA — [4]Center for Quantum Nanoscience, Institute for Basic Science, Seoul, Republic of Korea — [5]Ewha Womans University, Seoul, Republic of Korea — [6]Fritz- Haber-Institut, Berlin, Germany — [7]École Polytechnique Fédérale de Lausanne, Switzerland

The magnetic moment of rare earth elements originates from the electrons of the partially filled $4f$ orbitals. Accessing this moment electrically as in a scanning tunneling spectroscopy experiment is difficult due to the effective shielding by electrons in the further outward lying $5d$ and $6s$ orbitals. However, recently the influence of $4f$ spins on the EPR signal of neighboring $3d$ spins has been used for its detection [1]. Here we use a different approach to detect the magnetic moment of a single Ce adatom on a Cu_2N ultrathin film on Cu(100). We functionalize the tip apex with a second, Kondo screened spin which we can deliberately couple to other moments on the surface via the tunneling junction [2]. We calibrate this sensor against a well understood Fe atom and subsequently use the splitting of the Kondo resonance when approaching a spectroscopically dark Ce atom to determine its magnetic moment to $\approx 1\mu_B$. [1] F. D. Natterer, *et al.*, *Nature* **543**, 226 (2017). [2] M. Muenks, *et al.*, *Nature Comm.* **8**, 14119 (2017).

MA 45.4 Thu 11:30 H15

Scanning tunneling spectroscopy of Co atoms at long Cu chains — Neda Noei[1], •Alexander Weismann[1], Roberto Mozara[2], Oleg Kristanovski[2], Alexander I. Lichtenstein[2], and Richard Berndt[1] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — [2]Institut für Theoretische Physik, Universität Hamburg, D-20355 Hamburg, Germany

The interaction of an impurity atom carrying a localized spin with a host metal often leads to the many-body Kondo effect. We prepared atomic chains with lengths of hundreds of Cu atoms on a Cu(111) surface, and spectroscopically probed the Kondo resonance of Co adatoms on pristine terraces, at such chains, and at the end of chains. Distinctly different amplitudes, widths and spectroscopic line shapes are observed for the three cases and they are qualtatively reproduced by multi-orbital many body calculations that combine DFT with continuous-time quantum Monte Carlo.

MA 45.5 Thu 11:45 H15

Spin selective tunneling processes between Yu-Shiba-Rusinov states — •Haonan Huang[1], Jacob Senkpiel[1], Robert Drost[1], Ciprian Padurariu[2], Simon Dambach[2], Björn Kubala[2], Juan Carlos Cuevas[3], Alfredo Levy Yeyati[3], Joachim Ankerhold[2], Christian R. Ast[1], and Klaus Kern[1,4] — [1]MPI für Festkörperforschung, Stuttgart, Germany — [2]Institut für komplexe Quantensysteme, Universität Ulm, Ulm, Germany — [3]Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain — [4]EPFL, Switzerland

A Yu-Shiba-Rusinov (YSR) state is a pair of in-gap states resulting from the interaction of magnetic atoms with a superconductor. We are experimentally able to introduce any YSR state of desired energy position and peak heights to the apex of a superconducting vanadium STM tip, and then use this novel tip to characterize sample YSR defects to study spin selective tunneling. YSR-YSR tunneling happens resonantly when the bias voltage is at the sum of tip and sample YSR energies. If the temperature is finite, there is thermal occupation of the originally empty YSR state, which results in thermally assisted YSR-YSR tunneling that happens at the difference of tip and sample YSR energies. The relative spin orientation will change the intensity of both processes, and Green's function theory can readily explain the spin selection rules. We use a mK-STM to study the YSR-YSR tunneling processes from 15mK to 1K, and the temperature dependence of thermal and normal YSR-YSR processes gives insight of their spin dynamics.

MA 45.6 Thu 12:00 H15

Integrating Yu-Shiba-Rusinov states into a tunnel junction — •Christian R. Ast[1], Haonan Huang[1], Jacob Senkpiel[1], Robert Drost[1], Simon Dambach[2], Ciprian Padurariu[2], Björn Kubala[2], Juan Carlos Cuevas[3], Alfredo Levy Yeyati[3], Joachim Ankerhold[2], and Klaus Kern[1,4] — [1]MPI für Festkörperforschung, Stuttgart — [2]Institut für komplexe Quantensysteme, Universität Ulm, Ulm — [3]Universidad Autónoma de Madrid, Madrid, Spain — [4]EPFL, Lausanne, Switzerland

Magnetic impurities in a superconductor give rise to subgap features called Yu-Shiba-Rusinov (YSR) states. On or near surfaces, these impurities can be well studied locally by scanning tunneling microscopy (STM). We have observed a non-trivial energy dependence of the YSR state as a function of tip-sample distance, similar to findings that have been reported before. The occurrence of this phenomenon deep in the tunneling regime suggests a non-negligible influence of the tip on the YSR impurity. Therefore, in order to interpret this energy dependence, a more holistic model of the tunnel junction including the YSR state is necessary. To this end, we discuss a model that extends the existing Green's function description of YSR states and also bridges a gap to related models.

MA 45.7 Thu 12:15 H15

Interplay between Yu-Shiba-Rusinov states and spin-flip excitations on magnetic impurities on superconducting $NbSe_2$ substrate — •Shawulienu Kezilebieke[1], Rok Žitko[2], Marc Dvorak[1], Teemu Ojanen[3], and Peter Liljeroth[1] — [1]Department of Applied Physics, Aalto University School of Science, 00076 Aalto, Finland — [2]Jožef Stefan Institute, Jamova 39, SI-1001 Ljubljana, Slovenia — [3]Laboratory of Physics, Tampere University of Technology, Tampere FI-33101, Finland

Exchange coupling between a magnetic impurity and a superconducting substrate results in the formation of Yu-Shiba-Rusinov (YSR) bound states, which have been recently used in artificial designer structures to realize exotic quasiparticles known as Majorana fermions. At strong coupling, the energies of YSR states are deep in the superconducting gap. At weak coupling, the YSR states migrate towards the superconducting gap edge. Additional spectral features can appear in the presence of magnetic anisotropy with spin $S \geqslant 1$, in particular spin-flip excitations outside the superconducting gap. Despite extensive experiments on magnetic impurities that exhibit separately either spin-flip excitations or YSR states, these phenomena have not been observed simultaneously. Here, we investigate the spectral evolution in different metal phthalocyanine molecules on $NbSe_2$ surface as a function of the coupling with the substrate. Using scanning tunneling microscopy (STM), we tune the exchange coupling strength and for manganese phthalocyanine (MnPc) we demonstrate a smooth spectral crossover from the YSR states to intrinsic quantum spin states.

MA 45.8 Thu 12:30 H15

Fractional charge tunneling between Shiba states in STM devices — •Ciprian Padurariu[1], Haonan Huang[2], Björn Kubala[1], Simon Dambach[1], Christian R. Ast[2], and Joachim Ankerhold[1] — [1]Institute for Complex Quantum Systems and IQST, Ulm University, 89069 Ulm, Germany — [2]Max-Planck-Institut für Festkörperforschung, 70569 Stuttgart, Germany

We present the theory and experimental realization of tunneling between tip and substrate Shiba states in superconducting STM devices operating at 15 mK. The simple analytical results are in good agreement with conductance measurements exhibiting peaks in the tunnel current at a number of sub-gap bias voltages. [1] The voltages are identified as resonances of sub-gap discrete magnetic states, so called Shiba states, that form inside a volume around the magnetic impurity of coherence length size. [2]

When a Shiba state formed around an impurity in the STM tip is brought into proximity with a Shiba state formed around an impurity in the substrate, new resonances arise at characteristic values of the voltage. The tunnel current at the new resonances is a result of the interplay between coherent transport processes and incoherent relaxation. The elementary transport process carries a fractional charge proportional to the electron-hole asymmetry in the device.

[1] M. Ruby, F. Pientka, Y. Peng, F. von Oppen, B. W. Heinrich,

and K. J. Franke, Phys. Rev. Lett. **115**, 087001 (2015).
[2] M. I. Salkola, A. V. Balatsky, and J. R. Schrieffer, Phys. Rev. B **55**, 12648 (1997).

MA 45.9 Thu 12:45 H15

Renormalization of single-ion magnetic anisotropy by charge fluctuations — •David Jacob — Dpto. de Física de Materiales, Universidad del País Vasco UPV/EHU, San Sebastián, Spain — IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

Inelastic spin-flip excitations associated with single-ion magnetic anisotropy of quantum spins can be strongly renormalized by Kondo exchange coupling to the conduction electrons in the substrate, as shown recently for the case of Co adatoms on CuN_2 islands [1]. In this case, differential conductance spectra show zero-bias anomalies due to a Kondo effect of the doubly degenerate ground state, and finite-bias step features due to spin-flip excitations. Here I consider spin-1 quantum magnets with positive uniaxial anisotropy, where the ground state is nondegenerate and hence the Kondo effect does not take place [2]. Nevertheless, despite the absence of Kondo effect the magnetic anisotropy can still be strongly renormalized, both by exchange coupling to the conduction electrons and also by charge fluctuations. Interestingly, in contrast to the renormalization by Kondo exchange, charge fluctuations lead to asymmetric spectra, which, for strong charge fluctuations, mimic Fano-Kondo lineshapes, even though the origin is completely different.

References: [1] J. C. Oberg *et al.*, Nature Nanotechnol. **9**, 64 (2014); [2] D. Jacob, Phys. Rev. B **97**, 075428 (2018)

MA 46: Magnetic particles and clusters

Time: Thursday 11:30–13:15 Location: H52

MA 46.1 Thu 11:30 H52

Magnetic properties of nanocomposite Fe/Ge$_m$ thin films — •Thomas Reisinger, Cahit Benel, Gleb Iankevich, Ralf Witte, Di Wang, Leonardo Estrada, Robert Kruk, and Horst Hahn — Karlsruhe Institute of Technology, Institute of Nanotechnology, Eggenstein-Leopoldshafen, Germany

The functional properties of nanocomposites promise to meet many of the demanding material requirements faced by the modern high-tech industry. However, precise control over features such as chemistry, morphology and microstructure, as well as their preparation under well-defined conditions remain challenging. Here we show that the combination of size-selective cluster-ion-beam deposition and physical vapor deposition under ultra-high-vacuum conditions provides an excellent platform for the single-step synthesis of nanocomposite thin films with well-defined features such as for example cluster size and cluster concentration. In particular, we have used this method to prepare Fe/Ge$_m$ nanocomposite thin films with three different Fe cluster sizes (500, 1000, and 1500 Fe atoms per cluster and a spread in the mass distribution of less than 10%) and a range of Fe volume concentration (3-20 vol. %). The influence of these parameters on blocking temperature and saturation magnetization at low temperatures have been characterized using SQUID magnetometry. Further characterization of the chemistry, morphology and microstructure of the films has been investigated using transmission electron microscopy, X-ray photoelectron spectroscopy and energy-dispersive X-ray spectroscopy.

MA 46.2 Thu 11:45 H52

Testing energy landscapes with trapped magnetic beads — •Florian Ostermaier, Isiaka Lukman, Benjamin Riedmüller, and Ulrich Herr — Institut für Mikro- und Nanomaterialien, Universität Ulm, Ulm, Deutschland

Optical tweezers have been established as a powerful tool for passive microrheology of living cells and single molecule stretching. Magnetic tweezers offer a similar range of achievable force and particle localization, but may also be used in strongly absorbing environment. In addition, perspective Lab-on-Chip applications may benefit from the lack of requirement of high power Laser light.

We have already demonstrated successful trapping of single commercially available magnetic beads using a combination of the field gradient produced by a micro structured ring conductor and a superimposed homogeneous magnetic field.

Here we present studies of two magnetic beads simultaneously trapped in the same ring structure which are coupled via magnetic dipole-dipole interaction. The equilibrium distance between both beads depends on bead magnetization and the magnetic field gradient produced by the ring, and can therefore be tuned by varying the ring current. From the dynamics of the motion of the coupled beads in the trap potential, we extract information about the magnetic energy landscape formed by the combination of trap field and bead magnetization. In addition, interactions with the liquid environment and the walls of the trap can be extracted from analysis of the dynamics. We discuss possible applications in passive microrheology.

MA 46.3 Thu 12:00 H52

Magnetic structure of Fe chains on Re(0001) — •András Lászlóffy[1], László Udvardi[1,2], and László Szunyogh[1,2] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]MTA-BME Condensed Matter Research Group, Budapest University of Technology and Economics, Budapest, Hungary

We present first principles calculations for closed packed chains of 5, 10 and 15 Fe atoms on the top of Re(0001) surface. We use the Embedded Cluster Korringa-Kohn-Rostoker Green's function scheme to investigate the magnetic properties of the systems, as well as the Relativistic Torque method to generate tensorial interactions of a classical spin model. It turns out that the nearest neigbour isotropic couplings are antiferromagnetic and the easy axis is in-plane and perpendicular to the chain direction. The 5 and 10-atom-long Fe chains somewhat deviate from a collinear state due to Dzyaloshinskii-Moriya (DM) interactions and two-site anisotropies. The 15-atom chain displays a spin-spiral ground state being close to an AFM state, with a modulation wavelength of 14 atom. Because of the out-of-plane hard axis the spins lie in-plane and the DM interactions determine the chirality of the spin spiral. Direct *ab initio* simulation of the ground state results in a similar magnetic structure, but with opposite chirality. Supported by suitable magnetic force theorem calculations, we propose that introducing four-spin chiral interactions in the spin-model is crutial to understand the chirality of the spin-spiral ground state of the chain.

MA 46.4 Thu 12:15 H52

Mössbauer characterization of electrocatalytic ferrites — •Soma Salamon[1], Joachim Landers[1], Georg Bendt[2], Kalapu Chakrapani[2], Friedrich Waag[2], Stephan Schulz[2], Malte Behrens[2], Rossitza Pentcheva[1], Stephan Barcikowski[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Faculty of Chemistry and CENIDE, University of Duisburg-Essen

Mössbauer spectroscopy has been applied to a variety of different ferrite material systems that show great promise for the application in the oxygen evolution reaction. Using measurements in transmission geometry at low temperatures and high magnetic fields, we were able to obtain information on the degree of inversion in spinel systems, which was correlated with the catalytic activities of the respective materials. A further adjustment of the catalytic activity was performed via pulsed laser fragmentation as well as cation substitution of ferrite nanoparticles, with the resulting changes in magnetic and material properties also being observable in our Mössbauer spectroscopy results. These were additionally crosschecked via magnetometry measurements. Financial support by the DFG through CRC/TRR 247 (project B2) is gratefully acknowledged.

MA 46.5 Thu 12:30 H52

Accessing ferrofluid in-field dynamics via Mössbauer spectroscopy — •Joachim Landers[1], Soma Salamon[1], Hilke Remmer[2], Frank Ludwig[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Institute for Electrical Measurement Science and Fundamental Electrical Engineering, TU Braunschweig

Ferrofluids of coated iron-oxide nanoparticles were studied in the presence of external magnetic fields using Mössbauer spectroscopy, utilizing its ability to simultaneously gain insight into different magnetic phenomena. For nanoparticles ranging from 5 to 25 nm in core diameter, dynamic relaxation processes, namely Néel relaxation and Brownian particle motion, were analyzed by this method, with results being verified by AC-susceptometry and in agreement with the fluids' macroscopic viscosity. From the same set of Mössbauer spectra, additional information could be extracted regarding the particles' magnetic alignment relative to the field direction, as well as the degree of surface spin canting and the presence of particle agglomerates. Funding by the DFG within SPP 1681 is gratefully acknowledged.

MA 46.6 Thu 12:45 H52

Superparamagnetic limit of antiferromagnetic nanoparticles — Unai Atxitia[1,2], Levente Rózsa[3], Tobias Birk[1], •Severin Selzer[1], and Ulrich Nowak[1] — [1]Universität Konstanz, D-78457 Konstanz — [2]Freie Universität Berlin, D-14195 Berlin — [3]Universität Hamburg, D-20355 Hamburg

Antiferromagnetic materials are promising candidates for future spintronic devices. Compared to ferromagnets, they have no stray fields, a low susceptibility to external fields and faster spin dynamics. However, for many applications the size of the magnetic structures has to be scaled down to the nanometer regime. As for ferromagnets, the magnetic stability of antiferromagnetic nanoparticles will be limited by thermal excitations.

We investigate the superparamagnetic limit of antiferromagnetic nanoparticles theoretically, focusing on a comparison to the known properties of ferromagnetic particles. We find a drastically reduced thermal stability because of the exchange enhancement of the attempt frequencies and the effective damping during the antiferromagnetic switching process. We show that the order parameter in antiferromagnetic particles may strongly oscillate during the reversal at low damping values.

MA 46.7 Thu 13:00 H52

Strain and electric-field control of magnetism in iron oxide nanoparticle - BTO composites — Li-Ming Wang[1], •Oleg Petracic[1], Emmanuel Kentzinger[1], Ulrich Rücker[1], Jürgen Schubert[2], Stefan Mattauch[3], Alexandros Koutsioubas[3], Markus Schmitz[1], Xian-Kui Wei[4], Marc Heggen[4], Vanessa Leffler[5], Sascha Ehlert[5], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH — [2]Peter Grünberg Institute (PGI9-IT), JARA-Fundamentals of Future Information Technology Forschungszentrum Jülich GmbH — [3]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ) Forschungszentrum Jülich GmbH, Garching — [4]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich GmbH — [5]Jülich Centre for Neutron Science JCNS-1 and Institute of Complex Systems ICS-1, Forschungszentrum Jülich GmbH

Ferrimagnetic iron oxide nanoparticle monolayers either on top of ferroelectric BaTiO3 (BTO) substrates or embedded into a BTO film were prepared and a magnetoelectric coupling effect was observed. The data recorded at various electric field values show that the electric field is able to alter the magnetism of the nanoparticle monolayer by a strain mediated magnetoelectric coupling effect. The magnetic depth profile of the nanoparticle monolayer was probed by polarized neutron reflectivity.

MA 47: Magnetic anisotropy in thin films

Time: Thursday 11:30–13:00 Location: H53

MA 47.1 Thu 11:30 H53

X-ray magnetic circular dichroism on undoped TiO_2 anatase magnetic thin films with out-of-plane anisotropy — •Markus Stiller[1], José Barzola-Quiquia[1], Pablo D. Esquinazi[1], Angelika Chassé[2], Martin Trautmann[2], Alpha T. N'Diaye[3], Hendrik Ohldag[4], Thomas Lautenschläger[5], Daniel Spemann[5], Michael Lorenz[1], and Marius Grundmann[1] — [1]Felix-Bloch Institute for Solid-state Physics, Universität Leipzig, Linnestr. 5, D-04103, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg Von-Seckendorff-Platz 1, 06120 Halle — [3]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States — [4]SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, California, 94025 USA — [5]Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstraße 15, 04318 Leipzig, Germany

Epitaxial, polycrystalline and undoped TiO_2 anatase thin films were grown on LAO and STO substrates and irradiated with low energy argon ions (200eV). Field hysteresis as well as zero-field cooled and field cooled curves reveal that, after irradiation the samples show ferromagnetism at room temperature with an out-of-plane easy axis. XMCD measurements show that the band at the titanium L-edges is spin polarized, not at the O K-edge as is the case in ZnO. MultiX simulations can depict the experimental data and indicate that the magnetization is due to titanium di-Frenkel pairs. With electron beam lithography we prepared magnetic patterns of the anatase thin film measured with magnetic force microscopy.

MA 47.2 Thu 11:45 H53

Ru overcoat-induced anomalous magneto-optical behavior of Co films — •Patricia Riego[1,2], Lorenzo Fallarino[3], Jon Ander Arregi[1], Sara Arias[1], and Andreas Berger[1] — [1]CIC nanoGUNE, San Sebastian, Spain — [2]University of the Basque Country, Bilbao, Spain — [3]HZDR, Dresden, Germany

We studied the effect of ultrathin Ru overcoats onto the magnetic and magneto-optical properties of thin Co films with in-plane uniaxial anisotropy by means of generalized magneto-optical ellipsometry. This methodology can determine the full reflection matrix of any planar sample and thus separate optical from magneto-optical effects, as well as separate longitudinal, transverse and polar Kerr effects from each other. For reference samples without Ru overcoat, all experimental results can be consistently explained via a macrospin-type in-plane magnetization reversal. However, the addition of the Ru overcoat leads to an anomalous magneto-optical behavior that is not consistent with the magnetization reversal path observed in the overcoat-free films. The quantitative extent of this anomaly initially increases very strongly with increasing Ru thickness and saturates when the Ru overcoat thickness reaches 1.5 nm, which is indicative of the effect's interfacial origin. This is corroborated by the fact that the insertion of a 2-nm-thick SiO2 layer in between Co and Ru makes the anomaly disappear. The dependence of this effect with the Co film thickness is also consistent with it being an interface phenomenon.

MA 47.3 Thu 12:00 H53

L10-ordered ferrimagnetic FeCrPt thin films — •Nataliia Safonova[1], Florin Radu[2], Hanjo Ryll[2], Chen Luo[2,3], and Manfred Albrecht[1] — [1]Institute of Physics, University of Augsburg, Universitätsstrasse 1, D-86159, Augsburg, Germany — [2]Helmholtz-Zentrum Berlin, D-14109 Berlin, Germany — [3]Experimental Physics of Functional Spin Systems, Technische Universität München, James-Franck-Str. 1, 85748 Garching b. München, Germany

New magnetic materials designed for ultrafast all-optical switching (AOS) of magnetization are of high interest from a fundamental as well as technological point of view [1]. It was demonstrated that a low-remanent magnetization is a crucial criterion for AOS in ferrimagnets [2]. In this regard, a series of ((Fe(100-x)Cr(x))50Pt50 alloy thin films with a thickness of about 10 nm were prepared by epitaxial growth on MgO(100) substrates at 800°C. The Cr content x was varied in the range 0 - 100 at.%. All samples in the series reveal pronounced L10 chemical ordering. With substitution of Fe by Cr in L10 lattice up to 20% strong PMA is observed at 300 K. However, with further addition of Cr, PMA as well as coercivity get strongly reduced, which is accompanied by the film morphology change from island-like growth to more continuous film structure. Furthermore, x-ray magnetic circular dichroism studies at the Fe and Cr L3,2 edges revealed a strong antiferromagnetic coupling between Fe and Cr, which resulted in a reduction in net magnetization of the film.

[1] A. Kirilyuk et al., Rev. Mod. Phys. 82, 2731 (2010).
[2] A. Hassdenteufel et al., Phys. Rev. B 91, 104431 (2015).

MA 47.4 Thu 12:15 H53

Asymmetric domain wall nucleation in $Pt/Co/AlO_x$ micro-

wires with differing anisotropies — •Marvin Muller[1,2], Phuong Dao[1,3,4], Manuel Baumgartner[1], Zhaouchu Luo[3,4], Laura Heyderman[3,4], and Pietro Gambardella[1] — [1]Magnetism and Interface Physics, ETH Zurich, Switzerland — [2]Current Address: Laboratory for Multifunctional Ferroic Materials (M. Fiebig), ETH Zurich, Switzerland — [3]Laboratory for Mesoscopic Systems, ETH Zurich, Switzerland — [4]Paul Scherrer Institut, Switzerland

The ability to spatially and temporally control the magnetic state of a thin film by the application of charge current gives access to fascinating technologies with a prominent example being the racetrack memory. Among the existing heterostructures, Pt/Co/AlO_x with perpendicular magnetic anisotropy is a prototype system to study the effects of current-induced spin-orbit torques (SOTs) on the magnetization. The necessity of an external magnetic field for controlled domain wall nucleation i.e. data writing, however, holds back the integration of SOTs in magnetic memory applications. We tackle this issue by interfacing regions of differing magnetic anisotropy to minic the symmetry-breaking effect of an external magnetic field and achieve local asymmetric domain wall nucleation using current-induced SOTs in Pt/Co/AlO_x tri-layer films.

MA 47.5 Thu 12:30 H53

Total thickness dependence of the magnetic properties of ferromagnetic/non-magnetic thick multilayers — •L. Fallarino[1], A. Oelschlägel[1], J. A. Arregi[2], A. Bashkatov[3], S. Stienen[1], J. Lindner[1], R. Gallardo[4], K. Lenz[1], B. Böhm[5], F. Samad[5], K. Chesnel[6], and O. Hellwig[1,5] — [1]HZDR, Germany — [2]CEITEC BUT, Czech Republic — [3]HZDR, Germany — [4]USM, Chile — [5]TU Chemnitz, Germany — [6]BYU, USA

We present a study of the magnetic properties of [Co(3.0nm)/NM(0.6nm)]N multilayers as a function of Co/NM bilayer repetitions N (NM = Pt, Au and Cu). Magnetometry reveals that samples with high N exhibit two characteristic magnetization reversal mechanisms as a function of the applied magnetic field angle, giving rise to two different morphologies of the remanent domain pattern, either perpendicular stripe or maze-like domains. Furthermore, a detailed study of the influence of the magnetic history allows the determination of both N-range and magnetic field strengths, where a quasi-hexagonal lattice of bubble domains with remarkably high density is stabilized [1]. These modulations of the ferromagnetic order parameter are found to strongly depend on N, in terms of center-to-center bubble distance as well as of bubble diameter. Moreover, such Co/NM multilayers could be utilized to engineer field reconfigurable bubble domain lattices, which resemble magnonic crystals where tuning of the band-gap is enabled by the specific magnetic field history and material parameters [2].[1] K. Chesnel et al., accepted in Phys. Rev. B (25/10/2018) [2] L. Fallarino et al., submitted to Phys. Rev. B (13/10/2018).

MA 47.6 Thu 12:45 H53

Magnetocrystalline Anisotropy of Fe-based Alloys from Perturbative Treatments of the Spin-Orbit Interaction — •Maria Blanco-Rey[1,2], Jorge I. Cerda[3], and Andres Arnau[4,1,2] — [1]Universidad del Pais Vasco UPV/EHU, Spain — [2]Donostia International Physics Center DIPC, Spain — [3]Instituto de Ciencia de Materiales de Madrid ICMM, CSIC, Spain — [4]Centro de Fisica de Materiales CFM, CSIC-UPV/EHU, Spain

The magnetocrystalline anisotropy energy (MAE) of various Fe-based alloys of $L1_0$ structure has been calculated from first principles with various levels of approximation to the spin-orbit interaction (SOI). The performance of second-order perturbation theory (2PT) and the force-theorem (FT) has been tested against fully-relativistic self-consistent calculations. We find that 2PT is robust for lighter atoms, but it breaks down for 5d metals, whereas FT is more accurate in general. The difference is that 2PT is perturbative in the SOI strength parameter, while FT is perturbative in the charge density changes induced by the SOI. Both methods give a good description of easy-axis switchings under non-neutral charge conditions, as those that may be faced by alloys in magnetoelectric devices. Since 2PT makes use of the scalar-relativistic ground state, which is treated as a many-body system, it is efficient for predicting the MAE behaviour under applied gate biases or strains.

MA 48: Topological Semimetals - Experiment (joint session TT/MA)

Time: Thursday 15:00–17:45 Location: H2

MA 48.1 Thu 15:00 H2

Electronic structure of Weyl semimetal TaAs under pressure — •Zuzana Medvecka, Marcel Naumann, Markus Schmidt, Vicky Süss und Michael Nicklas — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Weyl semimetals are topological materials with linear band dispersion around pair of nodes with fixed opposite chirality. The quasiparticles from such nodes are predicted to induce novel quantum mechanical phenomena, such as Fermi arcs. However, to observe them in transport experiments, the Weyl nodes have to be sufficiently close to the Fermi level. Tantalum arsenide is a Weyl semimetal with a well-studied electronic structure, where the Weyl nodes lie 6 meV from Fermi level [1].

Here, we study how hydrostatic pressure impacts the Fermi level and electronic structure of TaAs. Quantum oscillations in resistivity of single-crystal TaAs samples are investigated in a piston type pressure cell. Pressure dependence of the electronic structure in TaAs is then obtained from the evolution of quantum oscillation frequencies.

[1] F. Arnold, M. Naumann, S.-C. Wu, Y. Sun, M. Schmidt, H. Borrmann, C. Felser, B. Yan and E. Hassinger, PRL 117, 146401 (2016)

MA 48.2 Thu 15:15 H2

Absence of the chiral anomaly - the longitudinal magnetoresistance in TaAs-type Weyl metals — •Marcel Naumann[1,2], Frank Arnold[1], Maja Bachmann[1], Kimberley Modic[1], Vicky Süss[1], Marcus Schmidt[1], Philip Moll[1], Brad Ramshaw[3], and Elena Hassinger[1,2] — [1]MPI CPfS, Dresden, Germany — [2]Technische Universität München, Garching, Germany — [3]Cornell University, Ithaca, NY, USA

The discovery of materials with 3D linear band-crossing points close to the Fermi level, such as Dirac and Weyl semimetals, has offered the possibility to study relativistic fermions in solid state systems. One manifestation, the 'chiral anomaly', should appear as a reduction of the longitudinal magnetoresistance (LMR), as was quickly observed in TaAs [1]. Subsequent studies found that current inhomogeneities ('current jetting') often induce an apparent negative LMR in semimetals, and that the true LMR is still unknown [2,3].

In this study, we determine the intrinsic LMR in the TaAs family (TaAs, TaP, NbAs, NbP) of Weyl semimetals. We reduced current jetting effects by trying to achieve a homogeneous current injection and by increasing the aspect ratio of our samples. The results show an *absence* of the negative LMR in chiral materials and a *presence* of a negative LMR in non-chiral materials. This suggests a chirality independent effect, which we believe to be weak-localisation physics.

[1] Huang et at., PRX 5, 031023 (2015)
[2] Arnold et al., Nat. Com. 7, 11615 (2016)
[3] dos Reis et al., New J. Phys. 18, 085006 (2016)

MA 48.3 Thu 15:30 H2

Magneto-optical response of the Weyl semimetal TaP — •Sascha Polatkan[1], Milan Orlita[2], Artur Slobodeniuk[2], Mark O. Goerbig[3], Chandra Shekhar[4], Claudia Felser[4], Martin Dressel[1], and Artem V. Pronin[1] — [1]1. Physikalisches Institut, Universität Stuttgart, 70569 Stuttgart, Germany — [2]LNCMI, CNRS-UGA-UPS-INSA-EMFL, 38042 Grenoble, France — [3]LPS, Univ. Paris-Sud, Univ. Paris-Saclay, CNRS UMR 8502, 91405 Orsay, France — [4]MPI für Chemische Physik fester Stoffe, 01187 Dresden, Germany

Theory predicts that TaP, being structurally akin to TaAs, hosts two distinct Weyl-type band crossings. Optical (infrared) spectroscopy in magnetic fields offers crucial information about the band structure by means of analyzing the inter-Landau-level transitions. We investigated the magneto-optical response of TaP up to $B = 33$ T in the infrared regime ($5 - 200$ meV). The reflection spectra are rich of features, many of which show a $\sqrt{B}$-dependence, hinting at the massless nature of the involved (presumably Weyl) bands. Moreover, we observe a peculiar fan-shaped subset of the transitions. In this subset, the energies of some of the transitions increase, while the energies of other transitions decrease with field. We discuss how the topological nature of the involved bands might be connected to this peculiar behavior.

MA 48.4 Thu 15:45 H2

Dirac semimetal $PtBi_2$: polymorphism and challenges in crystal growth — •Grigory Shipunov, Boy Roman Piening, Saicharan Aswartham, and Bernd Büchner — IFW-Dresden, Dresden, Germany

$PtBi_2$ is showing rich polymorphism, with at least 3 different crystal structures corresponding to this composition are reported. At least two of this structures, pyrite-type cubic (space group $Pa\bar{3}$) and hexagonal (space group $P31m$), are showing linearly dispersive Dirac states and anomalous transport properties, such as extremly large linear magnetoresistance.

Here, we present our results on targeted crystal growth of cubic or hexagonal modification. Cubic and hexagonal modifications were grown via self-flux method, with growth parameteres such as Pt:Bi ratio and temperature profile chosen based on thermodynamical phase diagram data. High quality of the crystals is confirmed by powder and single crystal x-ray diffraction and scanning electron microscopy with energy dispersive x-ray spectroscopy techniques. Optimization of the growth parameters for the metastable trigonal polymorph is also discussed.

MA 48.5 Thu 16:00 H2

Chemical-pressure effect on the optical conductivity of topological nodal-line semimetals of ZrSiS type — •Markus Krottenmüller[1], Jihaan Ebad-Allah[1,2], Juan Fernandez Afonso[3], Zhiqiang Mao[4], Jan Kunes[3,5], and Christine Kuntscher[1] — [1]Experimentalphysik II, Universität Augsburg, 86159 Augsburg, Germany — [2]Department of Physics, Tanta University, 31527 Tanta, Egypt — [3]Institute of Solid State Physics, TU Wien, 1020 Vienna, Austria — [4]Department of Physics and Engineering Physics, Tulane University, New Orleans, LA 70118, USA — [5]Institute of Physics, The Czeck Academy of Sciences, 18221 Praha, Czech Republic

ZrSiS is a prototype nodal-line semimetal, whose electronic band structure contains a diamond-shaped nodal line. We studied the optical conductivity of ZrSiS and other members of the compound family ZrXY with X=Si, Ge and Y =S, Se, Te by reflectivity measurements over a broad frequeny range. The optical conductivity spectrum of ZrSiS has a distinct U-shape, ending at a sharp high-energy peak. Other ZrXY compounds have a very similar profile of the optical conductivity, except ZrSiTe. We will discuss our findings in terms of the theoretical optical conductivity obtained by density functional theory calculations.

MA 48.6 Thu 16:15 H2

ZrP_2 family of materials as topological semimetal candidates — Jörn Bannies[1,2], Elia Razzoli[2], Matteo Michiardi[1,2], •Ilya Elfimov[2], Andrea Damascelli[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Quantum Matter Institute, University of British Columbia, Vancouver, Canada

In recent years transition metal pnictides including dipnictides have attracted much research interest in the context of topological semimetals. These include type-I and type-II Weyl semimetals, triple-point fermions and weak topological insulators. Here we propose group IV dipnictides as potential nodal line semimetals, a class with only a few verified members to date.

We have successfully grown crystals of ZrP_2 and $ZrAs_2$ and, for the first time, investigated their transport properties. These materials are isostructural and crystallize in the non-symmorphic space group *Pnma*. For ZrP_2 an unsaturated magnetoresistance of $1.5{\cdot}10^4$ % at 2 K and 9 T with nearly quadratic field dependence is observed. This is accompanied by a resistivity plateau up to 20 K in high magnetic fields. Similar behavior in other topological semimetals suggests a topological origin. Indeed, ZrX_2 (X = P, As) compounds were recently identified as topological materials. Our DFT band structure calculations show a Dirac like band crossing close to the Fermi level as well as a nodal line in the k_x=0 plane. We discuss the role of non-symmorphic symmetry in stabilizing these features.

15 min. break.

MA 48.7 Thu 16:45 H2

Effect of inversion symmetry on the excitations in WP_2 — •Dirk Wulferding[1,2], Peter Lemmens[1,2], Yurii Pashkevich[1,3], Tanya Shevtsova[3], Claudia Felser[4], and Chandra Shekhar[4] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]LENA, TU-BS, Braunschweig, Germany — [3]Galkin DonFTI, Kyiv, Ukraine — [4]MPI CPfS, Dresden, Germany

The two structural modifications of WP_2, one with and one without a center of inversion, allow to probe the effect of global symmetry on a Weyl semimetal. In our report we uncover phonon anomalies as well as electronic fluctuation of both phases using Raman scattering and compare their impact on anomalous charge transport [1,2,3].

Work supported by QUANOMET NL-4 and DFG LE967/16-1.

[1] Kumar et al., Nat. Commun. 8, 1642 (2017)
[2] Gooth el al., arXiv:1706.05925 (2017)
[3] Du et al., PRB 97, 245101 (2018)

MA 48.8 Thu 17:00 H2

Magnetotransport in microribbons of the magnetic Weyl semimetal $Co_3Sn_2S_2$ — •Kevin Geishendorf[1], Richard Schlitz[2], Praveen Vir[3], Chandra Shekhar[3], Claudia Felser[3], Kornelius Nielsch[1], Sebastian T.B. Goennenwein[2], and Andy Thomas[1] — [1]Leibniz Institute for Solid State and Materials Research Dresden, Institute for Metallic Materials — [2]Institut für Festkörper- und Materialphysik — [3]Max Planck Institute for Chemical Physics of Solids, Dresden

Magnetic Weyl semimetals exhibit intriguing phenomena due to their non-trivial band structure. Recent experiments in bulk crystals have shown that shandite-type $Co_3Sn_2S_2$ is a magnetic Weyl semimetal [1,2]. To access the length scales relevant for electrical transport, it is mandatory to fabricate microstructures of this fascinating compound. We therefore have cut microribbons (typical size 0.3 x 3 x 50 μm^3) from $Co_3Sn_2S_2$ single crystals using a focused beam of Ga^{2+}-ions (FIB) and investigated the impact of the sample dimensions and possible surface doping on the magnetotransport properties. The large intrinsic anomalous Hall effect observed in the microribbons is quantitatively consistent with the one in bulk samples [1]. It is evident from our results that FIB cutting can be used for patterning single crystalline $Co_3Sn_2S_2$, enabling future transport experiments in complex microstructures of this compound.

[1] E. Liu et al., Nat. Phys. **14**, 1125-1131 (2018)
[2] Q. Wang et al., Nat. Commun. **9**, 3681 (2018)

MA 48.9 Thu 17:15 H2

Comparative analysis of the effects of pressure on Bi, NbP and Cd_3As_2 — •Aleksandar Vasiljković[1], Filip Orbanić[2], Mario Novak[2], Malte Grosche[1], and Ivan Kokanović[2,1] — [1]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [2]Department of Physics, Faculty of Science, University of Zagreb, 10002 Zagreb, Croatia

Bismuth is a non-topological low carrier density semimetal, which has been investigated for a long time [1]. Cd_3As_2 is a symmetry-protected three dimensional Dirac semimetal with high carrier mobility [2]. Shubnikov-de Haas oscillations have previously been reported with frequencies of around 55 T, corresponding to tiny Fermi surface pockets in a semimetallic band structure [3]. NbP is a Weyl semimetal with large magnetoresistance and very high mobility[4]. We present a comparative analysis of the Shubnikov-de Haas oscillations of these three materials under pressure.

[1] L. Shubnikov, W. Y. de Haas, Comm. Phys. Lab. Univ. Leiden, 207a, 207c, 207d, 210a (1930)
[2] Z.Wang, et al., Phys. Rev. B 88, 125427 (2013)
[3] A. Pariari et al., Phys. Rev. B 91, 155139 (2015)
[4] C. Shekhar et al, Nat. Phys. 11, 724 (2015)

MA 48.10 Thu 17:30 H2

Spin-orbital texture in $MoTe_2$ and its response to the phase transition — •Andrew Patton Weber[1,2,3], Philipp Rüssmann[4], Nan Xu[2,3], Stefan Muff[2,3], Mauro Fanciulli[2,3], Arnaud Magrez[2], Philippe Bugnon[2], Helmuth Berger[2], Nicholas C. Plumb[3], Ming Shi[3], Stefan Blügel[4], Phivos Mavropoulos[4], and J. Hugo Dil[2,3] — [1]Donostia International Physics Center, 20018 Donostia, Gipuzkoa, Spain — [2]Institute of Physics, École Polytechnique Fédérale de Lausanne, CH-1015, Lausanne, Switzerland — [3]Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen, Switzerland — [4]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Ger-

many

The basis of exotic electromagnetic phenomena in $MoTe_2$ lies not only in the electronic band structure, but also in the crystal-momentum-dependence of spin-orbit-entangled wave functions. Here we discuss the challenges involved in obtaining this information directly from experiments and report the angular distribution of photoelectron spin-polarization and intensity dichroism in $MoTe_2$. A novel spin-orbital texture is uncovered in the bulk Fermi surface that is consistent with first-principles calculations. The spin-texture is three-dimensional and is not completely suppressed above the centrosymmetry-breaking transition temperature of the bulk crystal. The results indicate that a new form of polar instability exists near the surface when the bulk is largely in a centrosymmetric phase.

MA 49: Focus Session: Spins on Surfaces II (joint session O/MA)

Time: Thursday 15:00–18:00 Location: H15

Invited Talk MA 49.1 Thu 15:00 H15
Long-lived magnetic states in atomic-scale magnets — •Sebastian Stepanow — ETH Zürich, Switzerland

Magnetic atoms on surfaces are emerging as a new class of systems with exceptionally long spin relaxation times, which allows for reading and writing magnetic bits on the atomic scale. The magnetic properties of the single-ion magnets depend crucially on their atomic environment and enhancing their spin dynamics may lead to the development of single-atom qubits. Recent observations of magnetic remanence in individual Ho atoms adsorbed on ultrathin MgO(100) layers on Ag(100) provided the first evidence of a single atom magnet on a surface. The opening of the hysteresis loop indicates that the lifetime of Ho atoms is on the order of hours at cryogenic temperatures. Meanwhile more rare-earth adatom systems have been identified having exceptionally long spin relaxation time T_1. Despite the raising interest in these systems, it is still not clear which factors determine their very long relaxation time and if a long coherence time can be expected. The talk highlights our recent efforts in the understanding of the different contributing factors, i.e., the strong uniaxial magnetic anisotropy, the symmetry protection of the ground state from quantum tunneling and other first order scattering processes, and the peculiarities of the spin-phonon coupling with the supporting substrate.

MA 49.2 Thu 15:30 H15
Mechanism of spin-dependent electron transfer on ferromagnetic interfaces: an ab initio study — •Simiam Ghan, Karsten Reuter, and Harald Oberhofer — Chair of Theoretical Chemistry, Technical University of Munich, Garching, Germany.

Self-assembled monolayers of organic molecules (SAMs) on surfaces show great promise in the emerging field of molecular electronics due to tunable charge transport properties, long-range 2-dimensional order and ease of manufacture. Growth of SAMs on ferromagnetic surfaces offers the additional possibility of spin-dependent transport for molecular spintronics in e.g. spin-valves and magnetic tunneling junctions. To establish design principles for such applications, a thorough understanding of (spin)charge transport mechanisms over SAM-metal interfaces is of great importance.

As an initial benchmark, we report calculations of spin-dependent electron transfer in model systems of Argon monolayers on ferromagnetic Fe(110), Co(0001) and Ni(111) substrates. Spin-polarized charge transfer rates are calculated from the Fermi Golden Rule using a Hamiltonian derived from first-principles density functional theory. A faster transfer of minority spins from Argon to substrate is predicted, in excellent agreement with experiment. The scheme allows us to compare the roles of orbital geometries (i.e. their spatial character) and couplings, versus densities of acceptor states in determining a final preferential spin transfer. The benchmarked protocol is applied to thiol-based model SAMs with an aim towards predicting tunable spin-transport behavior.

MA 49.3 Thu 15:45 H15
Unraveling the Oxidation and Spin State of Mn-Corrole — •Reza Kakavandi[1], Mateusz Paszkiewicz[1], Hazem Aldahhak[2], Uwe Gerstmann[2], Wolfgang Schofberger[3], Wolf Gero Schmidt[2], Johannes V. Barth[1], and Florian Klappenberger[1] — [1]Physics Department E20, Technical University of Munich, Germany — [2]Department of Physics, Paderborn University, Germany — [3]Institute of Organic Chemistry, Johannes Kepler University, Austria

The ability of engineering oxidation states and spin configurations in metal-corroles have fueled the vision of metal complexes-based platform for faster catalysis and more efficient fuel cells. One of the challenges in the functionality of corroles is to devise ways to unveil and ultimately control the electronic structure of the metal centers. However, despite the importance in implementation this class of molecules in novel devices, their electronic structure is hardly accessible with traditional techniques and thus is still under debate, especially at the interfaces. Here, via X-ray spectroscopic investigations and density functional theory calculations we explore the electronic ground state of the prototypical Mn-5,10,15-tris(pentafluorophenyl) corrole complex within a highly pure multilayer. The theory-based interpretation of Mn photoemission and absorption fine-structure spectra (3s and 2p and L2,3-edge, respectively) evidence a Mn(III) oxidation state with an S = 2 high-spin configuration. Furthermore, we shine light on the influence of being in contact to a Ag(111) surface and discuss mechanism such as charge transfer and annealing induced chemical conversions and their impact on the spin properties.

MA 49.4 Thu 16:00 H15
Magnetic excitation spectra of single atoms on magnetic and non-magnetic substrates — •Juba Bouaziz, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

At low temperatures, inelastic scanning tunneling spectroscopy is a tool of predilection for the inspection of magnetic excitation spectra of single atoms deposited on surfaces. We employ a first-principles approach for the computation of the inelastic tunneling spectra relying on the Korringa-Kohn-Rostoker Green function method in combination with time-dependent density functional theory and many-body perturbation theory [1]. We extend the method to account for non-collinear magnetism and spin-orbit driven phenomena. The central quantity of our work is the electron's self-energy which encodes the coupling of the electron to the spin-excitation and renormalizes the electronic structure. We investigate 3*d* transition metal adatoms deposited on non-magnetic substrates such as Re(0001) and on magnetic surfaces such as PdFeIr(111) capable of hosting magnetic skyrmions [2,3].

[1] B. Schweflinghaus *et al.* Physical Review B **89**, 235439 (2014).
[2] N. Romming *et al.* Science **341**, 636-639 (2013).
[3] D. M. Crum *et al.* Nature Communications **6**, 8541 (2015).

This work was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC consolidator Grant No. 681405 DYNASORE).

MA 49.5 Thu 16:15 H15
Anisotropic spin-split surface states in momentum space from molecular adsorption — •Rico Friedrich[1,2], Vasile Caciuc[1], Bernd Zimmermann[1], Gustav Bihlmayer[1], Nicolae Atodiresei[1], and Stefan Blügel[1] — [1]Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany — [2]Present address: Center for Materials Genomics, Duke University, Durham, NC 27708, USA

Achieving control over the surface state spin texture can open new prospects in spintronics. We have recently demonstrated from first principles that the spin texture of a surface Rashba system can be controlled by the adsorption of molecules [1].

The molecular adsorption can also be employed to modulate the surface electronic structure in different momentum space directions, creating anisotropic spin splittings in **k**-space [2]. This effect is caused by an asymmetric adsorption of the molecules. Physisorbed NH_3 gives rise to variations of the surface state Rashba parameters up to a factor of 1.4 over the surface Brillouin zone. In contrast, chemisorption of BH_3 leads to variations by more than a factor of 2.5. Consequently, the anisotropy carries over to a modulation of the surface state spin texture: the spin direction can be changed from in-plane to predominantly out-of-plane by modifying the electronic momentum by 90°.

[1] R. Friedrich, *et al.*, New J. Phys. **19**, 043017 (2017).
[2] R. Friedrich, *et al.*, Phys. Rev. B **96**, 085403 (2017).
This work was supported by the Volkswagen-Stiftung (Optically Controlled Spin Logic project) and DFG SFB 1238 (Project C01).

MA 49.6 Thu 16:30 H15

Tuning the coupling of an individual magnetic impurity to a superconductor: quantum phase transition and transport — •Laëtitia Farinacci[1], Gelavizh Ahmadi[1], Gaël Reecht[1], Michael Ruby[1], Nils Bogdanoff[1], Olof Peters[1], Benjamin W. Heinrich[1], Felix von Oppen[2], and Katharina J. Franke[1] — [1]Freie Universität Berlin, Germany — [2]Dahlem Center for Complex Systems, Berlin, Germany

Magnetic impurities on superconductors induce via exchange scattering local bound states, so called Yu-Shiba-Rusinov states, in their vicinity. Depending on the coupling strength between the impurity and the substrate, the system can be in a free- or screened-spin ground state.

Here, we use the flexibility of a Fe-porphin molecule on a Pb(111) surface to tune continuously and reversibly between these ground states. By approaching the STM tip toward the molecule we modify on the one hand the bound state energy and on the other hand the junction transport properties so that we can resolve the YSR excitations by single-electron as well as by (multiple) Andreev reflections. [1]

[1] Farinacci et al., PRL 121, 196803 (2018)

MA 49.7 Thu 16:45 H15

Investigation of the effect of Mn adatoms on the critical current in a STM Josephson junction — •Nils Bogdanoff[1], Rika Simon[1], Olof Peters[1], Gaël Reecht[1], Clemens B. Winkelmann[2], and Katharina J. Franke[1] — [1]Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Univ. Grenoble Alpes, Inistitut Neél, 25 Avenue des Martyrs, 38042 Grenoble, France

Atomic spins on superconducting surfaces introduce so called Yu-Shiba-Rusinov (YSR) states inside the superconducting gap as fingerprint of a magnetic interaction. Furthermore, theory predicts a renormalization of the local order parameter. Differential conductance spectroscopy reveals the YSR states but not the intrinsic order of the superconducting groundstate. Using a Josephson junction the order parameter can be determined directly by measuring its characteristic critical current. We use a Pb tip in a scanning tunneling microscope (STM) and a Pb substrate as a SIS junction. The precise control over the STM tip enables high real-space resolution to study for example defects on atomic length scales. As was shown before [1], a reduction of the critical current can be observed on iron adatoms on a Pb(110) surface.
Here, we measure the critical current caused by Mn adatoms on Pb(111) in voltage- and current-biased Josephson junctions. We show that these more strongly reduce the critical current than the Fe adatoms.

[1] M. T. Randeria et al., Scanning Josephson spectroscopy on the atomic scale, Phys. Rev. B 93, 161115(R), 2016

MA 49.8 Thu 17:00 H15

Broadband noise spectroscopy of antiferromagnetic iron dimers — •Gregory McMurtrie[1,2,3], Max Hänze[1,2,3], Luigi Malavolti[1,2,3], and Sebastian Loth[1,2,3] — [1]Institute for Functional Matter and Quantum Technologies, Stuttgart, Germany — [2]Max Planck Institute for Structure and Dynamics of Matter, Hamburg, Germany — [3]Max Planck Institute for Solid State Research, Stuttgart, Germany

Spin and charge dynamics are particularly pronounced in nanoscale materials, where they give rise to exciting effects such as quantum interference or quantum critical behavior. Accessing these dynamics on their intrinsic length and time scales is an important step towards a microscopic understanding of quantum physics on the atomic scale. Applying pulses [1] or continuous wave signals [2] to individual atoms has proven a powerful technique for the characterization of fast magnetic surface dynamics using scanning tunneling microscopy. We show that the dynamics of individual atoms can be observed in the frequency domain using broadband noise detection, thereby non-invasively revealing picosecond-scale fluctuations. This method is a powerful tool for characterizing both state lifetimes and measuring surface scattering effects, giving deeper insight into the fundamental dynamic behavior of spins coupled to dissipative environments. [1] S. Loth, M. Etzkorn, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 329 1628 (2010) [2] S. Baumann, W. Paul, T. Choi, C. P. Lutz, A. Ardavan, A. J. Heinrich, Science 350 6259 (2015)

MA 49.9 Thu 17:15 H15

Ab-initio study of the electron-phonon interaction of a single Fe adatom on the MgO/Ag(100) surface — •haritz garaimarin[1,2], julen ibañez-azpiroz[3], peio g. goiricelaya[1,2], idoia g. gurtubay[1,2], and asier eiguren[1,2] — [1]Materia Kondentsatuaren Fisika saila, Euskal Herriko Unibertsitatea UPV/EHU, Bilbo, Spain — [2]Donostia International Physics Center, Donostia, Spain — [3]Centro de Física de Materiales CSIC-UPV/EHU, Donostia, Spain

Breakthrough experimental studies have recently shown that it is possible to create stable magnetic quantum states in individual adatoms [1,2]. While the role of electronic interactions on the magnetic stability has been thoroughly investigated theoretically [3], the coupling with phonons has attracted much less attention. The aim of this work is to study, via ab-initio calculations, the effect of the electron-phonon interaction (EPI) in Fe adatoms deposited on MgO/Ag(100), a benchmark system where the EPI is believed to determine to large extent its magnetic stability [2]. Here we present the calculated electronic structure and vibrational dynamics of this system, including the local vibrations of the adatom. Furthermore, we analyze the effect of the EPI on the magnetic stability via the renormalization of the electronic properties of the adatom.

[1] F. Donati *et. al.*, Science **352**, 318 (2016). F. D. Natterer *et. al.*, PRL **121**, 27201 (2018). [2] W. Paul *et. al.*, Nat. Phys. **13**, 403 (2017). [3] N. Lorente and J.-P. Gauyacq, PRL **103**, 176601 (2009). J. Fernández-Rossier, PRL **102**, 256802 (2009). J. Ibañez-Azpiroz *et. al.*, Nano Lett. **16**, 4305 (2016).

MA 49.10 Thu 17:30 H15

Spin excitations in non-collinear magnetic clusters deposited on Pt(111) from TD-DFT — •Sascha Brinker, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich

Small magnetic clusters hold great promise for future information technology. The smallest stable magnetic nanostructure on a metallic surface is a Fe trimer on Pt(111) [1]. The spin stability is strongly influenced by the excitation spectrum and by relativistic effects, like e.g. the Dzyaloshinskii-Moriya-interaction [2], which is among others responsible for non-collinear magnetic ground states. In this contribution, we generalize our time-dependent density functional theory calculations already including the spin-orbit interaction [3, 4] to non-collinear magnetic structures, focusing on magnetic clusters on Pt(111). We interpret our results with a generalized Landau-Lifshitz-Gilbert equation. We pay special attention to the anisotropic and non-local contributions to the spin pumping and damping, and to their dependence on the magnetic structure.
This work was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (ERC Consolidator Grant No. 681405 DYNASORE).

[1] J. Hermenau *et al.*, Nat. Comm. **8**, 642 (2017)
[2] J. Hermenau, S. Brinker *et al.*, arXiv:1811.02807 (2018)
[3] M. dos Santos Dias *et al.*, Phys. Rev. B **91**, 075405 (2015)
[4] F. S. M. Guimarães *et al.*, Phys. Rev. B **96**, 144401 (2017)

MA 49.11 Thu 17:45 H15

Hyperfine interaction of individual atoms on a surface — •Philip Willke[1,2,3], Yujeong Bae[1,2,3], Kai Yang[3], Jose Lado[4,5], Alejandro Ferrón[6], Taeyoung Choi[1,2], Arzhang Ardavan[7], Joaquín Fernández-Rossier[4], Andreas Heinrich[1,2], and Christopher Lutz[3] — [1]Center for Quantum Nanoscience, Seoul, Republic of Korea — [2]Ewha Womans University, Seoul, Republic of Korea — [3]IBM Almaden Research Center, San Jose, USA — [4]International Iberian Nanotechnology Laboratory, Braga, Portugal — [5]ETHZ, Zurich, Switzerland — [6]Universidad Nacional del Nordeste, Corrientes, Argentina — [7]University of Oxford, Oxford, UK

The combination of electron spin resonance (ESR) with scanning tunneling microscopy (STM) enabled spin resonance on individual atoms on surfaces [1]. Making use of the increased energy resolution of ESR-STM we can resolve and control the hyperfine interaction of single atoms [2]. Using atom manipulation we find that the hyperfine interaction strongly depends on the binding configuration of the atom as well as the proximity to other magnetic atoms. This allows us to extract atom- and position-dependent information about the electronic ground state as well as properties of the nuclear spin. Moreover, we show that the populations of the nuclear spin states can be controlled by utilizing the spin-polarized tunnel current [3].

[1] S. Baumann *et al.*, Science **350** (2015). [2] P. Willke *et al.*, Science **362** (2018). [3] K. Yang, PW, *et al.*, Nature Nano (2018).

MA 50: Topology and Symmetry-Protected Materials (joint session O/MA/TT)

Time: Thursday 15:00–17:45 Location: H24

MA 50.1 Thu 15:00 H24

Structural and electronic characterization of thin Fe(Se,Te) films on the quaternary (Bi,Sb)Se$_x$Te$_{1-x}$ 3D topological insulator — •Philipp Kagerer, Thiago R. F. Peixoto, Celso Fornari, Hendrik Bentmann, and Friedrich Reinert — Experimental Physics VII, Julius Maximilian University of Würzburg

The combination of an s-wave superconductor iron-chalcogenide and a 3D-topological insulator (TI) has become a vivid research topic in condensed matter physics due to the proposed emergence of bound Majorana zero modes at the interface under the presence of a time-reversal-breaking magnetic field [1]. Owing to its simple cubic structure and good growth properties, thin FeSeTe layers on (Bi,Sb)Se$_x$Te$_{1-x}$ pose a promising platform to test this prediction.

Here we report on the epitaxial growth and characterization of thin layers of Fe(Se,Te) on a quaternary (Bi,Sb)(Se,Te) TI single-crystal. LEED and XPS experiments as well as STM and STS scans confirm the formation of a few monolayers of Fe(Se,Te) on top of the TI substrate. Using ARPES we show the arising of the FeSeTe valence bands near the Fermi level, along with the heavily n-doped band structure of the underlying TI. In addition, photon-energy-dependent and resonant measurements using synchrotron radiation allow a distinction between substrate and overlayer bands, and show indications for strong electron correlation and a Hubbard-gap in the material [2].

[1] L.Fu, C.L. Kane, Phys. Rev. Lett. 100, 096407 (2008)
[2] M.D.Watson et al., Phys. Rev. B 95, 081106(R) (2017)

MA 50.2 Thu 15:15 H24

Magnetic and Electronic Structure of the proposed Antiferromagnetic Topological Insulator MnBi$_2$Te$_4$ — •Raphael Crespo Vidal[1], Hendrik Bentmann[1], Thiago Peixoto[1], Alexander Zeugner[2], Anna Isaeva[2], Anja Wolter[3], Bernd Büchner[3], Mikhail Otrokov[4], Evgueni Chulkov[4], and Friedrich Reinert[1] — [1]Chair for Experimental Physics VII, Universität Würzburg, Germany — [2]Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Germany — [3]Leibniz-Institute for Solid State and Materials Research, Dresden, Germany — [4]Centro de Fisica de Materials, Centro Mixto, Spain

The interplay auf magnetism and topology gives rise to new topological quantum phases with broken time-reversal symmetry like the quantum anomalous Hall state.

Here we will present single-crystal measurements on the magnetic and electronic structure of MnBi$_2$Te$_4$ [1], a van der Waals bonded system composed of septuple layers stacked along its [0001]-axis. The layered structure results in a high accessibility for surface science methods, while its stochiometric nature leads to intrinsic magnetism without the need of free parameters like dopand concentration. By X-Ray magnetic circular dichroism, linear dichroism and bulk magnetization measurements we determine an out of plane A-type antiferromagnetic ordering below $T_N = 24$ K. Angle-resolved photoemission spectroscopy shows a massive Dirac-like state with an energy gap of $\sim$100 meV.

[1] M. Otrokov et al., ArXiv., 1809.07389 (2018)

MA 50.3 Thu 15:30 H24

XAS/XMCD study of magnetically doped (Bi,Sb)$_2$Te$_3$ — •Abdul-Vakhab Tcakaev, Volodymyr Zabolotnyy, Steffen Schreyeck, Karl Brunner, Charles Gould, and Vladimir Hinkov — University Würzburg, Am Hubland, 97074 Würzburg

The magnetic topological insulators Cr:(BiSb)$_2$Te$_3$ and V:(BiSb)$_2$Te$_3$ have been extensively studied as realizations of the quantum anomalous Hall (QAH) effect. While the QAH state in V-doped films is found to be significantly superior, the differences in the electronic structure and in the mechanisms of magnetic ordering for V- and Cr-doping remain under intensive debate. Here we combine x-ray absorption(XAS) and x-ray magnetic circular dichroism (XMCD) to trace element-specific contributions to the electronic and magnetic properties of these systems. We use *ab initio* density functional theory (DFT) based multiplet ligand field theory calculations (MLFT) at Cr and V $L_{2,3}$ edges for understanding and interpreting experimental results and determine local electronic and magnetic properties of these topological insulators.

MA 50.4 Thu 15:45 H24

Laser-based ARPES and pressure dependent magneto-transport studies of BiSbTe3 topological insulator — •Shiv Kumar[1], Vinod Kumar Gangwar[2], Yufeng Zhang[3,4], Prashant Shahi[5], Hitoshi Takita[1], Swapnil Patil[2], Eike Fabian Schwier[1], Kenya Shimada[1], Yoshiya Uwatoko[4], and Sandip Chatterjee[2] — [1]Hiroshima Synchrotron Radiation Center, Hiroshima University, Higashi-Hiroshima City, 739-0046, Japan — [2]Dept. of Physics, Indian Institute of Technology (BHU) Varanasi 221005, India — [3]School of Physics and Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 211189, China — [4]ISSP, University of Tokyo, Kashiwa, Chiba 277-8581, Japan — [5]Dept. of Physics, D.D.U. Gorakhpur University, Gorakhpur 273009, India

In recent years, 3D topological insulators (TIs), have drawn significant attention in condensed matter physics. Many TIs are known as good thermoelectric (TE) materials. We have grown single-crystal BiSbTe3 3D TI sample and studied structural, TE as well as pressure dependent magnetotransport properties. Large positive Seebeck coefficient confirmed the p-type nature of BiSbTe3, which is consistent with Hall measurement. We have also studied the electronic band structure using Laser-based ARPES, which revealed the existence of a Dirac-cone like metallic surface state in BiSbTe3 with a Dirac Point situated exactly at the Fermi level. The large Seebeck coefficient and good TE performance at room-temperature attract great attention for the application in TE devices. Additionally, superconductivity emerges under pressure of 8 GPa with a critical temperature of ~2.5 K.

Invited Talk MA 50.5 Thu 16:00 H24

Luttinger liquid in a box: electrons confined within MoS$_2$ mirror twin boundaries — •Wouter Jolie[1,2], Clifford Murray[1], Philipp Weiss[3], Joshua Hall[1], Fabian Portner[3], Nicolae Atodiresei[4], Arkady Krasheninnikov[5,6], Carsten Busse[1,2,7], Hannu-Pekka Komsa[6], Achim Rosch[3], and Thomas Michely[1] — [1]II. Physikalisches Institut, University of Cologne, Germany — [2]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Germany — [3]Institute for Theoretical Physics, University of Cologne, Germany — [4]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich, Germany — [5]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [6]Department of Applied Physics, Aalto University, Finland — [7]Department Physik, Universität Siegen, Germany

Two- or three-dimensional metals are usually well described by weakly interacting, fermionic quasiparticles. This concept breaks down in one dimension due to strong Coulomb interactions. There, low-energy excitations are expected to be collective bosonic modes, which fractionalize into independent spin and charge density waves.

In this talk I will present how we construct a well-isolated, one-dimensional metal of finite length using mirror twin boundaries in molybdenum disulfide (MoS$_2$). We demonstrate how scanning tunneling spectroscopy can identify the unique fingerprints of confined, strongly interacting states, thereby providing a direct and local experimental tool to investigate spin-charge separation in real space.

MA 50.6 Thu 16:30 H24

Structure and electronic properties of antimonene layers on Bi2Se3 interfaces — •Kris Holtgrewe[1], Conor Hogan[2], and Simone Sanna[1] — [1]University of Giessen, Germany — [2]CNR-ISM, Rome, Italy

Topological insulators (TI) exhibit unconventional physical effects that have attracted the interest of the scientific community, especially when coupled to trivial insulators. A topologically insulating Bi$_2$Se$_3$ substrate covered by the trivial insulator antimonene, is an ideal testbed to study the interfacial phenomena [1], and is furthermore interesting for applications such as topological pn-junctions [2].

Much research effort has been dedicated to surface preparation [3], recording of STM and ARPES images, as well as band structure calculations. However, the Sb-coverage dependent spin texture (e. g. position of Dirac states, Rashba splitting) is still not fully understood. Our work is dedicated to the theoretical investigation of the relationships between structural motifs, band structures and STM pattern. Thereby we show that including both spin-orbit coupling and van-der-Waals interaction in our density functional theory based approach is crucial for the correct modelling of the system.

[1] K. Jin et al, Phys Rev B **93**, 075308 (2016)
[2] S. Kim et al., ACS Nano **11**, 9671 (2017)
[3] R. Flammini, S. Colonna, C. Hogan, S. K. Mahatha, M. Papagno, A. Barla, P. M. Sheverdyaeva, P. Moras, Z. S. Aliev, M. B. Babanly, E. V. Chulkov, C. Carbone, and F. Ronci, Nanotechnology **29**, 065704 (2018)

Invited Talk MA 50.7 Thu 16:45 H24

Quasiparticle interferences on Type I and Type II Weyl semimetal surfaces — •Hao Zheng — School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China

A Weyl semimetal is a new topological phase of matter that extends the topological classification beyond insulators, exhibits quantum anomalies, possess exotic surface Fermi arc electron states and provides the first ever realization of Weyl fermions in physics. In a Weyl semimetal, the chirality of the Weyl nodes give rise to topological charges, which can be understood as monopoles and anti-monopoles of Berry flux in momentum space. They are separated in momentum space and are connected only through the crystal boundary by an unusual topological surface state, a Fermi arc. The surface of a Weyl semimetal has been predicted to exhibit interesting tunneling and transport properties, leading to potential electronic and spintronic applications.

We employed scanning tunneling microscopy/spectroscopy to directly visualize the coherent quasiparticle interferences on both type-I and type-II Weyl semimetal surfaces. On NbP (type-I Weyl) surface, we reveal that the surface interference channels are restricted by their surface spin and/or orbit textures and discover the existence of surface Dirac cones. On $Mo_xW_{1-x}Te_2$ (type-II Weyl), the topological Fermi arc derived quantum interference is clearly discerned. Our results may pave a new way towards the future research on a Weyl fermion related surface transport phenomena and devices.

MA 50.8 Thu 17:15 H24

Bulk and Surface Electronic Structure of the Weyl-Semimetals TaP and TaAs — •Tim Figgemeier[1], Chul-Hee Min[1], Phillip Eck[2], Jennifer Neu[3], Maximilian Uenzelmann[1], Domenico Di Sante[2], Theo M. Siegrist[3,4], Giorgio Sangiovanni[2], Hendrik Bentmann[1], and Friedrich Reinert[1] — [1]Experimentelle Physik VII, Universitaet Wuerzburg — [2]Theoretische Physik I, Universitaet Wuerzburg — [3]National High Magnetic Field Laboratory, Tallahassee, Florida — [4]College of Engineering, FAMU-FSU, Tallahassee, Florida

Tantalum Arsenide (TaAs) and Tantalum Phosphide (TaP) are prototypical Weyl-Semimetals. We examine the electronic band structure using Angle-Resolved Photoemission Spectroscopy over a broad range of excitation energies from the VUV to the Soft X-Ray regime. With this high flexibility in photon energies, we are able to analyse the entire complex band structure of TaP in detail. In particular the surface states and the bulk band structure are identified at different photon energies and compared to first principles DFT calculations. By use of linear polarized light, we disentangle the orbital character of the Fermi arcs and other electronic states in the Fermi surface along with their connection to the bulk band structure [1].

[1] Min et al., "Orbital Fingerprint of Topological Fermi Arcs in a Weyl Semimetal", arXiv:1803.03977 (2018)

MA 50.9 Thu 17:30 H24

Exploring the spin-orbital texture in a Dirac heavy metal by spin-resolving momentum microscopy — •Ying-Jiun Chen[1,2], Christian Tusche[1,2], Markus Hoffmann[3], Bernd Zimmermann[3], Gustav Bihlmayer[3], Stefan Blügel[3], and Claus Michael Schneider[1,2] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Fakultät für Physik, Universität Duisburg-Essen, 47057 Duisburg, Germany — [3]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Entanglement of spin and orbital degrees of freedom in strongly spin-orbit coupled materials creates exotic spin/orbital textures in momentum space such as Rashba and topological protected surface states. Dichroism in spin-polarized photoemission plays a crucial role in understanding the influence of spin-orbit coupling on the electronic wave functions. By virtue of the recent invention of the spin-resolving Momentum Microscope, the spin-detection efficiency and momentum resolution has been improved tremendously. This development makes it now possible to probe the photoelectron spin polarization as well as linear and circular dichroism in the angular distribution over the whole Brillouin zone. In addition to the d-electron-drived Dirac-type helical spin texture, we directly characterize the momentum-dependent spin-orbital entangled states on W(110) throughout the entire surface Brillouin zone by using differently polarized light. Comparison between theory and experiment provides insights into the large anisotropy of spin relaxation in the prototype Dirac heavy metal.

MA 51: Magnetism Poster B

Time: Thursday 15:00–18:00 Location: Poster C

MA 51.1 Thu 15:00 Poster C

Ultrafast spin dynamics in antiferromagnetic semiconductors and dielectrics — •Fabian Mertens, Davide Bossini, and Mirko Cinchetti — Experimentelle Physik VI, TU Dortmund, Otto-Hahn-Straße 4, 44227 Dortmund, Germany

The ultrafast manipulation of spins is of great interest, both in regard to possible future applications and for the exploration of novel dynamical magnetic phenomena. Our group focusses on the investigation of antiferromagnetic semiconductors and delectrics. Antiferromagnets have intrinsically faster spin dynamics compared to ferromagnetic materials. The strong exchange coupling and absence of a stray field could allow for a more robust and densly packed design of possible future memory devices. However the strong exchange coupling makes a manipulation of spins with external magnetic fields difficult, that is why we use light as stimulus. In semiconductors and dielectrics there are no free electrons and thus the energy dissipations are limited, because no Joule heating takes place. Consequently, coherent spin dynamics can be be induced and observed. In addition, the physical interpretation of the detected spin dynamics is simplified since, unlike in a metal, this signal is not dominated by the laser-heating. We plan to perform pump-probe measurements with femtosecond time-resolution, with the possibility to excite and detect different processes by independently tuning the pump and the probe photon energies between 0.5 eV and 3.5 eV.

MA 51.2 Thu 15:00 Poster C

Approaching THz spin-wave generation in optically-driven acoustic resonators — •Dennis Meyer[1], Vitaly Bruchmann-Bamberg[1], Jakob Walowski[2], Vasily Moshnyaga[1], and Henning Ulrichs[1] — [1]I. Physikalisches Institut, Georg-August Universität Göttingen, Germany — [2]Institut für Physik, Universität Greifswald, Germany

Coherent spin-wave generation between 100 GHz and a few THz is hard to achieve with current methods which either produce incoherent or non-monochromatic spin-waves. While normally an unwanted dissipation channel in spintronics, it was already shown that magneto-elastic coupling can be exploited to generate spin currents and coherent magnetic oscillations in the low GHz regime. Here, we propose a novel design to generate THz spin waves by laser excitation of an acoustic nano oscillator magneto-elastically coupled to a ferromagnetic layer.

We acknowledge financial support by the DFG within CRC1073.

MA 51.3 Thu 15:00 Poster C

Ultrafast Spintronic Devices — •Bikash Das Mohapatra[1] and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, D-06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, Heinrich-Damerow-Straße 4, D-06120 Halle, Germany

Spin valves based on GMR (Giant Magnetoresistance) are to be investigated in the Terahertz frequency range. The GMR structures are fabricated using sputter deposition and spin valve stacks are formed by e-beam lithography and ion beam etching with end-point detection. These structures will be used for magnetoresistance measurements and optimization for ultrahigh frequency AC transport experiments. It was shown earlier that the magnetoresistance becomes frequency dependent and can even change its sign due to time dependent spin accumulation in spacer layers at high frequencies which would be relevant for Spintronic application in the THz regime. Furthermore, it is planned to integrate the structures into Coplanar waveguides and to study the electrical response to optical demagnetization on the picosecond timescale. The measurements will be done using a VNA (vector network analyzer). This study can lead to new insights into the ultra high frequency response of GMR structures and to an extension of the Valet Fert Model to very high frequencies.

MA 51.4 Thu 15:00 Poster C

THz-2D Scanning Spectroscopy — •Finn-Frederik Lietzow[1], Yuta Sasaki[2], Nina Meyer[1], Jakob Walowski[1], Christian Denker[1], Markus Münzenberg[1], and Shigemi Mizukami[2] — [1]Institut for Physics, University Greifswald, Germany — [2]Advanced Institute for Materials Research, Tohoku University, Sendai, Japan

THz radiation has become an increasingly important tool for quality control in the food industry as well as in the medicine sector [1,2]. Since most seald plastic packaging compounds are transparent to THz radiation, it is possible to verify the food or drug ingredients by detecting their absorption lines even without unpacking the investigated substances [1].

We customized a standard commercial THz Fourier Transform spectrometer based on an LT-GaAs Auston switch emitter and detector from Menlo systems by adding a motorized 2D scanning unit. To test this 2D THz spectrocopy scanning system, we investigated a test stripe pattern of Au on glass with decreasing slitwidth and pitch. The measured resolution is very close to the diffraction limit and at 1 THz (300 μm) we can distinguish two points separated by a distance around 338 μm. The next step is to replace the commercial system by a spintronic emitter and a ZnTe detector so that we reach a higher bandwidth.

[1] A. G. Davies et al., Mat. Today 11 (2008) 18.
[2] S. K. Mathanker et al., ASABE 56 (2013).

MA 51.5 Thu 15:00 Poster C

Emission properties of spintronic terahertz emitters — •Rieke von Seggern[1], Christopher Rathje[1], Nina Meyer[2], Christian Denker[2], Markus Münzenberg[2], and Sascha Schäfer[1] — [1]Institute of Physics, University of Oldenburg, Germany — [2]Institute of Physics, University of Greifswald, Germany

In recent studies, the emission of strong single-cycle terahertz (THz) pulses from spintronic bilayer structures has been demonstrated, using the inverse Spin-Hall effect [1] of optically excited spin-polarized currents [2]. The emission shows a gapless spectrum with a bandwidth of up to 30 THz and high peak fields, offering promising avenues for THz spectroscopy.

In this work, we investigate the THz emission properties of Pt(2 nm)/$Co_4Fe_4B_2$(2.08 nm) driven by ultrashort optical pulses (1030-nm central wavelength, 255-fs pulse duration). We present our approach for controlling the emission properties by structured emitter surfaces and characterize the emitted THz pulses by electro-optic sampling. Nano- and microstructured spintronic THz emitters may enable a detailed tailoring of spatial and spectral emission poroperties and have the potential for large amplitude THz near-field excitation.

[1] Saitoh et al., Appl. Phys. Lett. 88, 182509 (2006)
[2] Seifert et al., Nat. Photonics 10, 483-488 (2016)

MA 51.6 Thu 15:00 Poster C

Spin- and charge transport at THz frequencies in metallic multilayers — •Marcel Burgard[1], Dennis M. Nenno[1], Hans Christian Schneider[1], Tobias Kampfrath[2,3], and Lukáš Nádvorník[3] — [1]Physics Department and Research Center OPTIMAS, TU Kaiserslautern — [2]Department of Physical Chemistry, Fritz Haber Institute of the Max Planck Society, Berlin — [3]Department of Physics, Freie Universität Berlin

We theoretically investigate spin and charge currents in metallic films and magnetic multilayers. These currents are driven by THz-fields via the inverse spin-Hall effect [1]. Frequencies in the THz regime have been shown to drastically alter the transport properties for electrons close to the Fermi energy, as they are described a wave-diffusion equation instead of the quasi-static Fick's law [2]. Here, we solve the wave-diffusion equations self-consistently with Maxwell's equations for the fields set up by charge accumulation and study the effects of screening on the transport at THz frequencies.

[1] L. Nadvornik *et al.*, in preparation
[2] Y. H. Zhu, B. Hillebrands, and H. C. Schneider, Phys. Rev. B **78**, 054429 (2008)

MA 51.7 Thu 15:00 Poster C

VSM4VTI - thin film measurements with DIY-magnetometer — •Alfons Georg Schuck, Jörg Franke, and Michael Huth — Institute of Physics, Goethe University, Max-von-Laue-Strasse 1, 60438 Frankfurt am Main, Germany

A Vibrating Sample Magnetometer (VSM), which is designed as a top loading probe for a variable-temperature insert (VTI) is described. It is constructed as an affordable "do-it-yourself" alternative to commercial Physical Properties Measurement Systems (PPMS) with small samples like thin films in mind. The magnetometer uses a voice-coil drive in a resonator-setup. The sample oscillation is monitored by a quadrature encoder. The correct positioning of the sample in the center of a gradiometer coil is ensured by a stepper-motor driven linear actuator. Details of the VSM design are presented.

In combination with a common lock-in-amplifier, the device is highly sensitive. Measurements of a thin film at low temperatures are performed as well as complemental numerical simulations. Influences of the sample holder and the substrate on the measurements are described.

MA 51.8 Thu 15:00 Poster C

Fabrication of diamond tips for optical magnetometry — stefan dietel[1], •severine diziain[1], robert staacke[1], lukas botsch[1], bernd abel[2], jan meijer[1], and pablo esquinazi[1] — [1]Universität Leipzig - Felix-Bloch-Institut für Festkörperphysik, Linnéstraße 5, 04103 Leipzig — [2]Leibniz Institute of Surface Engineering (IOM), Permoserstr. 15, 04318 Leipzig

Nanoscale optical magnetometers based on negatively charged nitrogen - vacancy (NV) centers in diamond have been demonstrated for the detection and imaging of magnetic fields with both high spatial resolution and high sensitivity. They consist either of a diamond nanocrystal hosting a single NV center attached to the extremity of an atomic force microscopy tip or of a diamond nanopillar with a single NV center etched in a diamond cantilever. The latter allows for higher sensitivity and better light collection efficiency. However its fabrication is not very efficient since a large quantity of diamond has to be damaged for the production of only a few tips. We propose a technique that consumes less diamond. By angle etching only the surface of the diamond is used for the tip fabrication. With this technique the crystalline orientation can be chosen to optimize the light coupling and the NV center orientation.

MA 51.9 Thu 15:00 Poster C

Sensitivity enhancement of EPR-on-a-chip with sensor array — •Silvio Künstner[1], Anh Chu[2], Benedikt Schlecker[3], Boris Naydenov[1], Jens Anders[2], and Klaus Lips[1,4] — [1]Berlin Joint EPR Laboratory, Institut für Nanospektroskopie, Helmholtz-Zentrum Berlin für Materialien und Energie — [2]Institut für Mikroelektronik, Universität Ulm — [3]Institut für Intelligente Sensorik und Theoretische Elektrotechnik, Universität Stuttgart — [4]Berlin Joint EPR Laboratory, Fachbereich Physik, Freie Universität Berlin

Electron paramagnetic resonance (EPR) is the method of choice to investigate and quantify paramagnetic impurities in e.g. semiconductor devices, proteins, catalysts and molecular nanomagnets. The current design of conventional EPR spectrometers, however, limits the versatility for *operando* measurements. Here, we present an improved design of a miniaturised EPR spectrometer, implemented on a single microchip (EPRoC). On the chip, an array of coils each with a diameter of a few 100 μm is used as both a mw source and detector, allowing to perform both EPR spectroscopy and imaging. Due to its compactness, EPRoC can be incorporated in growth reactors, (electro)chemical cells or in UHV environments. The sensitivity of the new design is tested with standard EPR samples for various conditions such as conductive and polar environments to demonstrate its excellent capabilities for *operando* investigations of thin film solar cell materials and catalysts for solar fuel devices.

MA 51.10 Thu 15:00 Poster C

Examination of phase transition temperatures of magnetically doped polymer solutions — •Samira Webers[1], Melissa Hess[2], Joachim Landers[1], Annette M. Schmidt[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Institute for Physical Chemistry, University of Cologne

Magnetic cobalt ferrite nanoparticles incorporated in dilute and semidilute polymer solutions are used as tracer particles to probe the phase transitions of the hybrid material by measuring the temperature dependent magnetization. Here, a detailed investigation of polyethylene glycol/water systems are carried out to reveal the melting, freezing and glass transition temperature. Those results are compared to differential scanning calorimetry, which underlines the results measured by magnetization curves. By further studying the influence of nanoparticles in solutions to DSC curves, it was found that the corresponding glass features are suppressed. This work is supported by the DFG priority program SPP1681 (WE2623-7).

MA 51.11 Thu 15:00 Poster C

Studying chain formation in ferrofluids and ferrogels by Mössbauer spectroscopy — •Damian Günzing[1], Joachim Landers[1], Soma Salamon[1], Hajnalka Nádasi[2], Alexey Eremin[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Institute of Physics, University of Magdeburg

In this study we investigated the magnetic field induced chain formation of spherical iron oxide nanoparticles (diameter d $\approx$ 10 nm) dispersed in n-dodecan as a ferrofluid. The ferrogel was prepared by the mentioned ferrofluid and an additional gelator. The chain length was evaluated by measuring the diffusive mobility and orientation of the particles simultaneously via Mössbauer spectroscopy. The Mössbauer spectra were recorded at temperatures from 234 to 258 K in an applied magnetic field parallel (up to 150 mT) and perpendicular (up to 750 mT) to the incident γ-rays. The results from the Mössbauer spectra were compared to magnetometry data. From the comparison to numerical models we determined a magnetic field driven reversible chain formation with a mean chain length of up to ca. 3 particles. This work is financially supported by the DFG priority program SPP1681 (WE2623-7).

MA 51.12 Thu 15:00 Poster C

Finding magnetic ground state of deposited clusters from first principles — •Balázs Nagyfalusi[1], László Udvardi[1,2], and László Szunyogh[1,2] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]MTA-BME Condensed Matter Research Group, Budapest University of Technology and Economics, Budapest, Hungary

As the size of spintronic devices approaches the size of clusters containing few hundred of atoms the role of the simulations which are able to describe the magnetic properties of such a systems are more pronounced. We developed a method in the framework of the embedded cluster Green's function method[1] based on the the minimization of the overall torque on the magnetic moments. In order to find the local minimum we used the gradient descent method combined with the Newton-Raphson iteration where the torque and the Hessian matrix were calculated directly from first principles instead of relying on an effective spin Hamiltonian.

The procedure were applied on Fe trimers and on Fe chains deposited on Rh(111) surface. The geometry and the layer-layer distances were obtained from previous *ab initio* calculations. The sensitivity of the magnetic configuration on the geometry were studied by determining the ground state at different lattice relaxations. The overall results show the inherent symmetry and are more complex magnetic configuration than a trivial ferromagnetic alignment.

[1] B. Lazarovits, L. Szunyogh and P. Weinberger, Phys. Rev. B **65**, 104441 (2002)

MA 51.13 Thu 15:00 Poster C

Size-controlled synthesis of hexagonal magnetite nanoparticles — •Ilona Wimmer[1], Bastian Trepka[2], Sebastian Polarz[2], and Mikhail Fonin[1] — [1]Department of Physics, University Konstanz, D-78457 Konstanz — [2]Department of Chemistry, University Konstanz, D-78457 Konstanz

Magnetic nanoparticles show a variety of unique properties such as superparamagnetism, magnetic single domain states, enhanced magnetic moments and magnetic anisotropies. These phenomena are not found in their bulk counterparts and make magnetic nanoparticles highly interesting for many applications ranging from medicine to data storage. The orientation of the magnetization, the coercivity, the energy barriers which have to be overcome upon reversal and the blocking temperature of nanoparticles are affected by the crystal lattice in connection with the surfaces of nanoparticles.

Here we report on monodisperse magnetite (Fe_3O_4) nanoparticles which were synthesized by means of a solvothermal synthesis and characterized by means of x-ray diffraction and transmission electron microscopy. The particles show a pronounced hexagonal shape with the average particle size of 15 nm. Magnetic measurements reveal superparamagnetic behavior with a blocking temperature of 135 K.

MA 51.14 Thu 15:00 Poster C

Mössbauer study of the particle-matrix interaction of cobalt ferrite nanoparticles — •Juri Kopp[1], Samira Webers[1], Melissa Hess[2], Joachim Landers[1], Annette M. Schmidt[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Institute for Physical Chemistry, University of Cologne

Previous magnetorheological measurements of cobalt ferrite nanoparticles in a polymer sucrose solution showed a polymer length dependent particle-matrix interaction between the polymer and the nanoparticles. Here, we study cobalt ferrite nanoparticles in a sucrose solution without the polymer as a reference measurement. For this purpose, sucrose solutions of different concentration were used to study the temperature dependent particle mobility via the change in line broadening observed in Mössbauer spectra. As expected, lower sucrose concentration showed a more water-like behavior and a more sudden increase of the line broadening than the one with higher sucrose concentration. Subsequently the results from the reference measurement are compared to Mössbauer spectra of the polymer sucrose solution. This work is supported by the DFG priority programme SPP1681.

MA 51.15 Thu 15:00 Poster C

Optimizing the cultivation of Magnetospirillum gryphiswaldense bacteria by setup of a hypoxic chamber — •Fabian Kugel, Paula Weber, Maryam Youhannayee, and Mathias Getzlaff — Institut für Angewandte Physik, Heinrich-Heine-Universität Düsseldorf, Deutschland

Nano-magnetic hyperthermia as a novel cancer therapy commonly uses iron oxide nanoparticles (NP) to heat up tumor tissue. Magnetotactic bacteria such as Magnetospirillum gryphiswaldense (MSR-1) synthesize magnetite NP by biomineralisation. These bacterial particles have unique properties that are advantageous in hyperthermia applications.

We established a cost-efficient method to cultivate MSR-1. The necessary microaerobic environment was implemented by setup of a hypoxic chamber and an oxygen control system.

The cultured bacteria were studied by transmission electron microscopy (TEM). According to the TEM images the quality of the cultivated samples was comparable to commercial products. The diameter of the internal NP was found to be (46.4 ± 8.8) nm which corresponds to a magnetic single-domain state.

Further variations in the cultivation process where examined for their influence on the NP growth. The cultivation of MSN-1 at higher oxygen concentrations led to suppression of size in adolescent NP.

MA 51.16 Thu 15:00 Poster C

Wet-chemically prepared magnetic nanoparticles: Influence of different preparation methods — •Jan Martin Henke, Maryam Youhannayee, and Mathias Getzlaff — Institut für Angewandte Physik, Heinrich-Heine-Universität, Düsseldorf, Deutschland

Iron oxide nanoparticles (NP) are often used in hyperthermia for cancer therapy due to their unique magnetic properties in order to heat up the tumor cells. In this project magnetite nanoparticles are synthesized in coprecipitation method under different variable parameters such as iron salt, stirring speed and temperature. After synthesizing the particles, they are coated by 3-aminopropyltriethoxysilane (APTES) and tetramethylammoniumhydroxide (TMAOH).

The morphology and crystalline structure of the particles are characterized by transmission electron microscopy (TEM) and X-ray diffraction (XRD), resp. The average size measured by TEM is about (10.40 ± 2.88) nm. The crystalline structure of magnetite was confirmed by XRD.

The properties of particles prepared by different salts do not show significant changes in size and crystalline structure. The XRD-data were fitted with Gaussian and Voigt functions. The size was calculated with the Scherrer equation and confirm approximately the same diameter as measured by TEM. A reduced stirring speed did also not affect the particles diameter, but an increased temperature leads to smaller particles. The stability of the particles in aqueous solution was increased by APTES and TMAOH coating.

MA 51.17 Thu 15:00 Poster C

Magnetoimpedance biosensor for detecting stray fields of nanoparticles: experiment and model — •Elizaveta Golubeva[1], Benjamin Spetzler[2], Franz Faupel[2], and Galina Kurlyandskaya[1] — [1]Ural Federal University, Ekaterinburg, Russia — [2]Kiel University, Kiel, Germany

Magnetic nanoparticles (MNPs) offer great potential to be involved in a wide range of biomedical applications. One of the main challenges for the utilization of MNPs is their detection and precise localization in a patient's body. Magnetic field sensors based on the giant magnetoimpedance effect (GMI) are promising candidates for detection, due to potentially large sensitivities [1] and small detection limits [2]. However, a compromise must be reached between an optimum magnetic bias field for GMI sensitivity and the maximum net stray field of the MNPs. With this work, a comprehensive model is presented that describes the mutual interaction of the sample and the sensing element as well as the resulting electrical impedance. The model is used to find the optimum operation parameters for the sensor, including the geometric and magnetic configuration of the system. Finally, the results are compared with measurements on sensor prototypes with an amorphous wire or a ribbon as a sensitive element. General consequences are derived.

[1] N.A. Buznikov, et al., Biosensors and Bioelectronics, 117,366-372, (2018) [2] T. Uchiyama, et al., Physica Status Solidi (a), 206, 639-643, (2009)

This work is supported by the RSF grant 18-19-00090.

MA 51.18 Thu 15:00 Poster C

Perpendicular Magnetic Anisotropy for xMR Sensor Technology — •Clemens Mühlenhoff[1,2], Wolfgang Raberg[1], Armin Satz[1], Klemens Prügl[1], Dieter Süss[3,4], and Manfred Albrecht[2] — [1]Infineon Technologies AG, 85579 Neubiberg, Germany — [2]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — [3]Physics of Functional Materials, University of Vienna, 1090 Vienna, Austria — [4]Advanced Magnetic Sensing and Materials, Christian Doppler Research Association, 1090 Vienna, Austria

Magnetoresistive (xMR) technology has replaced Hall sensors in many high frequency and low field applications due to its higher sensitivity and large bandwidth. However, there are still yet unsolved challenges. For example, xMR sensors lack the ability to measure magnetic fields in a wide linear range, which is needed for high field applications, e.g. detecting high electrical current. Furthermore, there are no xMR sensors available that substitute z-sensitive Hall sensors with comparable linearity and low hysteresis. These challenges we tackle by introducing a magnetic layer with perpendicular magnetic anisotropy (PMA) into the xMR stack system. PMA is achieved by orbital hybridizations at the interfaces in CoFeB/MgO systems, as well as in Co/Pt multilayers. The influence of a Ru/Ta/Pt seed layer and a Ta(N) capping layer was studied in connection with deposition and annealing temperatures. Depending on the choice of anisotropy in free and reference layer, we obtain linear field ranges of +/-150 mT and realize a z-sensitive xMR technology with a perpendicular reference layer applicable up to 600 mT.

MA 51.19 Thu 15:00 Poster C

Noise level optimisation in PHE sensors for magnetic nanoparticles detection — •Anastasiia Moskaltsova, Luca Marnitz, Jan-Michael Schmalhorst, and Günter Reiss — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Universitätsstraße 25, Bielefeld 33615, Germany

Magnetoresistive (MR) sensors are well known for their various applications, including magnetic nanoparticles (MNPs) detection. In frame of the EU H2020 MADIA project [1] we focus on real-time MNPs detection using planar Hall effect (PHE) MR sensors. The main goal of the project is to develop a versatile and cost-effective tool for early diagnosis of Alzheimers and Parkinsons diseases. This can be achieved by combining high sensitivity sensors with microfluidics and functionalized MNPs. Noise level is among the relevant sensor characterisitics, as it gives the information on the minimum detectable magnetic field for a given frequency. Recently, the noise level of $\sim$ pT/$\sqrt{Hz}$ was achieved for magnetic tunnel junctions [2].

In this work we study PHE sensors noise in the frequency range from 1 Hz to 10 kHz. A study on influence of the PHE sensor size and the applied current on the noise level is conducted, as these parameters are inlcuded in the phenomenological Hooge model of noise [3].

[1] http://www.madia-project.eu
[2] Chaves et al. Appl. Phys. Lett. 91, 102504 (2007)
[3] F. N. Hooge, IEEE T. Electron. Dev., 41, 1926, (1994)

MA 51.20 Thu 15:00 Poster C

Influence of sputter conditions on domain configurations in patterned thin films — •Sukhvinder Singh[1], Leon Abelmann[2], Haibin Gao[1], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, Saarland University, Saarbrücken, Germany — [2]Korea Institute of Science and Technology (KIST)-Europe, Saarbrücken, Germany

Well-defined and technically relevant domain configurations are sought in patterned magnetic thin films [1,2]. We used Magnetic Force Microscopy to investigate domain configurations in square and disc shaped patterned Permalloy thin films. The films were prepared with sputter deposition by varying the Argon pressure from 1.5 micro-bar upto 30.0 micro-bar. The four domain configurations in squares and single vortex states in discs are found as the lowest energy states in the films prepared at 1.5 micro-bar Argon pressure. With the increase of the Argon pressure, higher energy complex domains are formed and irregularity in the domain configurations increases. From the magnetic and structural characterizations, an increase of the coercivity and a decrease of the film density with the increase of Argon pressure is observed. Moreover, the change in microstructure and composition of the films with the change of Argon pressure is linked to the formation of domain configurations inside the patterned samples.

[1] S. Cherifi et. al., Journal of Applied Physics, 98, 043901 (2005).
[2] J. McCord, Journal of Applied Physics, 95, 6855 (2004).

MA 51.21 Thu 15:00 Poster C

Surface acoustic wave driven magnetic resonance in CoFe thin films — •Adrian Gomez[1,2], Lukas Liensberger[1,2], Luis Flacke[1,2], Matthias Althammer[1,2], Hans Huebl[1,2,3], Rudolf Gross[1,2,3], and Mathias Weiler[1,2] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, Technische Universität München, Garching, Germany — [3]Nanosystems Inititative Munich, München, Germany

In communication technology, surface acoustic waves (SAWs) are ubiquitous as delay lines and bandpass filters. In research, SAWs regained interest for the investigation of the interplay of coherent phonons with other degrees of freedom in a solid state environment. In particular, we are interested in the magnon-phonon interaction within a low-damping thin film ferromagnet. We employ optical lithography to define SAW delay lines on a lithium niobate substrate. Our devices use interdigital transducers (IDTs) to convert the electrical stimulus to SAWs. In this presentation, we quantify the key performance aspects of our SAW delay lines operating in the GHz frequency range. Those frequencies enable the investigation of the resonant magnetoelastic excitation of spin waves in a ferromagnetic thin film of CoFe by coherent phonons. Technically, the film is sputter-deposited between the two IDTs. In addition to the phonon transmission information, we optically detect the generated magnetic excitations. We acknowledge financial support by DFG via projects WE5386/4 and WE5386/5.

MA 51.22 Thu 15:00 Poster C

Spin-resolved electronic structure of 3d transition metals during ultrafast demagnetization — •Beatrice Andres, Jonathan Weber, Wibke Bronsch, and Martin Weinelt — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

Spin-resolved experiments on magnetization dynamics are still rare. Few photoemission works have been published, which show not only spin- but also energy-resolved magnetization dynamics [1-3]. Refs. [1] and [3] demonstrated that in one material spin dynamics can be very different for the various electronic states and thus the outcome of any ultrafast demagnetization experiment depends on the probed electronic states. This emphasizes the importance of spin-resolved measurements in magnetization dynamics.

Continuing the research of these works, here we present new results on the ultrafast demagnetization of thin Fe films on W(110). In laser photoemission ($h\nu_{\text{Probe}} = 6.2$ eV) we find an ultrafast breakdown of the spin polarization after pumping the system with 70-fs pulses at $h\nu_{\text{Pump}} = 1.6$ eV. Measuring a minority-spin surface resonance close to the Fermi level at ~ 0.1 Å^{-1} in Γ-H direction, we observe only marginal changes in binding energy, while there is a pronounced drop of spin polarization. These findings corroborate a band mirroring effect similar to the ones observed in Refs. [1] and [2].

[1] Gort *et al.*, *Phys. Rev. Lett.* **121**, 087206 (2018)
[2] Eich *et al.*, *Sci. Adv.* **3**, e1602094 (2017)
[3] Andres *et al.*, *Phys. Rev. Lett.* **115**, 207404 (2015)

MA 51.23 Thu 15:00 Poster C

Fluence-dependent ultrafast magnetization dynamics in TbGd bilayers and their interfacial spin-coupling — •Markus Gleich[1], Kamil Bobowski[1], Dominic Lawrenz[1], Can Çağıncan[1], Niko Pontius[2], Daniel Schick[2], Christian Schüssler-Langeheine[2], Björn Frietsch[1], Unai Atxitia[1], Nele Thielemann-Kühn[1], and Martin Weinelt[1] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, 12489 Berlin

We studied the fluence-dependent ultrafast magnetization dynamics in TbGd bilayers by XMCD in reflection at the FemtoSpex facility of BESSY II. The bilayers were grown on a W(110) substrate and show a two-step demagnetization as observed in previous experiments on Gd and Tb [1-4]. Interestingly, the static magnetic properties and the spin dynamics of a Gd thin film can be significantly altered by depositing only a few monolayers of Tb on top. The temperature-dependent magnetization of Gd in TbGd bilayers is influenced by the Tb layer depending on the distance from the interface, which suggests a substantial spin-coupling between Gd and Tb.

[1] M. Wietstruk *et al.*, Phys. Rev. Lett. **106**, 127401 (2011).
[2] M. Sultan *et al.*, Phys. Rev. B **85**, 184407 (2012).
[3] A. Eschenlohr *et al.*, Phys. Rev. B **89**, 214423 (2014).
[4] K. Bobowski *et al.*, J. Phys.: Condens. Matter **29**, 234003 (2017).

MA 51.24 Thu 15:00 Poster C

Spin structure of superparamagnetic iron oxide nanoparticles — •Tobias Köhler[1], Artem Feoktystov[1], Oleg Petracic[2], Emmanuel Kentzinger[2], Tanvi Bhatnagar[2,4], Sascha Ehlert[3], Ulrich Rücker[2], Rafal Dunin-Borkowski[4], Andras Kovacs[4], and Thomas Brückel[2] — [1]Forschungszentrum Jülich GmbH, JCNS at MLZ, 85748 Garching, Germany — [2]Forschungszentrum Jülich GmbH, JCNS-2 and PGI-4, JARA-FIT, 52425 Jülich, Germany — [3]Forschungszentrum Jülich GmbH, JCNS-1, 52425 Jülich, Germany — [4]Forschungszentrum Jülich GmbH, Ernst Ruska-Centrum für Mikroskopie und Spektroskopie mit Elektronen, 52425 Jülich, Germany

We have studied superparamagnetic iron oxide nanoparticles by various experimental techniques in order to characterize the observed reduced saturation magnetization as compared to bulk. Particles of the size of 12 and 15 nm have been studied via small-angle X-ray scattering (SAXS), X-ray diffraction (XRD), high-resolution transmission electron microscopy (HRTEM), inductively coupled plasma with optical emission spectroscopy (ICP-OES) and magnetometry to obtain a detailed understanding of the internal magnetization distribution. Small amounts of spherical particles were dispersed in paraffin, so that inter-particle interactions can be neglected. The shapes of the magnetometry curves confirm a superparamagnetic behavior. The presence of exchange bias indicates an antiferromagnetic, wüstite contribution to the particle composition. Small-angle scattering of polarized neutrons (SANSPOL) will provide insights into the inner spin structure.

MA 51.25 Thu 15:00 Poster C

Growth, Structuring and Characterization of $La_{1-x}Sr_xMnO_3$|Pt-heterostructures — •Cinja Seick[1], Lukas Szabadics[2], Vitaly Bruchmann-Bamberg[1], Christian Jooss[2], Vasily Moshnyaga[1], Stefan Mathias[1], Daniel Steil[1], and Henning Ulrichs[1] — [1]I. Physikalisches Institut, Universität Göttingen, 37077 Göttingen, Germany — [2]Institut für Materialphysik, Universität Göttingen, 37077 Göttingen, Germany

The main goal of our project is the investigation of ultrafast magnetization dynamics in correlated materials under the influence of injected spins via the inverse spin Hall effect. For an effective spin injection, we need samples with a high SOC material in contact with the respective correlated material.

On our poster, we report on the fabrication of corresponding LSMO|Pt bilayer systems. We have tested a multitude of preparation techniques, namely metalorganic aerosol deposition, xenon ion sputtering and thermal vaporization, and compare our fabricated samples with respect to quality of epitaxial growth, interface quality and to the magnetic properties of the LSMO.

We acknowledge financial support by the DFG within the SFB 1073 - Atomic scale control of energy conversion.

MA 51.26 Thu 15:00 Poster C

Magnetic patterning of TMR thin film systems for controlled movement and detection of superparamagnetic beads — •Rico Huhnstock[1], Andreas Becker[2], Jendrik Gördes[1], Maximilian Merkel[1], Dennis Holzinger[1], Arno Ehresmann[1], and Andreas Hütten[2] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel — [2]Thin Films and Nanostructures, Department of Physics, Bielefeld University, P.O. Box 100131, D-33501 Bielefeld

Designing point-of-care diagnostic devices using magnetic particles as labels for disease specific biomolecules, an obstacle presents itself in directing the particles towards a highly sensitive detection area [1]. As a solution, we propose the novel combination of a magnetically patterned exchange bias thin film system for initialising particle movement with magnetic tunnel junction based sensor elements. In this work we demonstrate the successful fabrication of such hybrid systems by means of keV-He ion bombardment and verify the induced magnetic domain pattern. It is shown, that the magnetoresistance of the sensor elements is unharmed by the bombardment process and thus enables a detection of delivered magnetic particles. Finally the experimental realization of a directed particle transport above the hybrid system in a microfluidic environment proves the potential application of the here presented system within biomedicine.

[1] Weddemann *et al.* (2010), Biosensors and Bioelectronics, 26: 1152-1163.

MA 51.27 Thu 15:00 Poster C

Increased power transfer and heat generation in inductive heating applications through proper materials selection — •Marius Wodniok, Michael Feige, Werner Klose, Mikhail Tolstykh, Lennart Weber, and Sonja Schöning — Bielefeld Institute for Applied Materials Research (BIfAM), Bielefeld University of Applied Sciences, Department of Engineering Sciences and Mathematics, Interaktion 1, 33619 Bielefeld, Germany

Inductive heating is a well-established application of wireless power transfer. However, in this particular case there is a substantial need for optimization. Increasing the converted power while maintaining a high energy efficiency in combination with a homogeneous heat distribution are the leading requirements in that field.

We have performed finite element simulations using COMSOL Multiphysics in order to find the optimal material parameters of the transmitter coil environment and the receiving ferromagnetic metal film as well. An experimental induction heating setup is used to validate the simulated predictions. We have investigated a series of different ferrite materials, electrical steels and coil embedding environments.

According to our findings, it is possible to tailor the coil environment as well as the receiver's materials properties in a way that the energy transfer leads to in substantially increased heating performance.

MA 51.28 Thu 15:00 Poster C

The role of structural anisotropy in the magnetooptical response of an organoferrogel with mobile magnetic nanoparticles — Hajnalka Nadas1[1], Ralf Stannarius[1], Jing Zhong[2], Karin Koch[2], Annette M. Schmidt[3], Frank Ludwig[2], and •Alexey Eremin[3] — [1]Institute of Physics, Otto von Guericke Universität Magdeburg Germany — [2]Institute of Electrical Measurement Science and Fundamental Electrical Engineering, TU Braunschweig — [3]Institut fü Physikalische Chemie, Universität zu Köln, Köln, Germany

We study magnetooptical and dynamic magnetic properties of organoferrogels containing mobile and bound magnetic nanoparticles (MNPs). The aim of the study is to investigate the coupling between the MNPs and a fibrillar gel network on the gel structure and magnetooptical properties. We demonstrate that the mobile MNPs forming doublets are responsible for the field-induced birefringence. The magnetooptical response becomes strongly suppressed in samples where the magnetic particles are bound via hydrogen bonds. We show that the structural anisotropy of the gel has a profound effect on the optical and magnetic response of the ferrogel.

MA 51.29 Thu 15:00 Poster C

Ferromagnetic writing on B2 $Fe_{50}Rh_{50}$ thin films using ultra-short laser pulses — •Alexander Schmeink[1,2], Benedikt Eggert[3], Jonathan Ehrler[1], Mohamad Mawass[4], René Hübner[1], Kay Potzger[1], Jürgen Lindner[1], Jürgen Fassbender[1,2], Florian Kronast[4], Heiko Wende[3], and Rantej Bali[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Fakultät für Physik, Technische Universität Dresden, Germany — [3]Fakultät für Physik and CENIDE, Universität Duisburg-Essen, Germany — [4]Helmholtz-Zentrum Berlin, Germany

Laser manipulation of magnetic properties has potential applications in data storage. B2 $Fe_{50}Rh_{50}$ alloy is well-known to show a temperature-driven antiferromagnetic (AFM) to ferromagnetic (FM) transition at ≈380 K. In contrast to the temperature-driven transition, FM regions can be induced via atomic rearrangements leading to antisite disorder, to form A2 $Fe_{50}Rh_{50}$. The above B2 → A2 transition can be realised in alloy thin films using ion beams as well as laser pulses, resulting in localized non-volatile FM writing.[1] Here, we irradiate B2 $Fe_{50}Rh_{50}$ thin films of ≤30 nm thicknesses with ∼100 fs short laser pulses and observe the induced magnetic and structural changes. Depending on the laser fluence, transitions of B2 $Fe_{50}Rh_{50}$ to A2 and with further disordering to the A1 structure are observed. The deposited energy influences the resolidifcation of the alloy, thereby determining the structure.

This work is funded by the DFG (BA 5656/1-1).

[1] J. Ehrler et al. *ACS Applied Materials & Interfaces* **2018** 10 (17), 15232-15239

MA 51.30 Thu 15:00 Poster C

Fabrication of anisotropic magnetic nanostructures — •Irene Iglesias, Marina Spasova, Ulf Wiedwald, and Michael Farle — University Duisburg-Essen and Center for Nanointegration Duisburg-Essen (CENIDE), Germany

The study of anisotropic magnetic micro- and nanostructures is of great interest due to their potential use in a wide range of applications, ranging from biomedicine to storage devices. While the fabrication of the microstructured systems is nowadays widely studied, downsizing to the nanoscale is still a great challenge. In this work, we present the fabrication and magnetic properties of one-dimensional ferromagnetic functional nanostructures, such as nanowires, nanorods, nanotubes and semi-tubes, grown by electrodeposition in ion-track membrane templates. The shape and size, as well as the structural properties of the nanostructures, can be tuned by controlling the deposition parameters such as precursors, deposition potential, pH, Ar flow and others. Moreover, a novel approach for the fabrication of ferromagnetic core-shell nanorods with dimensions in the submicron scale was developed and established. As an example, we present here Co-Fe core-shell nanorods with a length of 1 μm and diameters ranging from 50 nm to 70 nm. The nanorods were structurally and magnetically characterized by scanning and transmission electron microscopy and SQUID magnetometry.

MA 51.31 Thu 15:00 Poster C

Thickness dependence of compensation temperature in GdCoFeB ferrimagnets — •Fabian Kammerbauer[1], Nico Kerber[1], and Boris Seng[1,2] — [1]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany. — [2]University of Lorraine, 54506 Vandoeuvre-lès-Nancy, France.

Magnetic skyrmions are topologically protected spin textures particularly suitable for next generation spintronics devices, like the skyrmion-based racetrack memory. Recent studies confirmed the current-driven skyrmion dynamics in ultrathin ferromagnets[1]. However, the topological Magnus effect leads to a transverse motion of ferromagnetic skyrmions due to their non-zero topological charge[1]. Antiferromagnetically exchange-coupled skyrmions or compensated ferrimagnets could suppress this effect owing to an overall zero topological charge. Especially at the angular momentum compensation temperature skyrmions dynamics is predicted to be collinear with the current[2].

We report here on a decrease in compensation temperature in the thin film ferrimagnetic system [Pt(5 nm)/GdCoFeB(d)/MgO(1.2 nm)/Ta(2 nm)] for increasing thickness d of the GdCoFeB alloy observed in multiple alloy compositions. Although this limits the accessible range of structures near compensation, it also allows for tuning the compensation through an additional parameter.

[1] K. Litzius et al., Nature Phys. 13, 170 (2017)
[2] Barker et al. Phys. Rev. Lett. 116, 147203 (2016)

MA 51.32 Thu 15:00 Poster C

A multiscale approach for magnetic skyrmion simulations — •Thomas Brian Winkler[1], Andrea de Lucia[1,2], Kai Litzius[1,2,3], Oleg Tretiakov[4], Benjamin Krüger[1], and Mathias Kläui[1,2] — [1]Johannes Gutenberg Universtät Mainz, — [2]Graduate School of Excellence - Material Science in Mainz, Staudingerweg 9, 55128 Mainz, Germany — [3]Max Planck Institute for Intelligent Systems, 70569 Stuttgart, Germany — [4]Institute for Material Research, Tohoku University, Sendai 980-8577 Sendai

Simulations of magnetization dynamics in a multiscale Environment enable a rapid evaluation of the Landau-Lifshitz-Gilbert equation in a mesoscopic samples. This approach [1] combines the necessary nanoscopic accuracy in areas where such precision is required. The normal micromagnetic solving routine of the micromagnum software package [2] has been expanded to include an accurate Heisenberg model in areas with strongly varying spin structures. The model is applied to study for instance the (thermal) stability of skyrmions [3]. [1] A. de Lucia et al., Phys. Rev. B 94, 184415(2016), [2] URL: http://micromagnum.informatik.uni-hamburg.de/, with additional modules for DMI and SOT from our Group, [3] A. de Lucia et al., Phys. Rev. B 96, 020405(R) (2017)

MA 51.33 Thu 15:00 Poster C

Designing non-conventional 3-D coils — •Assja Laas and Christian Schröder — Bielefeld Institute for Applied Materials Research (BIfAM), Computational Materials Science and Engineering (CMSE), University of Applied Sciences Bielefeld, Department of Engineering Sciences and Mathematics, Interaktion 1, D-33619 Bielefeld

Compact devices for inductive energy and information transfer require the design of appropriate non-conventional 3-D induction coils. This is because only a small volume for placing the coil inside the device is available, and one is only interested in the near-field characteristics of the generated magnetic field. In our study we focus on design strategies for appropriate three-dimensional induction coils by exploiting an inverse methodology. A target field is specified over a certain region and an approximation of the current density through a Fourier series expansion is derived which generates the desired field. Because of the ill-posed nature of this problem a Tikhonov regularization with a penalty term is used to calculate the unknown parameters of the Fourier series expansion. In this contribution we discuss the effect of different penalty terms, i.e. a 2-norm term, a gradient and a laplace term on the resulting current densities. Based on this, we obtain the coil windings by calculating the maximum of a current density map and applying a stream function approach.

MA 51.34 Thu 15:00 Poster C

Using Non-Linear Material Properties for the Optimization of Heat Generation in Inductive Heating Applications — •Lennart Weber, Christian Schröder, and Sonja Schöning — Bielefeld Institute for Applied Materials Research (BIfAM), Bielefeld University of Applied Sciences, Department of Engineering Sciences and Mathematics, Interaktion 1, D-33619 Bielefeld

Inductive power transfer is nowadays a widely used technology, e.g. for inductive heating in industrial applications and household appliances. An inductive heating system usually consists of a coil (transmitter) which is powered by an alternating current and a ferromagnetic material (receiver) which is heated by the generated eddy currents where the dissipated power is proportional to the square of the current density. With regard to energy efficiency and comfort it is desirable to be able to manipulate the current density distribution within the ferromagnetic material in a specific way. Here, we propose an approach which utilizes the non-linear material properties of the receiver in combination with a variable magnetic field generated by the transmitter that allows us to optimize the heat generation.

MA 51.35 Thu 15:00 Poster C

Why Your Computer Should Learn the Maxwell-Ampère Equation on its own — •Simon Bekemeier and Christian Schröder — Bielefeld Institute for Applied Materials Research (BIfAM), Computational Materials Science and Engineering (CMSE), Bielefeld University of Applied Sciences, Department of Engineering Sciences and Mathematics, Interaktion 1, 33619 Bielefeld, Germany

Neural networks are powerful tools for modelling unknown or complex functional relations in a relatively simple way. Using cascades of simple operations they can fit highly non-linear functions. In this contribution, we show how neural networks can be used to predict the magnetic field of coils given only the coil geometry. Namely, black-and-white raster graphics are used to present the geometry to the neural net, while colored graphics provide the training data for the respective magnetic field. Using a combination of an auto-encoder layout and elements of convolutional neural nets our network can learn the relationship between simple coil geometries and their generated magnetic fields. Finally, we present the application of such neural networks as surrogate models for the use in optimization problems. Using a surrogate model of the Maxwell-Ampère equation, we are able to find novel induction coil geometries very efficently using an iterative optimization approach rather than performing accurate but very time-consuming conventional simulations.

MA 51.36 Thu 15:00 Poster C

spin-phonon coupling in FCC-Fe — •duo wang and biplab sanyal — Departmenf of Physics and Astronomy, Uppsala University, Uppsala, Sweden

Unlike BCC-Fe, some theoretical studies show that FCC-Fe is a weak magnet exhibiting magnetovolume instability and non collinear magnetic structures under compression. We performed ab initio calculations for studying the volume dependence of spin-spiral dispersion in FCC-Fe by plane wave projector augmented wave method. It is shown that at low volumes, the magnetic configuration corresponding to the ground state is a spin-spiral of $q_2 = 2\pi/a(0.2, 0, 1)$, whereas for higher volumes, the ground state occurs for $q_1 = 2\pi/a(0, 0, 0.6)$. Our results are very much consistent with the data from full-potential linearized augmented-plane-wave method (FP-APW+lo) study (Physical Review B, 2002, 66(1): 014447). Moreover, our calculations of phonon dispersion spectra for different collinear and non-collinear magnetic structures show a strong dependence of phonon frequencies on the magnetic structures indicating strong spin-phonon interactions.

MA 51.37 Thu 15:00 Poster C

Transparent boundary conditions in micromagnetic simulations eliminate finite size effects — •Jan Masell — Institut für Theoretische Physik, Universität zu Köln, Köln, Deutschland

In systems where the magnetic texture varies on a considerably larger scale than the atomic lattice structure, effective micromagnetic models provide powerful approximations to the numerically too complex atomistic descriptions. However, even these effective models soon face the limits of numerical runtime or accuracy, in particular, when the considered effects require a long-ranged healing length. Common examples include the propagation of magnons through nanostructures, where a reflection and back-propagation from the end of the simulated area is usually suppressed by artificial absorbing boundary conditions but also the simulation of complex defects such as skyrmions or defects in a helical phase.

Here, I present my work on transparent boundary conditions which can be used in micromagnetic simulations to overcome the size limitations in these types of systems by effectively providing half-infinite boundary conditions.

MA 51.38 Thu 15:00 Poster C

Growth of La0.67 Sr0.33 MnO3/BaTiO3 and La0.67 Sr0.33 MnO3/PMN-PT: An approach for Voltage Control of Magnetism — •tanvi bhatnagar[1,2], anirban sarkar[1], markus waschk[1], emmanuel kentzinger[1], andras kovacs[2], lei jin[2], patrick schöffmann[3], michael faley[4], rafal e. dunin-borkowski[2], and thomas brückel[1] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT, 52425 Jülich, Germany — [2]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science (JCNS) at MLZ, 85747 Garching, Germany — [4]Forschungszentrum Jülich GmbH, Peter Grünberg Institute (PGI-5), 52425 Jülich, Germany

The voltage control of magnetism in oxide heterostructures has been extensively investigated for future spintronic devices. We grow single crystalline La0.67Sr0.33MnO3/BaTiO3 and La0.67Sr0.33MnO3/PMN-PT heterostructures by High Oxygen Pressure Sputtering System (HOPSS) and Oxide Molecular Beam Epitaxy (OMBE). Magnetometry measurements confirm the stability of the tetragonal phase of BaTiO3 down to 10K and the ferromagnetic state of La0.67Sr0.33MnO3. The manipulation of magnetization as a function of electric field will be studied with the combination of advanced scattering (neutron and X-ray) methods, electron microscopy and spectroscopy.

MA 51.39 Thu 15:00 Poster C

Non-reciprocal THz response of chiral Ni3TeO6 in magnetic field — •David Maluski[1], Malte Langenbach[1], David Szaller[2], István Kézsmárki[3], Vladimir Tsurkan[3], Sang-Wook Cheong[4], Joachim Hemberger[1], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für Festkörperphysik, Technische Universität Wien — [3]Experimentalphysik V, Universität Augsburg — [4]Department of Physics and Astronomy Rutgers, The State University of New Jersey

In the realm of multiferroicity, Ni3TeO6 stands out for the observation of non-hysteretic magnetic switching and the record linear magneto-electric coupling constant in single-phase materials [1]. The structure of Ni3TeO6 is both chiral and polar already at room temperature. The antiferromagnetically ordered phase below $T_N = 53$K features collinear ordered moments and a significantly enhanced electric polarization due to magneto-electric coupling [1]. In an external magnetic field, chiral structures show both natural optical activity as well as magnetic optical activity (Faraday effect). However, one may also expect more exotic non-reciprocal effects such as magneto-chiral dichroism or quadrochroism [2]. We use circularly polarised light in the THz range and high magnetic fields to prove the existence of this effect in Ni3TeO6 at low temperatures.

[1] Y. S. Oh et al., Nat. Commun. 5:3201 (2014) [2] I. Kézsmárki et al., Nat. Commun. 5:3203 (2014)

MA 51.40 Thu 15:00 Poster C

Growth and characterization of magnetite based artificial multiferroic heterostructure — •Anirban Sarkar and Thomas Brückel — Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science JCNS and Peter Grünberg Institute PGI, JARA-FIT, 52425 Jülich, Germany.

We study the morphology, electric, magnetic, magneto-electric coupling and magneto-transport properties of Fe_3O_4/Nb:$SrTiO_3$(001) and Fe_3O_4/PMN-PT(011) heterostructures. Studies like, interfacial capacitance, magnetic depth profile, ferroelectric ordering, stress and charge screening-control of the Verwey transition are of special interest. The Fe_3O_4 films are grown in an oxide molecular beam epitaxy system. We use x-ray diffraction and reflectometry for the structural characterizations, and atomic force microscopy (AFM) for the morphology of thin film. Magnetic and transport properties of the heterostructure are studied using superconducting quantum interference device (SQUID) magnetometer and physical property measurement system, respectively. We propose that probing the depth profile of magnetization using polarized neutron reflectometry (PNR) can reveal more information about the magnetic properties near the interface of such ferromagnetic/semiconductor heterostructures.

MA 51.41 Thu 15:00 Poster C

Spectroscopic and thermodynamic investigation of the new alternating chain system Fe(Te,Se)$_2$O$_5$Cl — •Ksenija Denisova[1,2,3], Dirk Wulferding[1,2], Peter Lemmens[1,2], Peter Berdonosov[4], Ekaterina Kozlyakova[3], and Alexander Vasiliev[3] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]LENA, TU-BS, Braunschweig, Germany — [3]Dept. of Phys., MSU, Moscow, Russia — [4]Dept. of Chem., MSU, Moscow, Russia

In the search for new materials with specific magnetic properties, the exploration of isostructural relatives of already known multiferroics [1,2] is essential. Alternating antiferromagnetic spin chains of Fe in a high spin state and Te, Se, both containing lone pair electrons, make Fe(Te,Se)$_2$O$_5$Cl a promising candidate for particular magnetic properties [3]. Being sensitive to many degrees of freedom, Raman scattering is a helpful tool to reveal an interplay of lattice dynamic and magnetism. Supported by DFG-LE967/16-1, RFBR project 16-03-00463a. [1] Choi, et al. JPCM 26, 086001 (2014). [2] Kim, et al., Phys. Status Solidi B 252, No. 4, 653 (2015). [3] Akhrorov, et al., Solid State Sciences 74, 37 (2017).

MA 51.42 Thu 15:00 Poster C

Interactions between superconductor-ferromagnet thin films — •Annika Stellhorn[1], Anirban Sarkar[1], Emmanuel Kentzinger[1], Sonja Schröder[1], Markus Waschk[1], Patrick

Schöffmann[2], Zhendong Fu[2], Vitaliy Pipich[2], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT, 52425 Jülich GERMANY — [2]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at MLZ, Lichtenbergstr. 1, 85748 Garching Germany

Interactions at superconductor-ferromagnet (S/F) interfaces have been studied on a prototype Nb (S)/ FePd (F) system. Our goal is to understand the proximity effects of FePd with different strength of perpendicular magnetic anisotropy (PMA) and magnetic domain texture on the superconducting Nb layer. Proximity effects at S/F interfaces with an inhomogeneous magnetic field texture result in various effects, like domain-wall superconductivity and long-ranged triplet cooper pairs in the F-layer, making them good candidates for superconducting spintronics. Epitaxial heterostructures of Nb/FePd are prepared on MgO (001) substrate using Molecular Beam Epitaxy. Magnetic Force Microscopy images of FePd grown by shuttered growth reveal a striped domain structure. Macroscopic magnetization measurements show weak PMA. However, a method combining co-deposition and shuttered growth results in samples with high PMA and a striped domain structure. Grazing-Incidence-Small-Angle-Neutron-Scattering reveals the depth profile of the magnetization in the heterostructure.

MA 51.43 Thu 15:00 Poster C

Spin-polarized ARPES studies of copper-based molecular spinterfaces — •David Janas, Henning Sturmeit, Giovanni Zamborlini, Stefano Ponzoni, and Mirko Cinchetti — Experimentelle Physik VI, TU Dortmund, Otto-Hahn-Straße 4, 44227 Dortmund, Germany

Spin-resolved angle-resolved photoelectron spectroscopy (spin-ARPES) is a powerful method to study the spin-dependent properties of molecular spinterfaces [1]. In a recent work [2] it was reported that layered structures of C_{60} deposited on metallic thin films show emerging ferromagnetic properties even on dia- or paramagnetic metals. Although the physical origin of the ferromagnetic order is not yet fully understood, there are strong evidences that the magnetic moment is localized at the metal-organic interface. In order to shed a light on the mechanism leading to these unexpected magnetic properties, we have performed spin-ARPES measurements on different prototypical copper-based interfaces where all the experimental conditions - e.g. metal and molecular film thickness, metal-molecule interaction - can be controlled at the nanoscale level. We will discuss the results on the different systems and highlight the observed similarities and differences.

[1] M. Cinchetti, V. A. Dediu, and L.E. Hueso, Nature Materials 16, 507 (2017)
[2] F. Al MaMari et al., Nature 524, 69 (2015)

MA 51.44 Thu 15:00 Poster C

Macrospin-based demonstration of a Boltzmann machine — •Timo Pulch, Daniele Pinna, and Karin Everschor-Sitte — Institut of Physics, Johannes Gutenberg University, Mainz, Germany

Spintronics has consistently proven itself in new technological applications such as racetrack storage and magnetic logic gates. Proper modeling of such devices requires an intimate understanding of spin-torque and thermal effects. In this work we present how a suitable combination of magnetic logic gates and ambient noise within the macrospin model to demonstrate a Boltzmann machine. We will argue that randomization is performed efficiently by energy harvesting of thermal fluctuations, and that the proposed design can be used to invert the operation of logic gates by efficiently sampling across all possible inputs. Advances in this area are expected to yield novel approaches capable of tackling non-deterministic Boolean problems.

MA 51.45 Thu 15:00 Poster C

Optimization of a Fabrication Process for Metallic Nanoconstrictions for Spin-Hall nano-oscillators — •Stephanie Lake[1], Philipp Dürrenfeld[1], Frank Heyroth[2], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany

Generating high frequency signals without a microwave source has been demonstrated using the spin-Hall Effect (SHE) in nano-oscillator devices.[1] The SHE can drive pure spin currents into a ferromagnetic material exciting spin waves detected electrically with powers up to 10 pW.[2] However, the efficiency of generating such signals significantly depends on device geometry. It is thus important to have excellent control of the nanoconstriction (NC) shape and dimensions.

In this poster, several parameters of the fabrication process are investigated to understand their effect on the dimensions and quality of Py-based NCs. The structures are made by first sputtering 5 nm of Py and 6 nm of Pt onto silicon. A positive bi-layer resist is patterned with sets of varied NC designs by e-beam lithography. Afterward, aluminum oxide is deposited and lifted off to serve as an etching mask for the metal stack. Variations of exposed pattern and exposure strategy during the e-beam lithography process result in different shapes and sizes of the NC structures and allow for future optimization.

[1]Vladislav E. Demidov *et al. Nat. Materials* **11**, 1028-1031 (2012).
[2]A. A. Awad *et al. Nat. Physics* **13**, 292-299 (2017).

MA 51.46 Thu 15:00 Poster C

Superconductor/Ferromagnet-Heterostructures for superconducting spintronics — •Manuel Müller[1,2], Mathias Weiler[1,2], Hans Huebl[1,2,3], Rudolf Gross[1,2,3], and Matthias Althammer[1,2] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, Technische Universität München, Germany — [3]Nanosystems Initiative Munich, München, Germany

The interplay and competition of superconducting and ferromagnetic ordering phenomena in thin film structures has attracted considerable attention over the last decade. In particular, the control of spin current transport properties in superconductors offer promising new possibilities in the field of spintronics. We here investigate the injection of quasiparticle spin currents into superconductors by spin pumping from an adjacent ferromagnetic layer. To this end, $NbN/Co_{25}Fe_{75}$ heterostructures are grown by reactive DC-sputtering under ultra-high vacuum conditions. For the broadband spin pumping experiments we excite the ferromagnetic resonance in the $Co_{25}Fe_{75}$ layer by placing the samples onto a coplanar waveguide. We study the spin pumping induced magnetization damping as function of temperature, especially in vicinity of the NbN superconducting transition temperature. A phase sensitive detection of the microwave transmission signal cite is used to quantitatively extract the inductive coupling strength and spin current transport in our heterostructures. We find that the inductive coupling strength is strongly influenced by the superconducting transition. In addition, we compare our results to theoretical models.

MA 51.47 Thu 15:00 Poster C

Effect of interlayer insertion on spin pumping in $Co_{40}Fe_{40}B_{20}$/X/Pt heterostructures — •Matthias Reinhard Schweizer[1], Sascha Keller[1], Evangelos Papaioannou[1], Simon Häuser[1], Moritz Hofherr[1,2], Benjamin Stadtmüller[1,2], Martin Aeschlimann[1], Burkard Hillebrands[1], and Andrés Conca[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Mainz, Germany

In many spin pumping experiments, Pt is used to detect a spin current indirectly via the inverse spin Hall effect (ISHE). However, Pt has been shown to also exhibit the magnetic proximity effect (MPE), which could have a substantial impact on the interface transparency and damping parameter. In this work, we investigate the $Co_{40}Fe_{40}B_{20}$/X/Pt multilayer system (X=Al,Ta,Cr) with varying thicknesses. Direct contact between $Co_{40}Fe_{40}B_{20}$ and Pt induces MPE in Pt. In this case, even a thin NM spacing layer is expected to suppress the MPE completely. We present VNA-FMR data on these systems and angle-resolved rectification voltage measurements, where anisotropic magnetoresistance (AMR) and the anomalous Hall effect signals are separated from the ISHE signal. We find that the formation of FM Pt gives rise to a strong AMR signal, but does not have a significant influence on the induced spin current. The existence of magnetic moments in Pt is verified my means of element sensitive measurements with pulses from high-harmonic generation. Support by M-era.Net, HEUMEM and SFB/TRR 173 SPIN+X is acknowledged.

MA 51.48 Thu 15:00 Poster C

Theory of antiferromagnetic resonance in Cu(en)(H2O)2SO4. — •Jaroslav Chovan[1,2] and Dominik Legut[1] — [1]IT4Innovations National Supercomputing Center VSB - Technical University Ostrava, CZ 708 33 Ostrava, Czech Republic — [2]Department of Physics, Matej Bel University, Banska Bystrica, Slovakia

Cu(en)(H2O)2SO4 is a quasi-two-dimensional antiferromagnet that orders below 0.9 K. Its magnetic anisotropy was thought to be easy-plane. However, recent experimental and theoretical study suggested the existence of the easy-axis within the easy-plane, and confirmed its existence via the observation of a spin-flop transition in the field applied along the b-axis. Thus the system should display two magnon modes. Follow-up AFMR study confirmed this picture, but also observed additional weak splitting of the two magnon modes, attributed to weak interplane coupling. Here we show theoretically that the interplane coupling - whether in the simple isotropic, or the most general anisotropic form - does not explain this splitting. In particular, the symmetry allowed coupling leads to four magnon modes, but two of them do not couple to the rf-field and should not be observed. We discuss the possible explanation.

MA 51.49 Thu 15:00 Poster C

Theory of antiferromagnetic resonance in Cu(en)(H2O)2SO4. — •Jaroslav Chovan[1,2] and Dominik Legut[1] — [1]IT4Innovations National Supercomputing Center VSB - Technical University Ostrava, CZ 708 33 Ostrava, Czech Republic — [2]Department of Physics, Matej Bel University, Banska Bystrica, Slovakia

Cu(en)(H2O)2SO4 is a quasi-two-dimensional antiferromagnet that orders below 0.9 K. Its magnetic anisotropy was thought to be easy-plane. However, recent experimental and theoretical study suggested the presence of the easy-axis within the easy-plane, and confirmed its existence via the observation of a spin-flop transition in the field applied along the b-axis. Thus the system should display the two magnon modes. Follow-up AFMR study confirmed this picture, but also observed additional weak splitting of the two magnon modes, attributed to weak interplane coupling. Here we show theoretically that the interplane coupling - whether in the simple isotropic, or the most general anisotropic form - does not explain this splitting. In particular, the symmetry allowed coupling leads to four magnon modes, but two of them do not couple to the rf-field and should not be observed. We discuss the possible explanation.

MA 51.50 Thu 15:00 Poster C

Field-induced anomalous Hall effect in 2D transition metal dichalcogenides — •Franz Fischer[1], Nicki F. Hinsche[1], and Ingrid Mertig[1,2] — [1]Martin Luther University Halle-Wittenberg , Institute of Physics, 06099 Halle/S., Germany — [2]Max Planck Institute of Microstructure Physics, 06120 Halle/S., Germany

Atomically thin layers of transition metal dichalcogenides (TMDC) attract remarkable interest due to their extraordinary electronic and optical properties. Their inherent crystal structure lacks inversion symmetry and therefore enables an extra valley degree of freedom in addition to charge and spin. Combining heavy metal atoms and chalcogenes results in strong spin-orbit interaction. The latter gives rise to large spin splittings in the Brillouin zone (BZ), leading to presumably large Berry curvature in those valleys. A consequence of the momentum-locked Berry curvature is the valley Hall effect, which can be validated via photo-optical experiments.

We are extending these concepts by gaining access to a net Berry curvature in the BZ as we tune the electronic band structure via applying electrical and magnetic fields. The latter entails time and spatial symmetry breaking, that allows us to induce spin-polarized currents and the realization of an anomalous Hall effect (AHE). We report on theoretical calculations based on a tight-binding model, for several TMDCs, e.g. MoS_2. In dependency on various parameters the evolution of the Berry curvature and with that the AHE is discussed. Our results will give a leap forward on new spin- and valleytronic devices incorporating TMDC/ferromagnet/ferroelectric interfaces.

MA 51.51 Thu 15:00 Poster C

Brillouin zone unfolding: Recovering information from supercell transmission maps — Michael Czerner, •Jonas F. Schäfer, Felix Scholler, and Christian Heiliger — Institut für Theoretische Physik, JLU Giessen

In order to accurately describe transport through tunnel barriers, it is often required to take perturbations into account. These could be chemical disorder, lattice defects, but also non-collinear magnetic structures in a ferromagnetic background. Within the NEGF formalism, which is implemented in our KKR code, it is possible to incorporate such effects using CPA with vertex corrections . However, it is sometimes more appropriate to describe the defect structure using supercells. In order to get a deeper insight into the underlying transport mechanism, it is often helpful to see k-resolved transmission maps. This method is not applicable for supercells, since here the information is contained in a much smaller BZ. To solve this issue we unfold the transmission into the specular and diffusive contribution, with a separate diffusive distribution map for each lead. This allows us to identify the relevant electronic states on both sides of the barrier even for k-scattering transport. As an example we take a look at a skyrmion in a thin magnetic iron layer adjacent to an MgO barrier. In this structure, the skyrmion may increase transport by allowing k-scattering to the Gamma-point.

MA 51.52 Thu 15:00 Poster C

Theoretical analysis of electronic states at the interface between MgO and nonmagnetic metals — •Ather Ahmad, Philipp Risius, Michael Czerner, and Christian Heiliger — Institut für theoretische Physik, Justus-Liebig-Universität Gießen, Gießen

A number of nonmagnetic metals may be grown epitaxially on magnesium oxide (MgO). In combination with a ferromagnetic material, semimagnetic tunnel junctions (SMTJ) can be constructed. These tunnel junctions may show tunnelling anisotropic magnetoresistance (TAMR), where the electronic transmission varies with the magnetization direction of the ferromagnetic layer. TAMR, which exploits the spin-orbit coupling at the ferromagnet-MgO interface, is a valuable tool for examining phenomena such as spin torque [1]. To find promising combinations of materials for MgO-based SMTJs, we calculate the Bloch spectral function (BSF) at the interfaces of MgO with various nonmagnetic metals. These BSFs can be compared to the BSF at ferromagnet-MgO interfaces to predict the electronic transmission of an SMTJ combining the two materials. We show that the transmission across an SMTJ can indeed be predicted from the combination of the interfaces' BSFs. Comparing the BSF of ferromagnet-MgO- and nonmagnet-MgO interfaces could thus help find nonmagnetic metals which provide a sizeable TAMR, enabling further studies.

[1] S. Miwa, J. Fujimoto, P. Risius, K. Nawaoka, M. Goto, and Y. Suzuki. "Strong Bias Effect on Voltage-Driven Torque at Epitaxial Fe-MgO Interface". *Physical Review X* **7**(3), 031018 (2017).

MA 51.53 Thu 15:00 Poster C

Fluctuation spectroscopy of the ferromagnetic semiconductor $HgCr_2Se_4$ — •Merlin Mitschek[1], Shuai Yang[2], Yongqing Li[2], and Jens Müller[1] — [1]Physikalisches Institut, Goethe-Universität, Frankfurt am Main, Germany — [2]Institue of Physics, Chinese Academy of Sciences, Beijing, China

$HgCr_2Se_4$ has been well known for several years as a member of the spinel family where one can observe the colossal magnetoresistance (CMR) effect, a field of research that expanded the knowledge of electron correlations, phase transitions and magnetism. The complexity of the physics behind the CMR makes it desirable to study a preferably simple system, where the relevant degrees of freedom, including spin, charge, orbital, and lattice, along with disorder and strong electron correlations are less intertwined as, e.g., for the mixed-valence perovskite manganites. This is true for the model system EuB_6 [1], and also for $HgCr_2Se_4$, which exhibits MR ratios of up to five orders of magnitude [2]. The phase transition from the paramagnetic to the ferromagnetic phase coincides with an insulator-metal transition at $T_C \approx 105$ K. Strikingly, the CMR effect is most pronounced when spin correlations between superexchange-coupled Cr^{3+} are significant. As a powerful probe to test possible scenarios for explaining the CMR effect, we employ fluctuation (noise) spectroscopy [1]. We analyze and discuss the observed generic $1/f$-type noise below the transition, which is superimposed by distinct two-level fluctuations above T_C, in terms of a model of percolating magnetic polarons.

[1] Phys. Rev. B 94, 224404,(2016). [2] Phys. Rev. B 86, 184425, (2012).

MA 51.54 Thu 15:00 Poster C

Comparative investigation of the magnetic proximity effect by XRMR and XMCD and the influence of patterning — •Dominik Graulich[1], Jan Krieft[1], Anastasiia Moskaltsova[1], Tristan Matalla-Wagner[1], Tobias Pohlmann[2,3], Joachim Wollschläger[2], Sonia Francoual[3], and Timo Kuschel[1] — [1]Center for Spineletronic Materials and Devices, Bielefeld University, Germany — [2]Center of Physics and Chemistry of New Materials, Osnabrück University, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

X-ray resonant magnetic reflectivity (XRMR) is a very sensitive technique to detect the proximity-induced spin polarization in heterostructures of the heavy metal Pt in contact to ferromagnetic (FM) materials [1]. This synchrotron-based reflectivity technique is directly sensitive to the interfacial spin polarization, which makes it independent of the total Pt thickness in contrast to more common x-ray magnetic circular dichroism (XMCD) measurements. In addition, the XRMR analysis provides information on the spin depth profile of the induced spin polarization. In this study, we quantitatively compare the results of the XRMR and XMCD analysis for different Pt/FM bilayers. Furthermore, the influence of patterning the samples on the XRMR and XMCD results as well as on the validity of the current analysis procedure are investigated to explore non-equilibrium spin polarizations by XRMR in future work.

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

MA 51.55 Thu 15:00 Poster C

Spin Seebeck, proximity-induced, and ferromagnetic-induced anomalous Nernst Effect in Pt/ferromagnet bilayers — •Oliver Ritter, Tobias Peters, Jan Krieft, Panagiota Bougiatioti, and Timo Kuschel — Center for Spinelectronic Materials and Devices, Bielefeld University, Germany

The generation, manipulation and detection of spin currents has recently been extensively studied. Spincaloritronic effects such as the spin Seebeck effect (SSE) enable the generation of spin currents in ferro(i)magnetic metals (FMM) and insulators (FMI) by applying a temperature gradient. Usually normal paramagnetic metals, such as Pt on top of the ferromagnet are used to detect spin currents via the inverse spin Hall effect. Using Pt as a spin detector can cause a spin polarization of the Pt at the Pt/FMM Interface due to the magnetic proximity effect (MPE). As a result of the MPE, a proximity-induced ANE can occure. In case of studying FMMs, the ferromagnetic-induced ANE can additionally contribute to the SSE signal [1].

In this work, we investigated different Pt/FMM and Pt/FMI bilayers concerning their SSE and ANE contributions. For the FMI samples the measured signal only consists of the SSE response. In case of Pt/FMM bilayers, different ANE contributions arise as discussed in this presentation.

[1] P. Bougiatioti et al., Phys. Rev. Lett. 119, 227205 (2017)

MA 51.56 Thu 15:00 Poster C

Enhancement of the spin Seebeck effect in lattice matched $NiFe_2O_4$ thin films — •Tobias Peters[1], Ankur Rastogi[2], Zhong Li[2], Amit Vikam Singh[2], Arunava Gupta[2], Panagiota Bougiatioti[1], Günter Reiss[1], and Timo Kuschel[1] — [1]Center for Spinelectronic Materials and Devices, University of Bielefeld, Germany — [2]MINT Center, University of Alabama, USA

We investigated the spin Seebeck effect (SSE) in $Pt/NiFe_2O_4$ films and studied the influence of thickness and film quality. Therefore, nickel ferrite (NFO) has been deposited in various thicknesses ranging from 50 nm to 1 μm on different substrates $MgAl_2O_4$ (MAO), $MgGa_2O_4$ (MGO) and $CoGa_2O_4$ (CGO) using pulsed laser deposition. These substrates present various lattice mismatches with respect to NFO ranging from 3.2 % for MAO to 0.2 % for CGO [1]. SSE measurements have been performed to investigate the influence of NFO-thickness and lattice mismatch, possibly accompanied by lattice defects and strain, on the magnon transport. For these measurements systematic errors could be eliminated via the normalization of the SSE driven electrical field to the applied heat flux instead to the temperature difference [2]. For the MGO- and CGO-samples we consistently found larger SSE signals compared to the MAO-samples, which could be connected to the lower lattice mismatch. Furthermore, magnon propagation lengths in the range of 100 nm to 1 μm have been determined, with the largest value attributed to NFO/MGO.

[1] A. V. Singh et al., Adv. Mater. 29, 1701222 (2017)
[2] A. Sola et al., Sci. Rep. 7, 46752 (2017)

MA 51.57 Thu 15:00 Poster C

Spin Seebeck effect in ultra-thin gadolinium iron garnet films — •Maxim Dietlein[1,2], Stephan Geprägs[1], and Rudolf Gross[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Fakultät für Physik, Technische Universität München, Garching, Germany — [3]Nanosystems Initiative Munich, München, Germany

The generation of a spin current in a magnetic material as a result of a temperature gradient known as spin Seebeck effect (SSE) has triggered intense research in the field of spin caloritronics. Recently, it has been demonstrated that the SSE is sensitive to the complexity of the magnon dispersion relation and can therefore be used as a probe for magnon properties in complex magnets [1]. In magnetically compensated ferrimagnetic insulator $Gd_3Fe_5O_{12}$ (GdIG) | heavy metal (Pt) heterostructures, the temperature dependence of the SSE amplitude shows two sign changes. One sign change is caused by the reversal of the sublattice magnetizations at the magnetic compensation temperature of GdIG, while the second sign change arises from the superposition of two main magnon modes with opposite chirality. We here discuss the temperature dependence of the SSE signal in ultra-thin epitaxial GdIG|Pt heterostructures on $Y_3Al_5O_{12}$ (YAG) substrates. We show that the temperature of both SSE sign changes as well as the SSE amplitude in GdIG|Pt heterostructures are highly sensitive to the thickness of the GdIG thin film. With this, we are able to draw conclusion on the magnon dispersion in ultra-thin GdIG films. [1] S. Geprägs *et al.*, Nature Comm. 7, 10452 (2016).

MA 51.58 Thu 15:00 Poster C

Vertical spin valves using the novel two-dimensional material $FeGe_2$ — •Dietmar Czubak, Samuel Gaucher, Jens Herfort, Holger T. Grahn, and Manfred Ramsteiner — Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institutim Forschungsverbund Berlin e. V., Hausvogteiplatz 5–7, 10117 Berlin, Germany

The formation of $FeGe_2$ in a layered tetragonal structure has been recently achieved by solid-phase epitaxy of Ge on Fe_3Si. This two-dimensional (2D) polymorph of $FeGe_2$ does not exist in bulk form and appears to be a promising material for spintronic applications. We investigate vertical spin valve structures based on this novel 2D material as an intermediate layer between the two Heusler alloy films Fe_3Si (bottom) and Co_2FeSi (top). At room temperature, these spin valves exhibit a magnetoresistance effect of around 0.1 % originating from the switching between the parallel and antiparallel magnetization configurations of the Fe_3Si and Co_2FeSi layers. A decrease of the operating temperature leads to a reduced magnetoresistance effect due to a phase change in the $FeGe_2$ layer from a non-magnetic into the ferromagnetic state. At cryogenic temperatures, the magnetoresistance value depends in a complex manner on the sample orientation relative to the external in-plane magnetic field. Two spin valve-like signals appear with opposite signs for particular orientations. The analysis of the observed anisotropic behavior allows for the extraction of information on the magnetization behavior of the $FeGe_2$ film sandwiched between two ferromagnetic Heusler alloy films.

MA 51.59 Thu 15:00 Poster C

Reduction of dead layer in $La_{0.7}Sr_{0.3}MnO_3$ at the $(SrO)_2$ buffered interface with $SrTiO_3$ — •Vitaly Bruchmann-Bamberg[1], Alexandr Belenchuk[2], Yury Khaydukov[3,4], Vladimir Roddatis[5], and Vasily Moshnyaga[1] — [1]I. Physik. Inst., G.-A.-Universität Göttingen, Friedrich-Hund-Pl. 1, 37077 Göttingen — [2]IIEN, Academy of Sciences of Moldova, str. Academiei 3/3, MD-2028 Kishinev, Republic of Moldova — [3]Max Planck Institute for Solid State Research, 70569 Stuttgart — [4]Max Planck Society Outstation at the Heinz Maier-Leibnitz Zentrum (MLZ), 85748 Garching — [5]Institut für Materialphysik, G.-A.-Universität Göttingen, Friedrich-Hund-Pl. 1, 37077 Göttingen

Magnetic tunnel junctions (MTJ) formed of $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) and $SrTiO_3$ (STO) show very large tunneling magnetorisistance at low temperatures [1]. However, the TMR effect is negligible at room temperature due to the presence of magnetic "dead" layers at the interfaces.

The LSMO/STO and LSMO/$(SrO)_2$/STO (Ruddlesden-Popper buffered) superlattices and ultrathin films were grown by means of metalorganic aerosol deposition technique and studied by polarized neutron reflectometry. A reduction of the dead layer was found at the buffered LSMO interfaces in contrast to the unbuffered LSMO at room temperature. An improvement of the MTJ performance of the LSMO-$(SrO)_2$-STO heterostructures is expected.

We gratefully acknowledge the financial support provided by the DFG within the SFB 1073 and the FRM II at the MLZ Garching.

[1] Werner, R. et al., Applied Physics Letters 98, 162505 (2011)

MA 51.60 Thu 15:00 Poster C

Spatially resolved observation of helicity dependent switching by PEEM — •Nina Novakovic[1], Mohamad A. Mawass[1], Alexander Steigert[1], Oleksii Volkov[2], Denys Makarov[2], and Florian Kronast[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, 12489, Berlin, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf e. V., Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany

Controlling the magnetization by light as opposed to magnetic fields has appeared as a promising alternative to current magnetic data storage technologies as it may lead to faster and denser memory devices.

It has been shown that circularly polarized femtosecond laser pulse can switch the magnetization of a thin film as function of laser helicity. Such effect is known as all-optical helicity dependent switching (AO-HDS).

We combine excitation by a diffraction limited laser spot with photoelectron emission microscopy to study AO-HDS on *m to nm length scale. Imaging the magnetic state before, during and after excitations by an ultrafast laser pulse allows us to observe helicity and relaxation driven effects. We will demonstrate all-optical switching in various systems from FeTb ferrimagnetic films to CoPt multilayers and discuss novel effects such as a thickness dependent inversion of the driven direction of AO-HDS. The research was done at the UE49PGMa beamline at BESSY II Synchrotron facility at Helmholtz-Zentrum Berlin using the SPEEM station.

MA 51.61 Thu 15:00 Poster C

2D Maps of Laser Induced Photocurrents in Ferromagnet-Topological Insulator Heterostructures — •Tobias Kleinke[1], Thomas Schumann[1], Nina Meyer[1], Gregor Mussler[2], Eva Schmoranzerová[3], Petr Němec[3], Helena Reichlová[4], Tobias Kampfrath[5], Christian Heiliger[6], and Markus Münzenberg[1] — [1]Physikalisches Institut, Universität Greifswald, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Juelich, Germany — [3]MFF, Charles University, Prague, Czech Republic — [4]FZU, Prague, Czech Republic — [5]FHI Berlin, Germany — [6]University of Gießen, Germany

Topological insulators provide theoretically dissipationless and 100 % spin polarized conduction channels for electrons. This property make them appealing for spintronic applications.[1] We will present 2D polarization dependend maps of laser induced photocurrents with fixed applied external magnetic field of +/- 30 mT. The sample consists of a topological insulator rectangle with a small 3 nm thick CoFeB rectangle on top. For the edges of the ferromagnet we found a lateral accumulation of spin polarization due to the spin Nernst effect. [2] We can also show that the spin-polarized current is dependend of the direction of the magnetization.

[1] C. L. Kane, E. L. Mele, Phys. Rev. Lett. 95, 146802 (2005)
[2] T. Schumann et al., arXiv:1810.12799

MA 51.62 Thu 15:00 Poster C

Dynamic control of cavity-magnon coupling — •Tim Wolz[1], Alexander Stehli[1], Andre Schneider[1], Isabella Boventer[2], Sergey Danilin[1], Alexey V. Ustinov[1,3], Mathias Kläui[2], and Martin Weides[1,4] — [1]Karlsruhe Insitute of Technology, Karlsruhe, Germany — [2]Johannes Gutenberg University, Mainz, Germany — [3]National University of Science and Technology MISIS, Moscow, Russia — [4]University of Glasgow, United Kingdom

Cavity-magnon-polaritons are hybrid modes consisting of magnon and photon excitations and are expected to pave ways for novel microwave technology based on magnon Rabi oscillations [1]. Static and dynamic control of the coupling strength between these two quasi-particles is imperative for future devices. Such a control is realized with an additional drive tone directly applied to the magnon. Depending on the relative phase and amplitude ratio between the two tones, the coupling strength can be reduced and turned off [2,3]. In our work, as the next step, we are implementing a dynamic control of the coupling on time scales similar to the inverse of the coupling strength. Using a heterodyne detection setup with single-sideband mixing, we are able to apply independent control pulses to magnon and cavity while recording the time resolved cavity response. For instance, for phase and amplitude matched excitations to magnon and cavity, both oscillators will "swing" in-phase and no energy exchange will take place, similarly to coupled mechanical pendula. Stopping one oscillator with another pulse will start the magnon Rabi oscillations again. [1] Zhang et al., PRL (2014); [2] Grigoryan et al., PRB (2018); [3] Boventer et al., in preparation

MA 51.63 Thu 15:00 Poster C

Structural and magnetic properties of hexagonal Mn_3X (X = Ga, Sn) thin films — •Philipp Zilske[1], Samer Kurdi[2], Jungwoo Koo[1], and Günter Reiss[1] — [1]Center for Spinelectronic Materials and Devices, Department of Physics, Bielefeld University, Germany — [2]Department of Materials Science and Metallurgy, University of Cambridge, United Kingdom

In the last decade, antiferromagnetic spintronics has established as an important field for future magnetic memory or logic [1]. Recently, $D0_{19}$ ε-Mn_3Y (Y = Ga, Ge, Sn) systems have emerged as new candidates for an active element in such systems. Theoretical calculations and first experimental results show large anomalous Hall and anomalous Nernst effects for those non-collinear antiferromagnets. However, these properties are only studied in detail for single crystalline bulk samples [2-4].

Here, we report on structural and magnetic properties of Mn_3X (X = Ga, Sn) thin films. Epitaxial Ru/Mn_3X films were grown on Al_2O_3 (0001) substrates via magnetron co-sputtering. For detailed structural analysis, we performed X-ray diffraction measurements and atomic force as well as transmission electron microscopy. Furthermore, the magnetic and transport properties of optimized samples will be discussed.

[1] T. Jungwirth et al., Nature Nanotech. 11, 231 (2016)
[2] Y. Zhang et al., Phys. Rev. B 95, 075128 (2017)
[3] S. Nakatsuji et al., Nature 527, 212 (2015)
[4] N. Kiyohara et al., Phys. Rev. Appl. 5, 064009 (2016)

MA 51.64 Thu 15:00 Poster C

Ab initio calculation of the magneto-optical Kerr effect in transition metal alloys — •Andreas Held[1], Ján Minár[2], and Hubert Ebert[1] — [1]Department Chemie, Ludwig-Maximilians-Universität München — [2]New Technologies-Research Center, University of West Bohemia, Pilsen

The magneto-optical Kerr effect (MOKE) is by now a well-established tool for investigating the properties of magnetic systems. Originating from the subtle interplay between magnetic order and spin-orbit coupling, a proper theoretical description of MOKE requires an appropriate framework. We included a calculation scheme based on the work of Huhne [1] into our fully relativistic spin-polarized Korringa-Kohn-Rostoker code that allows us to investigate both ordered and substitutionally disordered systems by means of the coherent potential approximation (CPA). With our code package we have access to the full optical conductivity tensor and this way to the complex Kerr angle. We present studies on Fe_xCo_{1-x} and Co_xPt_{1-x} in the full concentration range of these alloys. Manipulating the strength of the spin-orbit coupling further enabled us to investigate its impact on the MOKE in these alloys.

[1] T. Huhne, H. Ebert, *Phys. Rev. B* **60**, 12982 (1999); T. Huhne, H. Ebert, *Phys. Stat. Sol. B* **215**, 839 (1999)

MA 51.65 Thu 15:00 Poster C

Atom-by-atom engineering of associative memories in finite size spin systems — Alex Kolmus[1], Mikhail Katsnelson[2], •Alexander Khajetoorians[2], and Hilbert Kappen[1] — [1]Donders Institute for Neuroscience, Nijmegen, The Netherlands — [2]Institute for Molecules and Materials, Nijmegen, The Netherlands

We demonstrate that a two-dimensional finite and periodic array of spins coupled via RKKY-like exchange can exhibit tunable magnetic phases ranging from robust double well potentials, multi-well attractor potentials, towards spin glass-like landscapes. These magnetic phases can be tuned by one gate-like parameter, namely the ratio between the lattice constant and the long-range interaction wavelength. We characterize theoretically the various magnetic phases, quantifying the distribution of low energy states, aging relaxation dynamics, and scaling behavior. The glassy and multi-well behaviors result from the competing character of RKKY interactions at different distances, no disorder is assumed. The multi-well structure features multiple attractors, each with a sizable basin of attraction, which are the requirement for associative memory. We show that by embedding the atom array in a bi-associative memory, we obtain a learnable associative memory system.

MA 51.66 Thu 15:00 Poster C

Local magnetic properties and couplings of $Co_{2-x}Mn_xB$: A ^{59}Co and ^{55}Mn zero field NMR study — •P. Fritsch[1], F. Hammerath[1], S. Ener[2], M. Fires[2], I. Opahle[2], E. Simon[2,3], S. Wurmehl[1,4], H. Zhang[2], and O. Gutfleisch[2,5] — [1]Leibniz Institute for Solid State Research IFW, Dresden, Germany — [2]Department of Material Science, Technische Universität Darmstadt, Darmstadt, Germany — [3]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [4]Institute for Solid State Physics, Technische Universität Dresden, Dresden, Germany — [5]Fraunhofer-Projektgruppe für Wertstoffkreisläufe und Ressourcenstratgie IWKS, Hanau, Germany

Co_2B and its substitution variants show a magnetovolume effect around T_C, which is promising for magnetocaloric applications and the generation of thermomagnetic power. A series of $Co_{2-x}Mn_xB$ alloys was synthesized and the macroscopic magnetic properties were investigated. An anomalous behaviour of spontaneous magnetization and T_C with increasing Mn content as a result of competing exchange interactions. Zero field Nuclear Magnetic Resonance spectroscopy (NMR) was measured for ^{59}Co and ^{55}Mn nuclei to determine the element specific magnetic moments supported by density functional theory (DFT) calculations. A mutual combination of experimental and theoretical methods reveals that the observed anomaly originates in complex magnetic coupling, as shown by the exchange interactions.

S. Ener et al., accepted by Acta Materialia (2018)

MA 51.67 Thu 15:00 Poster C

New PLY Molecules for Spintronics — •Neha Jha[1], Christian Denker[1], Anand Paryar[2], Pavan K. Vardhanapu[2], Heba Mohamad[1], Christiane Helm[1], Swadhin Mandal[2], and Markus Münzenberg[1] — [1]Institut für Physik, Universität Greifswald, Germany — [2]Department of Chemical Sciences, IISER, Kolkata, India

Phenalenyl (PLY) based molecules, which can be regarded as Graphene fragments are promising candidates for molecular spintronic applications due to their flexibility and low spin-orbit interaction. We investigate organic magnetic tunnel junctions (OMTJ) using a closed shell PLY molecule barrier with different metal complexes (Cu, Zinc). The voltage dependent current shows non-linear behavior and yields a magnetoresistance effect (MR). TR-MOKE measurements give an insight into the Co/Molecule interface properties. They show an enhancement of exchange interaction and a tunability of the Gilbert damping due to π-d hybridization at the interface compared to bare Co, providing evidence for spin pumping. This is important effect for the development of STT-MRAM devices and molecular-scale quantum spin memory.

[1] Sanvito, S. Molecular spintronics: "The rise of spinterface science", Nature Phys. 6, 562-564 (2010)

[2] K.V. Raman, "Interface-engineered templates for molecular spin memory devices". Nature, 509-513 (2013)

MA 51.68 Thu 15:00 Poster C

Theory of noncollinear interactions beyond Heisenberg exchange — •Attila Szilva[1], Danny Thonig[1], Pavel Bessarab[2], Yaroslav O. Kvashnin[1], Debora C. M. Rodrigues[3], Ramon C. Cardias[3], Manuel Pereiro[1], Lars Nordström[1], Anders Bergman[1], Anagela B. Klautau[3], and Olle Eriksson[4] — [1]Department of Physics and Astronomy, Division of Materials Theory, Uppsala University, Box 516, SE-75120 Uppsala, Sweden — [2]Science Institute of the University of Iceland, 107 Reykjavik, Iceland, Department of Nanophotonics and Metamaterials, ITMO University, 197101 St. Petersburg, Russia — [3]Department of Physics and Astronomy, Division of Materials Theory, Uppsala University, Box 516, SE-75120 Uppsala, Sweden, Faculdade de Física, Universidade Federal do Pará, Belém, 66075-110, Brazil — [4]Department of Physics and Astronomy, Division of Materials Theory, Uppsala University, Box 516, SE-75120 Uppsala, Sweden, School of Science and Technology, Örebro University, SE-701 82 Örebro, Sweden

We show for a simple noncollinear configuration of the atomistic spins (in particular, where one spin is rotated by a finite angle in a ferromagnetic background) that the pairwise energy variation computed in terms of multiple-scattering formalism cannot be fully mapped onto a bilinear Heisenberg spin model even in the absence of spin-orbit coupling. An Eg T2g symmetry analysis based on the orbital decomposition of the exchange parameters in bcc Fe leads to the conclusion that the nearest-neighbor exchange parameters related to the T2g orbitals are essentially Heisenberg-like.

MA 51.69 Thu 15:00 Poster C

Magnetic ordering and spin dynamics in the honeycomb lattice compound InCu2/3V1/3O3 — •Margarita Iakovleva[1,2], Hans-Joachim Grafe[1], Angela Möller[3], T. Taetz[4], Evgeniia Vavilova[2], Bernd Büchner[1], and Vladislav Kataev[1] — [1]IFW Dresden, Dresden, 01069, Germany — [2]KPhTI, Kazan, 420029, Russia — [3]IAAC, JGU Mainz, Mainz, 55128, Germany — [4]Institut für Anorganische Chemie, Universität zu Köln, Köln, 50939, Germany

We report Nuclear Quadrupole Resonance (NQR) investigation of the $S = 1/2$ quasi-two-dimensional (2D) honeycomb lattice antiferromagnet $InCu_{2/3}V_{1/3}O_3$. Previous studies on this compound have revealed signatures of an antiferromagnetic transition at $T_N = 38$ K [1,2], though the nature of the magnetic ground state still remains an open question. In the NQR experiment the ^{115}In spectra exhibit a line splitting at $T < T_N$ signaling the development of local magnetic fields in the vicinity of a magnetic phase transition. The T-dependence of the longitudinal nuclear relaxation rate T_1^{-1} shows a characteristic sharp peak upon approaching T_N=38 K, which we associate with 2D magnetic order. Remarkably, with further decreasing temperature a second, much broader peak develops at T* = 15 K suggesting rearrangement of the magnetic state. We discuss this peculiar feature and possible scenarios of magnetic order in $InCu_{2/3}V_{1/3}O_3$.

[1] V. Kataev, et al.: JMMM **290-291**, 310 (2004) [2] M. Yehia, et al.: Phys. Rev. B **81**, 060414 (2010)

MA 51.70 Thu 15:00 Poster C

Competing orders of spin-orbit entangled j=1/2 moments in frustrated fcc magnets — •Dominik Kiese[1], Finn Lasse Buessen[1], Jan Attig[1], Arun Paramekanti[2], and Simon Trebst[1] — [1]Institute for Theoretical Physics, University of Cologne, Germany — [2]Department of Physics, University of Toronto, Canada

The interplay of spin-orbit coupling, crystal field effects, and electronic correlations in 4d and 5d materials can give rise to Mott insulators with local spin-orbit entangled j=1/2 moments. Motivated by the recent synthesis of the double perovskite Ba2CeIrO6, we have explored the physics of j=1/2 moments on the fcc lattice subject to both geometric and exchange frustration. Using a pseudo-fermion functional RG approach(pf-FRG), we have identified an extensive phase diagram of competing magnetically ordered and spin liquid states. Exploring thermodynamic signatures such as the Curie-Weiss temperature and magnetic ordering transition, we can not only quantify the amount of frustration in this model system, but can also connect back to a number of experimental measurements of the actual material.

MA 52: Annual General Meeting of the MA division

Time: Thursday 18:00–19:00 Location: H48

General Meeting of the MA division

MA 53: Magnetic Heuslers, half-metals and oxides

Time: Friday 9:30–12:45 Location: H33

MA 53.1 Fri 9:30 H33

In-situ imaging of martensitic phase transitions in thin films of NiMnGa — •Bruno Weise[1], Sebastian Fähler[1], Kornelius Nielsch[1,2], and Anja Waske[1,3] — [1]Leibniz Institute of Solid State and Materials Research (IFW), Dresden — [2]Technische Universität Dresden — [3]Federal Institute for Materials Research and Testing (BAM), Berlin

In magnetocaloric material, extrinsic sample properties affect the phase transition remarkable. In recent studies it was found that e.g. the surface morphology [1] as well as defects on the surface [2] have a significant influence on nucleation and growth of the magnetocaloric phase. With this work, studying NiMnGa thin films, we show the temperature dependent growth of martensite.

The microstructure of NiMnGa thin films is monitored by scanning electron microscopy equipped with a custom-built temperature stage. This set-up allows in-situ imaging of the temperature-induced phase transition. Advanced image analysis is used to determine the phase fractions and is compared to magnetic measurements. With in-situ investigation of the transformation of both, type X and Y martensite, the impact of external influences on the martensite growth is assessed.

[1] A. Waske, et al., APL Mater. 4, 106101 (2016)

[2] R. Niemann, et al., APL Mater. 4, 064101 (2016)

MA 53.2 Fri 9:45 H33

Designing rare-earth free permanent magnets with tetragonally distorted Heusler compounds by light interstitials — •Qiang Gao, Ingo Opahle, and HongBin Zhang — Institute of Materials Science, TU Darmstadt, 64287 Darmstadt, Germany

Permanent magnets are crucial materials for energy harvesting and conversion.[1] Rare-earth (RE) based magnets with good performance are subjected to criticality and environmental issues, resulting in great need for RE free magnets. To this goal, we explore the possibility of engineering permanent magnets based on Heusler compounds with transition metals. Starting from the known stoichiometric $L2_1$ Heusler compounds, we investigated the effect of light interstitial H, B, C, and N atoms. It is observed that the interstitials will occupy the octahedral holes, leading to effective tetragonal distortion and hence enhanced magnetocrystalline anisotropy. The uniaxial magnetic anisotropy energy can be as large as 1.43 MJ/m^3 for Ni_2FeGa with N interstitial, of which the value is three times larger than that of the same tetragonal distortion for Ni_2FeGa without interstitials. Detailed analysis based on the Bruno's model[2] reveals that the local distortions around the interstitials play an important role. [1] O. Gutfleisch, M.A. Willard, E. Brück, C.H. Chen, S.G. Sankar, J.P. Liu, Adv. Mater. **23**, 821 (2011). [2] P. Bruno, Phys. Rev. B **39**, 865 (1989).

MA 53.3 Fri 10:00 H33

In-situ spin polarized time-of-flight momentum microscopy of the Heusler alloy films $Co_2MnGa(001)$, $Co_2MnSi(001)$, and $Co_2Fe_{0.4}Mn_{0.6}Si(001)$ — •Sergey Chernov[1], Christian Lidig[1], Olena Fedchenko[1], Katerina Medjanik[1], Dmitry Vasilyev[1], Sergey Babenkov[1], Martin Jourdan[1], Jürgen Braun[2], Hubert Ebert[2], Gerd Schönhense[1], and Hans-Joachim Elmers[1] — [1]Institut für Physik, Johannes Gutenberg-Universität, Staudingerweg 7, 55128 Mainz, Germany — [2]Department Chemie, Ludwig-Maximilians-Universität München, Butenandtstrasse 11, 81377 München, Germany

Half-metallic ferromagnets are an important class of materials as they provide fully spin polarized conduction electrons that may be exploited by spintronic devices. Although first-principles calculations predict many half-metallic Heusler alloys, only a few have been experimentally proven[1]. Theoretical studies indicate that local electron correlations in Heusler compounds are often significant and surface states play a dominant role. We have measured spin polarized electronic dispersions in the valence band region up to 1.5 eV binding energy using spin polarized time-of-flight k-microscopy and photoexcitation by the 4^{th} harmonic of a Ti-sapphire laser (6 eV). The comparison of spin-integrated photoemission spectra obtained with exitation at 6 eV and in the hard X-ray regime allows one to discriminate surface related from bulk states. This allows for a thorough test of theoretical models, indicating the need to extend the single particle approach to include many-body effects. [1] M. Jourdan et al., Nat. Commun. 5, 3974 (2014)

MA 53.4 Fri 10:15 H33

First principles prediction of new quaternary half-metallic ferromagnets with large Curie temperatures — Biplab Sanyal[1], •Ashis Kundu[2], Srikrishna Ghosh[2], Rudra Banerjee[1], and Subhradip Ghosh[2] — [1]Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden — [2]Department of Physics, Indian Institute of Technology Guwahati, Guwahati-781039, Assam, India

For spintronic applications, new magnetic materials with high Curie temperatures are perpetually sought for. Here, we present first principles calculations of structural, electronic and magnetic properties of quaternary Heusler compounds $CoX'Y'Si$ where X' is a transition metal with $4d$ electrons and Y' is either Fe or Mn. Our study finds five new half-metallic ferromagnets with spin polarisation nearly 100% with very high Curie temperatures. The variation of Curie temperatures as a function of valence electrons can be understood from the calculated inter-atomic exchange interaction parameters. A few other compounds have been identified, which could be potential half-metals with suitable application of pressure or with controlled doping. Our analysis shows that the half-metallicity in these compounds is intricately related to the arrangements of the magnetic atoms in the Heusler lattice and hence, the interatomic exchange interactions between the moments.

MA 53.5 Fri 10:30 H33

IrMnGa - a disordered Half-Heusler compound with spin glass ground state — •Johannes Kroder[1], Kaustuv Manna[1], Dominik Krieger[1], Alexandr S. Sukhanov[1,2], Enke Liu[1], Horst Borrmann[1], Walter Schnelle[1], Johannes Gooth[1], Dmytro S. Inosov[1,2], Gerhard H. Fecher[1], and Claudia Felser[1] — [1]Max Planck Institut für chemische Physik fester Stoffe, Dresden, Germany — [2]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, Dresden, Germany

Heusler compounds with heavy atoms often have interesting non-collinear magnetic structures. We therefore studied the magnetic, structural and transport properties of IrMnGa, which crystallizes within the ordinary Half-Heusler space group 216 but with some disorder. The comparison of neutron and X-ray diffraction experiments indicate that the compounds forms a Y structure (prototype LiMgPdSn). Manganese atoms distribute on two non-equivalent sites, which causes competing exchange interactions and prevents the establishment of long-range magnetic order. Instead, magnetization and AC susceptibility measurements reveal typical spin glass behavior at low temperatures. This involves for example the formation of uniaxial anisotropy during field cooling and the observation of the memory effect. Furthermore, the AC susceptibility shows a sharp cusp at the freezing temperature, whose shift as function of AC frequency can be described by the Vogel-Fulcher law and a critical scaling approach. Our work demonstrates that IrMnGa is the first canonical spin glass within the group of Half-Heusler compounds.

MA 53.6 Fri 10:45 H33

Magnetic Compensation in Mn_3Ge-based Heusler Alloys with Addition of Ni, Pt and Pd — •Johannes Seyd, Natalia Yurievna Safonova, and Manfred Albrecht — Institute of Physics, University of Augsburg, D-86159 Augsburg, Germany

Mn_3Ge is a ferrimagnetic Heusler alloy with promising properties for spintronic applications, for example a high coercive field and low saturation magnetization[1]. We investigated substitution effects of Ni, Pt and Pd on phase formation and magnetic properties of $D0_{22}$-Mn_3Ge thin films with the intent of further lowering the saturation magnetization[2]. We prepared $(Mn_{1-x}M_x)_3Ge$ (with M=Ni, Pt, Pd) thin films by magnetron sputtering with x varying from 0.03 to 0.6 and analysed the composition and film thicknesses by Rutherford backscattering spectroscopy.

XRD analysis showed that the $D0_{22}$-structure formed only at the lowest concentrations for Ni and Pt, but it was still observed until 20% of Pd content. This was confirmed by SQUID-VSM investigation, but nevertheless the Ni and Pt samples still showed perpendicular magnetic anisotropy at 10% dopant concentration. Magnetizations and coercive fields generally decreased with increasing dopant concentration, as did the perpendicular magnetic anisotropy. At the highest concentration of Ni, a soft ferromagnetic phase formed. For the Pt samples, the $L1_0$ phase of MnPt formed for higher Pt content.

[1] Kurt et al., Appl. Phys. Lett. 101, 132410 (2012) ;
[2] Balluff et al., Phys. Rev. B 97, 014403 (2018) .

MA 53.7 Fri 11:00 H33

Observation of topological Hall effect in antiskyrmion hosting compound Mn1.4PtSn — •Praveen Vir[1], Jacob Gayles[1], Alexandr Sukhanov[1], Nitesh Kumar[1], Yan Sun[1], Jürgen Kübler[2], Chandra Shekhar[1], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Nöthnitzer Str. 40

Skyrmions are topologically stable vortex-like spin structure which are considered as a potential candidate for future high-density memory devices. They have been detected in many chiral and polar compounds. Recently, antiskyrmions, the antiparticle of skyrmions[1], have been discovered in Mn1.4PtSn and Mn1.4Pt0.9Pd0.1Sn[2]. Due to topological charge, it can give rise to nonzero topological Hall Effect (THE). We have synthesized the single crystals of Mn1.4PtSn and measured its directional dependent magnetic and transport properties. By means of powder neutron diffraction measurement, a noncoplanar spin structure was found at low temperature. In the noncoplanar magnetic region, we found a large anisotropic THE, which has possibly a topological origin. We show for the first time that THE has contributions both from real and momentum-space Berry phase.

15 min. break

MA 53.8 Fri 11:30 H33

Microscopic understanding of the magnetic phase diagram of $Gd_{1-x}Ca_xMnO_3$ — •Hichem Ben Hamed[1], Martin Hoffmann[2], Waheed A. Adeagbo[1], Arthur Ernst[2,3], Wolfram Hergert[1], Teemu Hynninen[4], Kalevi Kokko[4], and Petriina Paturi[4] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Germany — [2]Institute for Theoretical Physics, Johannes Kepler University Linz, Austria — [3]Max Planck Institute of Microstructure Physics, Halle, Germany — [4]Department of Physics and Astronomy, University of Turku, Finland

Rare-earth doped manganites ($RMnO_3$) exhibit a rich variety of promising properties like colossal magnetoresistance, metal-insulator transition and multiferroicity for small rare-earth cations. These properties are primary controlled by the coupling between various types of structural, magnetic, charge and orbital degrees of freedom. The magnetic phase diagram of one prominent member of the $RMnO_3$ series, $GdMnO_3$ with Calcium (Ca) doping, is investigated by methods based on density functional theory and Monte Carlo simulations. A quasi-random distribution of Gd and Ca ions is adopted for each doping concentration.

A robust ferromagnetic (FM) ground state was obtained for the hole doped region ($x < 0.5$). On the other hand, a strong competition between FM and many different anti-ferromagnetic orders was found in the ($x > 0.5$) region. These competitions are discussed in terms of the Heisenberg exchange interactions. Theoretical results are compared with experimental findings.

MA 53.9 Fri 11:45 H33

Tunable magnetic phases at $Fe_3O_4/SrTiO_3$ oxide interfaces — •Mai Hussein Hamed[1], Ronja Anika Hinz[1], Marek Wilhelm[1], Andrei Gloskovskii[2], Peter Bencok[3], Claus M. Schneider[1,4], and Martina Müller[1,5] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Julich GmbH, Germany — [2]Photon Science, DESY, Hamburg, Germany — [3]Diamond Light Source, Didcot, UK — [4]Fakultät für Physik, Duisburg-Essen Universität , Germany — [5]Experimentelle Physik I, Technische Universität Dortmund, Germany

Oxide heterointerfaces can reveal exciting physical phenomena and pave the ground for novel applications. The prospect of designing and controlling the magnetic properties at the atomic scale of oxide heterointerfaces is one of the major challenges, as this would pave the route towards spintronic applications with novel quantum phases. In this context, merging transition-metal oxides into heterostructures is very promising, owing to their many remarkable properties, such as emerging conductivities, magnetism or ferroelectricity. My research demonstrates the emergence and control of magnetic phases between magnetite (Fe_3O_4), a half-metallic ferrimagnetic, and $SrTiO_3$, a transparent non-magnetic insulator. Using the bulk and interface elemental X-ray techniques, the depth-dependent electronic and magnetic properties of the films and interfaces are studied. This provides an analytical proof for the formation of a magnetically active $\gamma-Fe_2O_3$ intralayer. By taking control of the redox chemical processes at the oxide interface, the efficient reduction into a fully stoichiometric and ferrimagnetic $Fe_3O_4/SrTiO_3(001)$ system can be realized.

MA 53.10 Fri 12:00 H33

Spin-pumping in STO/LSMO/LNO/SRO heterostructures — •Christoph Hauser[1], Camillo Ballani[1], Frank Heyroth[2], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Heinrich-Damerow-Str. 4, 06120 Halle(Saale), Germany

We have investigated spin pumping and the inverse spin-Hall effect in heterostructures based on La0.7Sr0.3MnO3(LSMO), LaNiO3(LNO), and SrRuO3 (SRO). The layers are deposited by pulsed laser deposition. Structural characterization is done by X-ray diffraction and transmission electron microscopy (TEM). The magnetic properties are determined by SQUID magnetometry, and ferromagnetic resonance at a temperature of 190 K. Spin pumping and inverse spin-Hall effect are measured below the Curie temperature of the LSMO but above the one of SRO. For LSMO/LNO/Pt multilayers increased damping in FMR is detected [1], however no ISHE can be measured. For LSMO/LNO a weak ISHE is visible, however the signal cannot be unambiguously identified because of thermo voltages. In the LSMO/LNO/SRO heterostructure a clear ISHE can be measured, which can be separated from side effects stemming from anisotropic magnetoresistance (AMR) and spin rectification [2].

[1] Y. Tserkovnyak *et al.*, Phys. Rev. B, **66**, 224403 (2002)
[2] A. Azevedo *et al.*, Phys. Rev. B, **83**, 144402 (2011)

MA 53.11 Fri 12:15 H33

Magnetic properties of layered $(Cr_{0.5}Mn_{0.5})_2AuC$ films — •Ruslan Salikhov[1], Chung-Chuan Lai[2], Quanzheng Tao[2], Johanna Rosen[2], Ulf Wiedwald[1], and Michael Farle[1] — [1]University of Duisburg-Essen, Duisburg, Germany — [2]Linköping University, Linköping, Sweden

The $M_{n+1}AX_n$ (n =1,2,3) phases are family of nanolaminated ceramics with more than 170 members discovered so far. Mn-based ternary and quaternary compounds led to a new class of magnetic materials, for example $(Cr_{0.5}Mn_{0.5})_2GaC$ [1] and Mn_2GaC [2]. Most recently the synthesis of A = Au MAX phases has been reported [3]. The Au-containing MAX phases were formed by thermally induced substitutional reaction in ternary and quaternary compounds [3]. Following this post-synthesis modification applied to the $(Cr_{0.5}Mn_{0.5})_2GaC$ films the new magnetic $(Cr_{0.5}Mn_{0.5})_2AuC$ system has been stabilized [4]. The substitution of Au for resulted in a expansion of c-axis by about 3.3% perpendicular to the basal plane. Here we present a direct comparative study of magnetic properties of $(Cr_{0.5}Mn_{0.5})_2GaC$ and $(Cr_{0.5}Mn_{0.5})_2AuC$ films and suggest a pathway for tuning magnetic properties in inherently nanolaminated hexagonal MAX phase carbides. This work is supported by DFG, Grant No. SA 3095/2-1 [1] A. Petruhins, et al., J. Mater. Sci. 50, 4495 (2015). [2] A. S. Ingason, et al., Mater. Res. Lett. 2, 89 (2014). [3] H. Fashandi, et al., Nature Mat. 16, 814 (2017). [4] C.-C. Lai, et al., APL Mat. 6, 026104 (2018).

MA 53.12 Fri 12:30 H33

Stabilization of metallic phase in epitaxial NdNiO3 films by Nd excess — Henrike Probst[1], •Marius Keunecke[1], Sebastian Merten[1], Vladimir Roddatis[2], Daniel Steil[1], Sabine Steil[1], Stefan Mathias[1], and Vasily Moshnyaga[1] — [1]Erstes Physikalisches Institut, Georg-August-Universität Göttingen — [2]Institut für Materialphysik, Georg-August-Universität Göttingen

Rare earth nickelates (RENiO3, RE=Sm, Nd, Pr, etc.) are well known for their rich phase diagram, controlled by strong electron-lattice electronic interactions, the mechanism of which is still not well understood. We report the growth of epitaxial NdNiO3 (NNO) thin films by metalorganic aerosol deposition (MAD) technique on (100)- and (111)-oriented LaAlO3 and SrTiO3 substrates. The stoichiometric films demonstrate a metal-insulator (MI) transition, coupled to a structural (orthorhombic/monoclinic) phase transition at Tmi=120-160 K, depending on the epitaxy stress and film thickness. Over stoichiometric films with Nd/Ni ratio>1.5 show overall metallic behavior, remaining in the orthorhombic structure even at low temperatures. We believe the suppression of MI transition is related to a unique nanostructure of the NNO, induced by Nd-rich Ruddlesden-Popper Nd2NiO4 phase observed by high resolution TEM. Financial support from DFG (SFB 1073 TPA02, B07, Z02, and MO2255-4) is acknowledged.

MA 54: Magnetic textures: Transport and dynamics III

Time: Friday 9:30–12:30 Location: H37

MA 54.1 Fri 9:30 H37

Development of a Miniature Polarisation Analysis Device — •Ran Tang[1], Henrik Gabold[1], Robert Georgii[2], and Peter Böni[1] — [1]James-Franck-Str. 1, Physik-Department E21, TU München, 85748 Garching, Germany — [2]Lichtenbergstr. 1, MLZ, 85748 Garching, Germany

Spherical neutron polarimetry (SNP) has been systematically developed and applied over the last decades since the cryogenic polarisation analysis device (CryoPAD) presented by Tasset et al. in 1989. This technique allows to determine all the nine components in the polarisation matrix at once and therefore to solve the Blume-Maleyev equations. The biggest advantage of SNP over conventional polarisation analysis methods is the ability to separate nuclear and magnetic contributions in the scattering processes even with finite nuclear-magnetic interference terms. Hence the magnetic properties, e.g. magnetoelectricity, non-collinear magnetic structures, different types of magnetic domains in antiferromagnetic structures, and commensurate and incommensurate structures, can be finely determined. Inspired by the CryoPAD, the Mu-metal Polarisation Analysis Device (MuPAD) presented by Janoschek et al., and the following Mini MuPAD, introduced by Haslbeck and Kindervater et al., with a more compact form, we want to report on the currently being developed cylindrical Mini PAD. In comparison to the existing Mini MuPAD, the precession coils are bent into cylindrical shape around the sample, and the scattering angles are hence no longer restricted to be smaller than 10°. Furthermore, thanks to its size, it is simple to handle and can be combined with a cryostat.

MA 54.2 Fri 9:45 H37

Pressure induced modification of the anomalous Hall effect — Rafael Gonzales[1,2], •Bertrand Dupé[2], and Jairo Sinova[2] — [1]Universidad del Norte, Barranquilla, Colombia — [2]Johannes Guttenberg Universität of Mainz, Mainz, Germany

The Anomalous Hall Effect (AHE) consists of the presence of a transverse voltage when an electrical current is applied on a ferromagnetic material [1]. The anomalous Hall conductivity (AHC) is proportional to the saturation magnetization in the Kaplus Luttinger theory [2] and to the spin orbit coupling in the Berry phase theory [3]. Here, we studied the dependence of the AHC of pressure in 3d transitions metals by mean of Density function theory. We interpolated the band structure by means of Wannier functions. By using the Berry phase theory, we show that the in the AHC is in general not proportional to the magnetization and the spin orbit coupling. [1] N. Nagaosa et al., Rev. Mod. Phys. 82, 1539 (2010). [2] R. Kaplus et al., Phys. Rev. 95, 1154 (1954). [3] M. V. Berry, Proc. R. Soc. London 392, 45 (1984).

MA 54.3 Fri 10:00 H37

Composition dependent exchange interactions and Gilbert damping in (Mn,Fe)Ge B20 alloys — •S. Mankovsky and H. Ebert — Dept. Chemistry, LMU Munich, D-81377 Munich, Germany

First-principles investigations of the magnetic properties of various materials with B20 crystal structure have been performed for different composition and structure parameters. The calculations are based on the fully relativistic multiple scattering Korringa-Kohn-Rostoker (KKR) formalism. A particular issue of these investigations is the Gilbert damping (GD) parameter and its strong dependence on the conditions of sample preparation as it was demonstrated experimentally for the FeGe compound [1]. Therefore, detailed investigations on the temperature and composition dependence of the GD have been performed for pure FeGe and MnGe compounds as well as for (Mn,Fe)Ge alloys. This study shows in particular an increase of the GD by an order of magnitude when going from MnGe to FeGe. The impact of the structure parameters and different types of defects (e.g. vacancies and antisite defects) was investigated to understand the dependence on sample preparation conditions. In addition, the exchange parameters, both isotropic and Dzyaloshinskii-Moriya interactions (DMI), have been calculated accounting simultaneously for thermal lattice vibrations and spin fluctuations, vacancies and antisite defects. From this we find in particular a significant increase of the DMI, namely diagonal $D^{\alpha\alpha}$ elements, in the pure MnGe limit. All results are compared with available experimental data as far as possible.

[1] Phys. Rev. B 95, 134416 (2017)

MA 54.4 Fri 10:15 H37

Topological Hall effect in thin films of $Mn_{1.5}PtSn$ — •Peter Swekis[1,2], Anastasios Markou[1], Dominik Kriegner[1], Jacob Gayles[1], Richard Schlitz[2,3], Walter Schnelle[1], Sebastian T. B. Goennenwein[2,3], and Claudia Felser[1] — [1]Max-Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — [3]Center for Transport and Devices of Emergent Materials, Technische Universität Dresden, 01062 Dresden, Germany

Spin chirality in metallic materials with non-coplanar magnetic order can give rise to a Berry phase induced topological Hall effect. Here, we report the observation of the topological Hall effect in high-quality films of $Mn_{1.5}PtSn$ below a spin reorientation transition temperature. We find, that the maximum topological Hall resistivity is of comparable magnitude as the anomalous Hall resistivity, with their relation depending on the spin reorientation. Further, we underline the robustness of the topological Hall effect in $Mn_{2-x}PtSn$ by extracting the effect for multiple stoichiometries (x = 0.5, 0.25, 0.1).

MA 54.5 Fri 10:30 H37

Transport effects in magnetic textures of non-Abelian frustrated antiferromagnets — •Patrick M. Buhl[1], Frank Freimuth[1], Stefan Blügel[1], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg-University Mainz, 55128 Mainz, Germany

The topological Hall effect as the main transport signature of skyrmion textures has proven to be a key phenomenon for skyrmion detection and device design utilizing skyrmions. Interpretation of experimental measurements requires theoretical predictions that can be obtained in the adiabatic limit through semiclassical equations of motion in combination with the Boltzmann formalism. A conceptually similar method was employed recently to estimate the non-Abelian topological spin Hall effect of skyrmion lattices in collinear antiferromagnets [1].

Here, we consider an extension of the non-Abelian wave-packet dynamics to magnetic textures made of frustrated antiferromagnets, with particular focus on the impact of local non-collinearity on traversing electrons. Based on model calculations, we investigate the impact of the modified non-Abelian electron dynamics on the transport properties of various frustrated imprinted textures of different topological character, and provide possible material candidates where the novel type of non-Abelian dynamics could be observed. This work is supported by SFB 1238 of the DFG.

[1] P.M. Buhl, et al., PSS RRL 11, 1700007 (2017)

MA 54.6 Fri 10:45 H37

Magnetic excitations of the ferrimagnetic spin spiral in FeP — •Dmytro S. Inosov[1], Yuliia V. Tymoshenko[1], Yevhen A. Onykiienko[1], Alistair S. Cameron[1], Alexandr S. Sukhanov[1,5], Igor V. Morozov[2,3], Saicharan Aswartham[3], and Helen C. Walker[4] — [1]TU Dresden, Germany — [2]Moscow State University, Russia — [3]IFW Dresden, Germany — [4]ISIS Neutron and Muon Source, Didcot, UK — [5]MPI CPfS, Dresden, Germany

Iron phosphide (FeP) is a very unusual itinerant helimagnet, in which the spin spiral derives from a ferrimagnetic arrangement of spins ("double helix" structure). There are two magnetic sublattices with different sizes of the magnetic moment, which are twisted into a helical spiral propagating along the orthorhombic c axis. As a consequence, two nonequivalent pairs of incommensurate magnetic Bragg peaks with associated helimagnon modes form near the allowed and forbidden structural Bragg peaks (101) and (110), respectively. We present the first measurements of spin-wave excitations by inelastic neutron scattering and discuss the hierarchy and possible origin of magnetic interactions.

MA 54.7 Fri 11:00 H37

Characterizing breathing modes of magnetic (anti-)skyrmions with the Hamiltonian formalism — •B. F. McKeever[1], D. R. Rodrigues[1], D. Pinna[1], Ar. Abanov[2], Jairo Sinova[1,3], and K. Everschor-Sitte[1] — [1]Johannes Gutenberg University Mainz, Germany — [2]Texas A&M University, College Station, USA — [3]Institute of Physics ASCR, Prague, Czech Republic

We derive an effective Hamiltonian system describing the low energy dynamics of circular magnetic skyrmions and antiskyrmions using collective coordinates [1]. An effective energy landscape reveals two qualitatively different types of breathing behavior. For small energy perturbations we reproduce the well-known small breathing mode excitations, where the magnetic moments of the skyrmion oscillate around their equilibrium solution. At higher energies we find a rotational breathing behavior, transforming Neel to Bloch skyrmions and vice versa. For a damped system we observe the transition from the continuously rotating and breathing skyrmion into the oscillatory one. We analyze the characteristic frequencies of both types, as well as their amplitudes and energy dissipation rates. For rotational (oscillatory) breathing modes we predict on average a linear (exponential) decay in energy. This stark difference in dissipative behavior should be observable in the frequency spectrum of excited (anti-)skyrmions.

[1] B. F. McKeever et al., arXiv:1811.09949

15 min. break

MA 54.8 Fri 11:30 H37

On rate theory for continuous multidimensional magnetic systems — •Grzegorz Kwiatkowski[1,2] and Pavel F. Bessarab[1,3] — [1]University of Iceland, Reykjavík, Iceland — [2]Immanuel Kant Baltic Federal University, Kaliningrad, Russia — [3]ITMO University, St. Petersburg, Russia

The search for optimal magnetic memory bits combining high stability and energy-efficient writability is a key problem in the field of future information technologies. In this respect, designing samples characterized by low attempt frequency appears to be particularly promising. Here we demonstrate that internal degrees of freedom have a crucial impact on thermal stability of magnetic systems. Due to the effect of the internal modes, even monodomain particles which reverse their magnetization by strictly uniform rotation can have much lower attempt frequency compared to the values predicted by the rate theory due to Néel and Brown [1,2]. Our results also demonstrate the need for revision of classical rate theories for 2D- and 3D-systems due to inherent divergent behaviour. We propose a generalization of the rate theories for continuum systems in line with ideas of Debye [3] and present illustrative examples. Our results are particularly important for describing the thermal stability of magnetic skyrmions which are praised to be the information-carrying bits in next-generation data storage and logic devices.

[1] L. Néel, Ann. Geophys. **5**, 99 (1949).
[2] W. F. Brown, Phys. Rev. **130**, 1677 (1963).
[3] P. Debye, Ann. Phys. **344**, 14 (1912).

MA 54.9 Fri 11:45 H37

Characterization of MnGe thin films and nanostructures — •David Schroeter[1], Nico Steinki[1], Thomas Kimmel[1], Alexander Fernández Scarioni[2], Hans Werner Schumacher[2], Stefan Süllow[1], and Dirk Menzel[1] — [1]Institut für Physik der Kondensierten Materie, TU Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

In the recent years thin films of the B20 compound like MnSi and MnGe became subject of great interest, since the magnetic properties of bulk material are modified due to the dimensional reduction and the uniaxial anisotropy with a proposed stabilized skyrmionic phase [1,2]. Additionally, bulk material MnGe is known for its short periodicity of the magnetic spin structure of roughly 3 nm [2], making MnGe thin films an ideal candidate for the investigation of thin films exhibiting high-skyrmion density.

In this situation, we have set out to investigate the (magneto-)resistivity, Hall effect and magnetization in MnGe thin films and nanostructures. We have analyzed the electronic transport properties in Hall geometries of various sizes to determine the intrinsic behavior and potential finite size effects. We compare the thin film and nanostructure data to experiments performed on nanostructured MnSi thin films and discuss our results in terms of the structural and morphologic characterization of the samples.

[1] A. B. Butenko et al., Phys. Rev. B 82, 052403 (2010). [2] N. Kanazawa et al., Phys Rev. Lett. 106, 156603 (2011).

MA 54.10 Fri 12:00 H37

Dynamics of confined magnetic skyrmions under application of an oscillatory magnetic field — •Sakineh Abdizadeh Kalan[1,2], Jahanfar Abouie[1], and Khalil Zakeri Lori[2] — [1]Institute for Advanced Studies in Basic Sciences(IASBS), Zanjan 45137-66731, Iran — [2]Heisenberg Spin-dynamics Group, Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede-Str. 1, D-76131 Karlsruhe, Germany

We report a detailed micromagnetic study of the dynamics of a magnetic skyrmion confined in a 120-nm-diameter disk of 0.6 nm thickness, using the Object Oriented Micromagnetic Framework (OOMMF). We observe that the dynamics depends on the frequency as well as the amplitude of the applied magnetic field, as expected. Our results indicate that there is a threshold field amplitude above which the dynamics becomes more complex. In the second step, the gyroscopic motion of field-driven skyrmion is investigated by analytical calculations. We use the Thiele equation for massive skyrmions in the presence of a magnetic field. The time dependent trajectory of skyrmion core is analytically calculated for different magnetic fields and different field geometries. Comparing the results of micromagnetic simulations to those of the analytical calculations, we discuss the details of the observed complex skyrmion dynamics.

The work has been supported by the Deutscher Akademischer Austauschdienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) through the DFG grants ZA 902/3-1 and ZA 902/4-1.

MA 54.11 Fri 12:15 H37

Damping of spin wave modes in magnetic skyrmions — •Levente Rózsa, Julian Hagemeister, Elena Y. Vedmedenko, and Roland Wiesendanger — University of Hamburg, Hamburg, Germany

Magnetic skyrmions are localized noncollinear spin configurations, which have attracted significant research attention lately in the field of magnonics due to their spin wave excitation modes connected to the magnetic structure [1]. Understanding the damping mechanisms determining the lifetimes of the magnons is required for future technological applications.

Here the connection between noncollinear spin configurations and the effective damping parameters of spin waves is investigated, which are shown to be mode-dependent and enhanced compared to the Gilbert damping α [2]. It is demonstrated how these effective damping parameters can be calculated based on the elliptic polarization of the modes in the limit of vanishing α, and how excitations may become overdamped for larger α values. The results are illustrated for the example of isolated $k\pi$ skyrmions, cylindrically symmetric spin configurations where the out-of-plane spin component rotates by $k\pi$ between the center and the collinear background. The role of effective damping parameters is discussed close to the instabilities of the skyrmions at low and high field values [3].

[1] M. Garst et al., J. Phys. D: Appl. Phys. **50**, 293002 (2017).
[2] L. Rózsa et al., Phys. Rev. B **98**, 100404(R) (2018).
[3] L. Rózsa et al., arXiv:1810.06471 (2018).

MA 55: Electron theory and micromagnetism

Time: Friday 9:30–13:15 Location: H38

MA 55.1 Fri 9:30 H38

Ab-initio calculations of the spin wave stiffness constant for permalloy doped with V, Gd, and Pt — •Ondřej Šipr[1], Sergey Mankovsky[2], and Hubert Ebert[2] — [1]Institute of Physics, Czech Academy of Sciences, Praha — [2]Ludwig-Maximilians-Universität München

The modification of the properties of magnetic materials by doping is a promising and intensively studied way to make progress in device technology and spintronics. A very important system in this respect is permalloy $Fe_{20}Ni_{80}$ — not only because of its high magnetic permeability but also because of its transport properties characterized by a high and low electrical conductivity in the majority and minority spin channel, respectively. As the spin dynamics of materials is governed by the spin wave stiffness D or the closely connected exchange stiffness A, we perform *ab-initio* investigation of this quantity for permalloy (Py) doped with V, Gd, and Pt. Our study is based on electronic structure calculations by means of the Korringa-Kohn-Rostoker (KKR) Green's-function method, with disorder treated within the coherent potential approximation (CPA). For Gd as a dopant the open core formalism was employed. The calculated results are in a good agreement with experiment [Lepadatu *et al* PRB **81**, 020413 (2010) and APL **97**, 072507 (2010); Yin *et al* IEEE Magn. Lett. **8**, 3502604 (2016); Hrabec *et al* PRB **93**, 014432 (2016)], correctly reproducing the trends when the chemical type (V, Gd, or Pt) or the concentration (1–10 %) of the dopant are changed.

MA 55.2 Fri 9:45 H38

An extension of the Heisenberg Hamiltonian: temperature dependent and multi-spin exchange parameters from first principles — •Sergiy Mankovsky and Hubert Ebert — Dept. Chemistry, LMU Munich, D-81377 Munich, Germany

We will present an extension of the Heisenberg model by accounting for multi-spin exchange and temperature dependent exchange interactions calculated from first principles based on the electronic structure calculations by means of the Korringa-Kohn-Rostoker (KKR) Green function method. The temperature dependent behaviour of the exchange parameters is obtained accounting for thermal lattice vibrations and spin fluctuations treated by means of the CPA alloy theory within the alloy analogy model [1]. To calculate the multi-spin exchange interactions, we follow the approach reported previously [2], using a higher order expansion of the Green function entering the free energy expression accounting this way for a deviation of magnetic moments from a reference configuration. To demonstrate the impact of these contributions we represent results of calculations for different types of system: pure elemental materials, ordered compounds as well as alloys with chemical disorder.

[1] H. Ebert, S. Mankovsky, et al., Phys. Rev. B **91**, 165132 (2015)
[2] S. Mankovsky, S. Polesya, H. Ebert, arXiv:1810.13175 (2018)

MA 55.3 Fri 10:00 H38

Coupled charge and spin dynamics in a photo-excited doped Mott insulator — •Nikolaj Bittner[1], Denis Golez[1], Hugo Strand[2], Martin Eckstein[3], and Philipp Werner[1] — [1]Department of Physics, University of Fribourg, 1700 Fribourg, Switzerland — [2]Flatiron Institute, Simons Foundation, 162 Fifth Avenue. New York, NY, 10010, USA — [3]Department of Physics, University of Erlangen-Nuernberg, 91058 Erlangen, Germany

Using a nonequilibrium implementation of the extended dynamical mean field theory (EDMFT) we simulate the relaxation of a photo-excited doped Mott insulator. We consider the t-J model and focus on the interplay between the charge- and spin-dynamics in different excitation and doping regimes. The appearance of string states after a weak photo excitation manifests itself in a nontrivial scaling of the relaxation time with the exchange coupling. Moreover, we observe a correlated oscillatory evolution of the kinetic energy and spin-spin correlation function, which is a direct consequence of a strong spin-charge coupling. A strong excitation of the system, on the other hand, suppresses the spin correlations and results in a relaxation that is controlled by hole scattering. Finally, we propose a pump-probe setup, which allows to directly observe oscillations in the optical conductivity originating from string states.

MA 55.4 Fri 10:15 H38

Hybridization-switching induced Mott transition in magnetic ABO_3 perovskites — •Atanu Paul[1], Anamitra Mukherjee[2], Indra Dasgupta[1], Arun Paramekanti[3], and Tanusri Saha-Dasgupta[4,5] — [1]School of Physical Sciences, Indian Association for the Cultivation of Science, Kolkata, India — [2]School of Physical Sciences, National Institute of Science Education and Research, Jatni, India — [3]Department of Physics, University of Toronto, Ontario, Canada — [4]Department of Condensed Matter Physics and Materials Science, S.N. Bose National Centre for Basic Sciences, Kolkata, India — [5]School of Mathematical & Computational Sciences, Indian Association for the Cultivation of Science, Kolkata, India

We propose the concept of "hybridization-switching induced Mott transition" which is relevant to a broad class of magnetic ABO_3 perovskite materials including $BiNiO_3$ and $PbCrO_3$ which feature extended 6*s* orbitals on the A-site cation (Bi or Pb), and A-O covalency induced ligand hole. Using *ab initio* electronic structure and model Hamiltonian calculations, we show that such systems exhibit a breathing phonon driven A-site to oxygen hybridization-wave instability which conspires with strong correlations on the magnetic B-site transition metal ion (Ni or Cr) to induce an antiferromagnetic Mott insulator. These Mott insulators with active A-site orbitals are shown to undergo a pressure induced antiferromagnetic insulator to ferromagnetic metal transition accompanied by a colossal volume collapse due to ligand hybridization switching.

MA 55.5 Fri 10:30 H38

Ferromagnetism in alternating Hubbard ladder — •Kaouther Essalah[1], Ali Benali[1], Anas Abdelwahab[2], Eric Jeckelmann[2], and Richard Scalettar[3] — [1]University of Tunis El-Manar, Tunis, Tunisia — [2]Leibniz University, Hannover, Germany — [3]University of California, Davis, USA

We are using Density Matrix Renormalization Group (DMRG) method to study spin correlations in chains with many variants of alternating number of legs. The system is described using the half-filled Hubbard model. We are calculating excitation gaps, charge and spin densities as well as correlation functions. We compare our results to those of the well known geometries of even and odd number of leg ladders.

MA 55.6 Fri 10:45 H38

Broken symmetry states of magnetic molecular complexes — •Yaroslav Pavlyukh, Wolfgang Huebner, and Georgios Lefkidis — Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67653 Kaiserslautern, Germany

The broken-symmetry (BS) approach is broadly used to extract the magnetic properties of many-body systems from a DFT calculation. However, there is an ambiguity in the nature of the underlying electronic states and the corresponding spin densities: the spin density from DFT is not a well-defined property and the Kohn-Sham determinants need not be eigenfunctions of the square of the total spin ($\hat{\mathbf{S}}^2$).

Here we propose a procedure, in which the detailed analysis of a redundant number of electronic many-body excitations gives insight into the intrinsic magnetic properties of the system. We perform highly correlated multi-determinant calculations on two prominent synthesized and characterized metallacrown molecules with frustrated antiferromagnetic order driven by the superexchange mechanism, i.e., $\{CuCu_4\}$ and $\{CuFe_4\}$ [1]. For those we unambiguously show that the BS states are not eigenstates of $\hat{\mathbf{S}}^2$ and, in addition, theoretically compute several magnetic (exchange coupling J [2]) and relativistic properties (g-tensors), which we find to be in close agreement with experiment.

[1] Y. Pavlyukh, E. Rentschler, H. J. Elmers, W. Hübner, and G. Lefkidis, Phys. Rev. B **97**, 214408 (2018)
[2] W. Hübner, Y. Pavlyukh, G. Lefkidis, and J. Berakdar, Phys. Rev. B **96**, 184432 (2017)

MA 55.7 Fri 11:00 H38

Spin excitations in magnetic nanostructures with spin-orbit coupling from first-principles time-dependent DFT+U — •Manuel dos Santos Dias, Sascha Brinker, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany

Time-dependent density functional theory has been very successful in describing spin excitations and spin fluctuations of surface-supported magnetic adatoms and dimers [1,2]. However, orbital correlation effects are poorly described by the adiabatic local spin density approximation. We combined our linear-response theory of magnetic nanostructures with spin-orbit coupling in real-space [3] with a parameter-free Hubbard-U-like kernel [4]. Magnetic adatoms on Cu(111) and Pt(111) serve as a benchmark to explore whether orbital polarization impacts dynamical quantities such as spin pumping or spin relaxation. Dimers and trimers are used to study the interplay between orbital correlation and delocalization, and to show the scalability of this approach.
This work was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator Grant No. 681405-DYNASORE).

[1] J. I. Azpiroz *et al.*, J. Phys.: Condens. Matter **30**, 343002 (2018)
[2] F. S. M. Guimarães *et al.*, Phys. Rev. B **96**, 144401 (2017)
[3] M. dos Santos Dias *et al.*, Phys. Rev. B **91**, 075405 (2015)
[4] N. Tancogne-Dejean *et al.*, Phys. Rev. B **96**, 245133 (2017)

15 min. break

MA 55.8 Fri 11:30 H38

Critical temperature and effective magnetic moment of experimentally known magnetic Heusler alloys from first principles — •Roman Kováčik[1], Phivos Mavropoulos[2], and Stefan Blügel[1] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics, National and Kapodistrian University of Athens, GR-15784 Zografou, Greece

We present systematic calculations of the critical temperature (Curie or Néel) and the effective magnetic moment of a large number (∼150) of experimentally known magnetic Heusler alloys. The method of calculation comprises three steps: (i) calculation of the ground-state electronic structure within density functional theory (local spin density approximation and generalized gradient approximation) employing the Korringa-Kohn-Rostoker Green function method [1], (ii) extraction of exchange parameters to fit the Heisenberg model [2], and (iii) Monte Carlo simulation based on the Heisenberg model. We analyze the critical temperature dependence on various parameters defining the alloys and address the effect of the longitudinal spin fluctuations on selected alloys. The effective magnetic moment reflecting the degree of short range order above the critical temperature is obtained by fitting the magnetic susceptibility to the Curie-Weiss law and compared to available experimental data. Support from JARA-HPC (jara0182) and the EU CoE MaX (grant no. 676598) is gratefully acknowledged.
[1] H. Ebert *et al.*, Rep. Prog. Phys. 74, 096501 (2011), also see: www.judft.de. [2] A. I. Liechtenstein *et al.*, JMMM 67, 65 (1987).

MA 55.9 Fri 11:45 H38

Spin-model study of magnetism in graphene-based systems — László Oroszlány[1,2], Jaime Ferrer[3], András Deák[4,5], László Udvardi[4,5], and •László Szunyogh[4,5] — [1]Eötvös Loránd University, Budapest, Hungary — [2]MTA-BME Lendület Topology and Correlation Research Group, Budapest, Hungary — [3]Universidad de Oviedo & CINN, Oviedo, Spain — [4]Budapest University of Technology and Economics, Budapest, Hungary — [5]MTA-BME Condensed Matter Research Group, Budapest, Hungary

We briefly present the implementation of the method by Lichtenstein *et al.* [1] for evaluating isotropic exchange interactions from density functional theory based on the SIESTA code. We demonstrate that in case of simple metallic ferromagnets the Heisenberg interactions obtained from well–established computational methods are well reproduced. We then study magnetic correlations in single-side flourinated graphene (C2F) and in zig-zag graphene ribbons representing *sp* magnetism. Similar to Ref. [2], our calculated exchange interactions support a Néel type of magnetic ground state for C2F. For the graphene ribbons we calculate a stiffness constant over 3000 meVÅ^2, even larger than in Ref. [3], and find a transition between 1D and 2D long-range behavior depending on the thickness of the ribbon.

[1] A. I. Lichtenstein *et al.*, J. Magn. Magn. Mater. **67**, 65 (1987)
[2] A.N. Rudenko *et al.*, Phys. Rev. B **88**, 081405(R) (2013)
[3] O. V. Yazyev and M. I. Katsnelson, Phys. Rev. Lett. **100**, 047209 (2008)

MA 55.10 Fri 12:00 H38

Extending Liechtenstein's method to strong spin-orbit coupled systems — •Louis Ponet[1,2] and Sergey Artyukhin[1] — [1]Istituto Italiano di Tecnologia, Genova, Italia — [2]Scuola Normale Superiore di Pisa, Pisa, Italia

Localized magnetism in transition metal compounds has been very successfully modeled using a variation on the classical Heisenberg model. Calculating the model parameters, so-called magnetic exchange constants, from first-principles has been a notoriously difficult task, usually involving the comparison of total energies from numerous supercell ab-initio calculations. For simple compounds with small magnetic unit cells this approach is feasible and indeed has produced accurate results. A computationally more efficient Green's function-based method developed by Liechtenstein et al., and later adapted for use with Wannier functions by Rudenko et al., remedies this by calculating the exchange coefficients from a single DFT calculation. However this method was only formulated in the situation where there is low-strength atomic SOC present in the material. The crucial assumption is that the spins can rotate without perturbing other degrees of freedom. This picture breaks down when the localized spins are situated on atoms with strong spin-orbit coupling, such as the 5d-transition metal ions. This is because the low-energy degrees of freedom entangle spins and orbitals (describing the charge distribution). This leads to strongly anisotropic magnetic interactions, not contained in the Heisenberg model, leading to new physical phenomena as discussed by Jackeli et al. Here we explore the extension of the Liechtenstein method to this situation.

MA 55.11 Fri 12:15 H38

Micromagnetic Study of Magnetization States in FeGe Nanospheres — •Swapneel Amit Pathak and Riccardo Hertel — Université de Strasbourg et CNRS, Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504, 67000 Strasbourg, France

Magnetic structures in nanoscale ferromagnets are known to depend strongly on the particle size and shape, with recent attention being drawn towards three-dimensional nanomagnets [1]. However, in the case of chiral magnets, with pronounced Dzyaloshinskii-Moriya interaction, three-dimensional finite-size effects remain largely unexplored. Most of the studies on these materials pertain to thin-film geometries or disk shapes [2]. In this work, we employ micromagnetic finite-element simulations to investigate magnetic structures unfolding in FeGe particles of spherical shape. We find a variety of chiral equilibrium states as a function of the diameter and the external applied field. The structures can be categorized as helical states, merons, skyrmions, and chiral bobbers in different variants. The results, summarized in a phase diagram, show that specific magnetic structures can be stabilized depending on the particle size. For example, chiral bobbers can occur at much smaller dimension ($r \geq 50nm$) as compared to skyrmions ($r \geq 70nm$). The study furthers the understanding of these complex spin structures, which have recently been proposed as candidates for fundamental units of information in spintronics applications [3].

[1] A. Fernandez-Pacheco *et al.*, Nat. Comm., **8**, 15756 (2017)
[2] M. Beg em *et al.*, Sci. Rep., **5**, 17137 (2015)
[3] F. Zheng *et al.*, Nat. Nano., **13**, pp. 451-455 (2018)

MA 55.12 Fri 12:30 H38

Micromagnetic simulations for static and dynamic characterization of a linear chain of 20 magnetite nanoparticles — •Thomas Feggeler[1], Benjamin Zingsem[1,2], Alexandra Terwey[1], Michael Winklhofer[3], Ralf Meckenstock[1], Michael Farle[1], Heiko Wende[1], and Katharina Ollefs[1] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Lotharstr. 1, 47057 Duisburg — [2]Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]School of Mathematics and Science, University of Oldenburg, 26129 Oldenburg, Germany

We simulated the angular dependent Ferromagnetic Resonance (FMR) of a chain of 20 cubic magnetite nanoparticles (30 nm x 30 nm x 30 nm, truncated edges), resembling a particle chain within a bacterium Magnetospirillium Gryphiswaldense (strain MSR-1, wild-type). A simulated external magnetic field has been rotated 180 degrees in-plane around the chain, varying the field strength from 450 mT to 50 mT at each angle. In the simulated angle dependent Ferromagnetic Resonance spectrum multiple angular dependent resonance lines are visible, indicating an angular dependent anisotropy with a periodicity of 180 degrees, which is in good agreement to the experimental FMR measurements on such a sample. By the help of the simulation it is possible to identify the parts of the particle chain, in which each resonant eigenstate is localized. Partial financial support by DFG Project: OL513/1-1 is acknowledged.

MA 55.13 Fri 12:45 H38

Calculation of micromagnetic parameters from atomistic simulations in presence of crystal defects — •Matteo Rinaldi, Matous Mrovec, and Ralf Drautz — ICAMS, Ruhr-Universität Bochum, Germany

The purpose of this work is to elucidate the relationship between the microstructure and the magnetic properties of electrical steels (Fe-Si) using scale-bridging computational techniques that combine atomistic simulations with mesoscopic micromagnetic framework. The relevant parameters for the micromagnetic model (build up from the Landau-Lifshitz-Gilbert and the Landau-Lifshitz-Bloch equations) will be calculated with atomistic techniques such as density functional theory(DFT) and tight-binding(TB) models. The parameters analyzed are the spin-wave stiffness constant and the prefactors in the expression for the magnetocrystalline anisotropy. For the calculation of these quantities some of the available methods will be tested in both frameworks (TB and DFT). This combination enables simulations of extended defects (such as dislocations, grain and phase boundaries, interfaces) that are crucial for the microstructure and the study of their influence on the micromagnetic parameters. The micromagnetic calculations will be subsequently employed and compared with experimental data.

MA 55.14 Fri 13:00 H38

Novel magnetic states in nano clusters — •Robert Baldock and Nicola Marzari — Theory and Simulation of Materials (THEOS), and National Centre for Computational Design and Discovery of Novel Materials (MARVEL), École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

We predict that very small clusters of ferromagnetic spins may exhibit stable magnetic states with fractional overall magnetisation in two and three dimensions. These ultra small systems, which are dominated by finite size effects, do not conform to mean field models of the magnetization. Instead, exotic magnetisation field temperature phase diagrams are observed, where discrete fractional magnetisations are stabilised at finite fields and temperatures.

We study these systems using advanced free energy methods, including nested sampling, which enable us to directly obtain magnetisation-temperature free energy surfaces, from which the magnetisation field temperature phase diagrams can be computed directly.

MA 56: Multiferroics and Magnetoelectric coupling II (joint session MA/KFM)

Time: Friday 9:30–11:45 Location: H39

MA 56.1 Fri 9:30 H39

Reversible magnetoelectric interconversion of ferroic domain patterns in (Dy,Tb)FeO_3 — •Ehsan Hassanpour[1], Mads C. Weber[1], Yusuke Tokunaga[2], Yasujiro Taguchi[3], Yoshinori Tokura[3], Thomas Lottermoser[1], and Manfred Fiebig[1,3] — [1]ETH Zurich, Switzerland — [2]University of Tokyo, Japan — [3]RIKEN CEMS, Japan

Multiferroic materials can show a variety of exquisite effects due to hosting coexisting and complex magnetic and electric orders. Recently it was reported that a ferroelectric domain pattern from one layer is transfered to a ferromagnetic layer in a multiferroic heterostructure[1]. Here we show that we can reversibly interconvert magnetic and ferroelectric domain patterns in a single phase of multiferroic bulk system $Dy_{0.7}Tb_{0.3}FeO_3$. In this material, it was shown that a ferroelectric polarization is induced as a result of interaction of two magnetic sublattices of iron Fe^{3+} and rare-earth (Dy,Tb) R^{3+} via exchange forces. The strong coupling of these three order parameters creates a variety of composite domains and domain walls. Using magnetooptic imaging, we show that electric field pulses of specific speeds and amplitudes can generate and tune those domains/domain walls. Ultimately, by imprinting a domain pattern in the rare-earth's antiferromagnetic order, we transfer it from the ferromagnetic order of iron to the ferroelectric order and vice versa using magnetic and electric fields, respectively.

[1] De Luca *et al. Phys. Rev. Applied* **10**, 054030 (2018)

MA 56.2 Fri 9:45 H39

Coupled electric and magnetic domains and domain walls in h-RMnO$_3$ at the microscale — •Marcela Giraldo, Thomas Lottermoser, and Manfred Fiebig — ETH Zurich, Switzerland.

Fundamental understanding of the cross-coupling between ferroic orders at the level of domains and domain walls is crucial for the manipulation of multiferroics. It was shown for the first time on h-$RMnO_3$ that coupling between ferroelectricity and antiferromagnetism –with order parameters P and l, respectively– occurs in a type-I multiferroic where ferroic orders emerge independently. At the macroscopic scale, it was observed that the antiferromagnetic domain pattern (l) is defined by two independent domain patterns formed by P and the multiferroic order parameter Pl [1]. Albeit, coupling on the microscopic regime, on the level of the ferroelectric vortex domains which are characteristic for these materials has remained under debate. For the first time, we investigate the coupling between electric and magnetic domains in h-$RMnO_3$ on the microscopic scale using second-harmonic microscopy. We reveal that two of the three order parameters (P, l and Pl) change their sign simultaneously at every domain wall while the third one retains its sign. This confirms the earlier observation [1] that P and Pl form independent domain patterns. In addition, we show a new type of domain wall where P and Pl change their sign, while l remains constant. Our observations solve the open debate about coupling of domains and domain walls at the microscale and add new findings to understand the unique coupling nature in a type-I multiferroic.

[1] M. Fiebig *et al.*, Nature **419**, 818 (2002).

MA 56.3 Fri 10:00 H39

Magnetoelectric Polarizability in Magnetic Insulators — •Maximilian Merte[1,2], Frank Freimuth[1], Stefan Blügel[1], and Yuriy Mokrousov[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

In the field of spintronics, the interaction of insulators with external electromagnetic fields plays a crucial role for future prospects related to fundamental understanding and technological applications of magnetic oxides. In a situation of reduced symmetries, magnetic insulators can exhibit a finite electric polarization. Recently, a semiclassical approach describing the positional shift of Bloch electrons due to interband mixing induced by an external electromagnetic field was proposed [1]. These shifts can be computed via response matrices, which are constructed from interband velocity elements and band energies. Here we want to report on the implementation of this approach by means of Wannier interpolation, which can be applied as a postprocessing step to first-principles calculations performed with the Jülich DFT code FLEUR [2], an implementation of the FLAPW method. We apply the developed method to the study of magnetoelectric polarizability to selected magnetic insulators.

[1] Qian Niu *et al.*, Phys. Rev. Lett. 112, 166601 (2014).
[2] www.flapw.de .

MA 56.4 Fri 10:15 H39

Artificial multiferroic domain walls in oxide heterostructures — •Elzbieta Gradauskaite, Manfred Fiebig, and Morgan Trassin — Department of Materials, ETH Zurich, Switzerland

Ferroelectric domain walls possess symmetry-dependent functional properties enabled by confinement. Enhanced conductivity, for instance, is observed in charged domain walls. Regrettably, domain walls of this type are very scarce in nature due to energetically unfavourable electrostatics, which hinders technological development of domain wall nanoelectronics. We propose ferroic thin film oxide interfaces as an alternative. The polar state of $BaTiO_3$ and $BiFeO_3$ ferroelectrics can be manipulated via atomically precise surface termination control and monitored with in-situ second harmonic generation (ISHG) during the growth. Using this approach, stable head-to-head and tail-to-tail polarization-oriented configurations of ferroelectric layers can be created. Their interfaces are charged and can be regarded as artificial domain walls. By inserting an ultrathin $La_{1-x}Sr_xMnO_3$ ferromagnetic film at the junction we design a magnetoelectric multiferroic interface. Using a combination of ISHG and SQUID magnetometry, we show that the interlayer magnetic moment can be enhanced or diminished when the artificial domain wall has a head-to-head or tail-to-tail configuration, respectively. Our work provides new insights into electrical control of magnetism in multiferroic oxide heterostructures.

MA 56.5 Fri 10:30 H39

Complex magnon spectrum of the simple collinear antiferromagnet $Co_2Mo_3O_8$ — •Stephan Reschke[1], Dániel Farkas[2], Sandor Bordács[2], Vladimir Tsurkan[1], and István Kézsmárki[1] — [1]University of Augsburg, Augsburg, Germany — [2]Budapest University of Technology and Economics, Budapest, Hungary

$Co_2Mo_3O_8$ belongs to a family of hexagonal lattice type-I multiferroics, showing peculiar magnetoelectric effects. In this compound the magnetic Co^{2+} ions are in either tetrahedral or octahedral oxygen coordination and form honeycomb layers in the ab plane. Based on neutron powder diffraction, $Co_2Mo_3O_8$ is a 4 sub-lattice collinear easy-axis antiferromagnet below $T_N = 42$ K. By THz time-domain spectroscopy measurements the magnon excitation spectra of differently oriented single crystals were investigated in magnetic fields up to 7 T. Interestingly, we observed magnon spectra far more complicated than expected for the proposed simple antiferromagnetic structure, with more than 20 magnon modes. Most of these modes show a splitting for magnetic fields applied along the c axis, which supports the predominantly easy-axis character of the antiferromagnetic state. Furthermore, we also observed directional dichroism for some of the modes, a consequence of the dynamic magnetoelectric effects.

MA 56.6 Fri 10:45 H39

Vacuum encapsulated high frequency magnetic field sensors based on the ΔE effect — •Benjamin Spetzler[1], Florian Niekiel[2], Fabian Lofink[2], Bernhard Wagner[2], and Franz Faupel[1] — [1]Kiel University, Kiel, Germany — [2]Fraunhofer ISIT, Itzehoe, Germany

Investigations into the ΔE effect of magnetoelastic materials have revealed the exciting promise of detecting low frequency and small amplitude magnetic fields [1]. Typical approaches are based on electrically exciting a resonator by applying an alternating voltage to a magnetoelectric composite structure with soft magnetic properties [2]. Previously presented sensors are operated either in the first or second bending mode with resonance frequencies in the lower kHz regime [3]. Due to the low resonance frequencies and comparatively large quality factors, the bandwidth of these sensors is too small for many biomedical applications. Here, we present vacuum encapsulated cantilever resonators operating at high frequency modes with bandwidths in the kHz regime. In addition to common bending modes, longitudinal and more complex modes are also used. The various modes are analyzed experimentally and theoretically for sensitivity, detection limit, mechanical properties and loss mechanisms with a comprehensive magneto-electromechanical model. Important consequences for future sensor designs are derived.

[1] B. Gojdka, et al., APL, 99 (22), (2011)
[2] S. Zabel, et al., APL, 107 (15), (2015)
[3] J. Reermann, et al., IEEE Sensors, 16 (12), (2016)

MA 56.7 Fri 11:00 H39

High magnetic field phases of magnetoelectric LiFePO4 and LiNiPO4 — •Botond Forrai[1], Atsuhiko Miyata[2], Dávid Szaller[3], Vilmos Kocsis[4], Yasujiro Taguchi[4], Yoshinori Tokura[4], István Kézsmárki[5], and Sándor Bordács[1] — [1]Department of Physics, Budapest University of Technology and Economics, Budapest 1111, Hungary — [2]Laboratoire National des Champs Magnetiques Intenses, Toulouse 31400, France — [3]Institute of Solid State Physics, Vienna University of Technology, Vienna 1040, Austria — [4]RIKEN Center for Emergent Matter Science (CEMS), Wako, Saitama 351-0198, Japan — [5]Zentrum für Elektronsiche Korrelation und Magnetismus, Institut für Physik, Universität Augsburg

Olivine-type orthophosphates has been attracting much attention due to their strong linear magnetoelectric effect. The low-field magnetic phases giving rise to the magnetoelelctric effect are well charachterized, however, their high field phase diagrams have not been fully explored. Therefore, we studied the magnetic phases of LiFePO4 and LiNiPO4 at 5K by magnetization measurements till their magnetization reach the saturation. The competing exchange interactions leads to several phase transitions in LiNiPO4, while in LiFePO4 a single spin-flop transition is detected due to the strong anisotropy. The magnetic phase diagrams are interpreted in a classical mean-field model, which allowed us to identify the key terms in spin Hamiltonian.

MA 56.8 Fri 11:15 H39

Electric field control of the nonreciprocal light absorption in $Ba_2CoGe_2O_7$ — •Jakub Vít[1], Toomas Rõõm[2], Urmas Nagel[2], Johan Viirok[2], Vilmos Kocsis[1,3], Yoshinori Tokura[3], István Kézsmárki[1,4], and Sándor Bordács[1] — [1]Budapest University of Technology and Economics, Hungary — [2]National Institute Of Chemical Physics And Biophysics, Estonia — [3]RIKEN CEMS, Japan — [4]Experimental Physics 5, University of Augsburg, Germany

In crystalline solids where space inversion and time-reversal symmetries are simultaneously broken, the propagation of (quasi)particles can be different when the wave vector is reversed. Strong nonreciprocal light absorption has been observed on spin-wave excitations of multiferroics, i.e. ferroelectric and magnetic materials, where the sign and the magnitude of the effect were controlled by an external magnetic field. Here, we report an electric-field control of the nonreciprocal light absorption on THz excitations of $Ba_2CoGe_2O_7$. In the canted antiferromagnetic phase, we demonstrate that an electric field can be used to switch between low- and high-absorption states of magnetoelectric excitations. Our finding can facilitate the use of multiferroics in low-power consumption switchable optical diodes.

MA 56.9 Fri 11:30 H39

Manipulating Coercivity and Mangetization Reversal in Bulk Ferromagnetic Metals with Small Voltages — •Xinglong Ye, Robert Kruk, and Horst Hahn — Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, Eggenstein-Leopoldshafen, 76344, Germany

Voltage control of magnetic properties in ferromagnetic metals is usually restricted to the scale of atomic layer due to their strong electric-field screening. Here we show that magnetic properties of bulk ferromagnetic metals can be hugely and reversibly tuned by small voltages through charging and discharging of hydrogen atoms. We manipulated the coercivity of micrometer-sized ferromagnetic metals by an amplitude of 2500 Oe with voltages only around 1 volt. Through this effect voltage-assisted and -gated magnetization reversal have been demonstrated. Experimental and density functional theory simulation results suggest that this phenomenon originates from the change of magnetocrystalline anisotropy at the surface layers with absorption and desorption of hydrogen atoms, which changes the nucleation field of reversed domains. This work may open up a new route for voltage control of magnetic properties in bulk metals, and voltage-assisted magnetization reversal also has implications for magnetic recording.

MA 57: Focus Session: Spins on Surfaces III (joint session O/MA)

Time: Friday 10:30–13:00 Location: H24

Invited Talk MA 57.1 Fri 10:30 H24

Quantum simulation through atomic assembly — •Sander Otte — Delft University of Technology, Delft, The Netherlands

The magnetic and electronic properties of materials often find their origin in basic atomic- scale interactions. Yet, due to the large number of atoms involved, many phenomena can be very difficult to predict: we call these 'emergent'. The ability to build structures atom-by-atom by means of scanning tunneling microscopy (STM) provides an excellent platform to explore emergence as a function of system size. By properly tuning the anisotropy and coupling of magnetic atoms on a thin insulator, we have been able to engineer finite spin chains hosting spin waves [1] as well as the beginnings of a quantum phase transition at a critical magnetic field [2]. In a more recent experiment, we have engineered spin structures that are frustrated by design, exhibiting a spin spiral that can snap between different configurations. Unfortunately, the maximum size of assembled structures is often limited due to e.g. crystal impurity and crystal strain. In this talk, I will present a way to mitigate these limitations and show recent advances in sample preparation that will allow us to build much larger spin structures [3].

[1] A. Spinelli et al., Nature Matererials 13 (2014) 782
[2] R. Toskovic et al., Nature Physics 12 (2016) 656
[3] J. Gobeil et al., Surface Science 679 (2019) 202

MA 57.2 Fri 11:00 H24

Exploring magnetic frustration in atomically engineered closed chains — •Jeremie Gobeil, David Coffey, Shang-Jen Wang, and Alexander F. Otte — Department of Quantum Nanoscience, Kavli Institute of Nanoscience, Delft University of Technology, Delft, The Netherlands

Modelling quantum systems with a large number of degrees of freedom can be a daunting task from a computational standpoint. Scanning Tunneling Microscopy (STM) offers an alternative path by enabling atom-by-atom engineering and probing of such systems. Spin-Polarized STM (SP-STM) can provide direct insight into a system's spin configuration, while at the same time providing a tunable interaction parameter. This enables the study of frustrated spin systems, which pose a particular modelling challenge as they are governed by a delicate balance of competing interactions.

Here we present the study of such a frustrated spin system, consisting in closed chains of single iron atoms assembled on a single nitride layer grown on $Cu_3Au(100)$. As in the similar Cu_2N system, the nitride layer provides a uniaxial framework with different ferromagnetic and antiferromagnetic interatomic couplings depending on the relative position on the lattice. This allows us to assemble closed loop chains with an odd number of antiferromagnetic couplings, leading to frustration. We explore the role of an external magnetic field, interatomic exchange, as well as the exchange interaction with the spin-polarized tip in the stabilization of the resulting spin configuration.

MA 57.3 Fri 11:15 H24

Revealing spin states in Co-salophene chains grown on $GdAu_2$ — •Maciej Bazarnik[1,2], Micha Elsebach[1], Emil Sierda[1,2], Maxim Ilyn[3], Jan Dreiser[4], Jens Brede[3], and Roland Wiesendanger[1] — [1]Department of Physics, University of Hamburg, Jungiusstrasse 11, D-20355 Hamburg, Germany — [2]Institute of Physics, Poznan University of Technology, Piotrowo 3, 60-965 Poznan, Poland — [3]Centro de Física de Materiales, P° Manuel de Lardizabal 5, Donostia - San Sebastián, E-20018 Spain — [4]Swiss Light Source, Paul Scherrer Institut (PSI), CH-5232 Villigen, Switzerland

Lately, a polymerization of well-aligned organic nanowires was presented on a magnetic $GdAu_2$ surface alloy [1]. Apart from growing graphene on, i.e., a Ni surface, this was the first successful approach to a surface catalyzed reaction on a magnetic substrate. Such a ferromagnetic substrate in combination with magnetic molecules offers a very interesting interface for spintronic applications.

Here, we will present the growth behaviour of Co-salophene oligomers on the $GdAu_2$ surface alloy prepared on a Au(111) substrate. By combining spin-polarized scanning tunneling microscopy and X-ray magnetic circular dichroism we have revealed the evolution of the spin-* state residing on the Co-centers of the salophene molecules upon adsorption and thermally activated Ullmann coupling.

[1] M. Abadia et al. ACS Nano, 2017, 11 (12), pp 12392-12401

MA 57.4 Fri 11:30 H24

Noncollinear spin density of an adatom on a magnetic surface — •Soumyajyoti Haldar and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel, 24098, Kiel, Germany

Today, noncollinear spin structures at surfaces and interfaces receive great attention due to potential applications in spintronic devices. In such magnetic structures, the spin direction changes from atom to atom. Besides this inter-atomic noncollinear magnetism, there is also intra-atomic noncollinear magnetism in which the spin direction varies for different orbitals of an atom [1]. It can occur due to spin-orbit coupling or due to a noncollinear spin structure.

Here, we demonstrate that intra-atomic noncollinear magnetism can occur for adatoms on a magnetic surface with a noncollinear spin structure [2]. As an example, we study Co and Ir adatoms on Mn/W(110) using density functional theory. We find that the canted spin structure of the Mn surface layer is encoded into different orbitals of the adatoms. Our conclusions apply in general to adatoms on surfaces with a noncollinear magnetic structure e.g. spin spirals, skyrmions or domain walls and explain recent experimental results of spin-polarized scanning tunneling microscopy experiments [3].

[1] L. Nordström *et al.*, Phys. Rev. Lett. **76**, 4420 (1996)
[2] S. Haldar and S. Heinze, arXiv:1811.00865 (2018)
[3] D. Serrate *et al.*, Phys. Rev. B **93**, 125424 (2016)

MA 57.5 Fri 11:45 H24

Interplay of spin-orbit and exchange interaction in ultrathin Ni films on W(110) — •Pascal Jona Grenz[1], Philipp Eickholt[1], Koji Miyamoto[2], Eike Schwier[2], Taichi Okuda[2], and Markus Donath[1] — [1]Institute of Physics, Westfälische-Wilhelms-Universität Münster, Germany — [2]Hiroshima Synchrotron Radiation Center, Japan

Ferromagnetic adsorbates on W(110) are prototypical systems for studying the influence of spin-orbit and exchange interaction on electronic states. We investigated ultrathin Ni films on W(110) with spin- and angle-resolved photoemission with particular emphasis on (i) the influence of the Ni adsorbates on the Dirac-cone-like surface state of W(110), (ii) the spin dependence of electronic states at the interface between Ni and W, and (iii) the appearance of ferromagnetic order in the Ni overlayer. We will discuss our results in relation to similar systems reported in literature, Fe/W(110) and Co/W(110) [1,2].

[1] K. Honma *et al.*, Phys. Rev. Lett. **115**, 266401 (2015).
[2] P. Moras *et al.*, Phys. Rev. B **91**, 195410 (2015).

MA 57.6 Fri 12:00 H24

Spin-dependent electron reflection at W(110) — •Christoph Angrick[1], Jürgen Braun[2], Hubert Ebert[2], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany — [2]Department Chemie, Ludwig-Maximilians-Universität München, Germany

The knowledge of the occupied, spin-dependent electronic structure of surfaces offers insights into spin phenomena and their possible use in spintronic devices. This knowledge can be obtained by photoemission techniques with subsequent spin-polarization analysis of the photoelectrons. The spin-polarization analysis relies on spin-dependent electron scattering and can be used in single- and multichannel modes [1,2,3,4].

Due to its strong spin-orbit coupling the W(110) surface is a promising candidate for the use as a scattering target in a spin-polarization analyzer. Therefore, the spin-dependent electron reflectivity of the W(110) surface was experimentally investigated for a wide range of incident electron energies and polar angles and compared with calculations. Two possible working points for spin-polarization analysis with a reversed sign in the Sherman function were found. The characteristics of the working points are discussed in view of an implementation in a single- and multichannel spin-polarization analyzer.

[1] Winkelmann *et al.*, Rev. Sci. Instrum. **79**, 083303 (2008).
[2] Okuda *et al.*, Rev. Sci. Instrum. **79**, 123117 (2008).
[3] Kolbe *et al.*, Phys. Rev. Lett. **107**, 207601 (2011).
[4] Tusche *et al.*, Appl. Phys. Lett. **99**, 032505 (2011).

MA 57.7 Fri 12:15 H24

Investigation of superconductivity in spin chains on Re(0001)
— •Lucas Schneider, Manuel Steinbrecher, Levente Rósza, Thore Posske, Jens Wiebe, and Roland Wiesendanger — Department of Physics, Hamburg University, 20355 Hamburg, Germany

Chains of magnetic atoms on high-Z s-wave superconductors can exhibit topological superconductivity and therefore host Majorana bound states at their ends [1, 2]. Most previous experimental work focused on self-assembled systems [3-4] where a change of the composition along the chain is difficult to achieve. In this study, we use the superconducting Re substrate which enables scanning tunneling microscope-tip induced assembly of chains that show indications for topological superconductivity [5]. This technique allows us to perfectly control the geometric properties and chemical composition of the chains. We evaporate different $3d$ transition metal adatoms as building blocks, assemble various linear chains and investigate their in-gap states. In particular, we studied the transition between magnetic and nonmagnetic regions in composite chains.

We acknowledge funding by the ERC via the Advanced Grant ADMIRE (No. 786020).

[1] Klinovaja *et al.*, PRL **111**, 186805 (2013). [2] J. Li *et al.* PRB **90**, 235433 (2014). [3] S. Nadj-Perge *et al.*, Science **346**, 6209 (2014). [4] M. Ruby *et al.*, Nano Letters **17**, 4473, (2017). [5] H. Kim *et al.*, Science Advances **4**, eaar5251 (2018).

MA 57.8 Fri 12:30 H24

Thin film formation and processes in organic diradicals —
•Tobias Junghöfer[1], Nolan Gallagher[2], Andrzej Rajca[2], and Maria Benedetta Casu[1] — [1]Eberhard Karls Universität Tübingen, Institut für Physikalische und Theoretische Chemie, 72076 Tübingen, Germany — [2]Department of Chemistry, University of Nebraska, Lincoln, Nebraska 68588-0304, USA

Organic radical thin films are of great interest for organic electronics such as spin filtering devices, data storage devices, and as quantum bits for quantum computing devices. The investigated diradicals possess two coupled spins with a combined magnetic moment (S = 1) which is of interest for novel applications in spintronics. In our work, we investigate chemically stable diradicals, deposited via organic molecular beam deposition (OMDB) in ultra-high vacuum. For our experiments, we use soft X-ray techniques, such as X-ray photoelectron spectroscopy (XPS) and near-edge X-ray absorption fine structure (NEXAFS) spectroscopy, as well as atomic force microscopy (AFM). We demonstrate that we are able to deposit thin films of intact diradicals. We investigate their film formation properties and stability towards different environments.

MA 57.9 Fri 12:45 H24

Optical and spin-orbit induced spin orientation of photoelectrons in the soft X-ray range —
•Dmitry Vasilyev, Katerina Medjanik, Sergey Babenkov, Martin Ellguth, Gerd Schönhense, and Hans-Joachim Elmers — Institut für Physik, Johannes Gutenberg-Universität, Mainz, Germany

Angular- or k-resolved photoelectron spectroscopy in the soft X-ray range gives access to the bulk electronic structure of materials. Time-of-flight momentum microscopy with parallel spin detection extends this information to the spin degree of freedom. We choose tungsten as a paramagnetic model system in order to exclude any initial-state spin polarization from exchange-split bands. By measurement of four independent photoemission intensities for two opposite spin directions and opposite light helicity, we distinguish between spin polarization contributions of optical spin-orientation by circularly polarized X-rays (Fano component) and a second contribution with polarization direction perpendicular to the scattering plane. The latter phenomenon has been observed for surface states and is usually attributed to the surface-related inversion symmetry breaking. In the case of soft X-ray radiation, only inversion symmetric bulk states of tungsten are probed. Their finite perpendicular spin polarization thus represents a novel phenomenon originating from the spin-dependent interference of final state partial waves.