MA 5: Posters Magnetism II

Topics: Skyrmions (5.1-5.14), Non-Skyrmionic Magnetic Textures (5.15-5.20), Weyl Semimetals (5.21-5.22)

Time: Tuesday 10:00–13:00 Location: P

MA 5.1 Tue 10:00 P

Robust Formation of Nanoscale Magnetic Skyrmions in Easy-Plane Anisotropy Thin Film Multilayers with Low Damping — •Luis Flacke[1,2], Valentin Ahrens[3], Simon Mendisch[3], Lukas Körber[4,5], Tobias Böttcher[6], Elisabeth Meidinger[1,2], Misbah Yaqoob[1,2], Manuel Müller[1,2], Lukas Liensberger[1,2], Attila Kákay[4], Markus Becherer[3], Philipp Pirro[6], Matthias Althammer[1,2], Stephan Geprägs[1], Hans Huebl[1,2,7], Rudolf Gross[1,2,7], and Mathias Weiler[1,2,6] — [1]Walther-Meißner Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physics Department, Technical University of Munich, 85748 Garching, Germany — [3]Department of Electrical and Computer Engineering, Technical University of Munich, 80333 Munich, Germany — [4]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [5]Fakultät Physik, Technische Universität Dresden, 01062 Dresden, Germany — [6]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [7]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany

We investigate magnetic superlattices based on the low-damping and high saturation magnetization binary alloy Co25Fe75. The formation of stable sub-100 nm diameter skyrmions is confirmed and analyzed by magnetic force microscopy within an $K_{\mathrm{eff}} < 0$. The relatively low damping of the superlattice spin dynamics is quantified by broadband ferromagnetic resonance measurements.

MA 5.2 Tue 10:00 P

Exchange- and Dzyaloshinskii-Moriya interactions in magnetic bilayers at surfaces — •Tim Drevelow, Mara Gutzeit, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel, Leibnizstraße 15, 24098 Kiel, Germany

Magnetic skyrmions in synthetic antiferromagnets exhibit favorable transport properties [1], e.g. the absence of the skyrmion Hall effect and have recently been stabilized at room temperature [2]. Here, we investigate synthetic antiferromagnets built from trilayers composed of Co and Fe layers coupled via a Rh spacer layer. *Ab initio* calculations using density functional theory were performed to obtain the strength of the inter- and intralayer exchange and Dzyaloshinskii-Moriya interactions which allows to parametrize an atomistic spin model. We studied freestanding trilayers as well as trilayers on the Ir(111) surface since both Rh/Co and Rh/Fe bilayers have previously been grown on this surface [3,4].

[1] Zhang *et al.* Nat. Com. **7**, 10293 (2016)
[2] Legrand *et al.* Nat. Mat. **19**, 34 (2020)
[3] Romming *et al.* Phys. Rev. Lett. **120**, 207201 (2018)
[4] Meyer *et al.* Nat. Com. **10**, 3823 (2019)

MA 5.3 Tue 10:00 P

The Skyrmion Radius Calculator — •Moritz Sallermann, Bernd Zimmermann, Fabian Lux, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The skyrmion radius is an important quantity for any skyrmion characterisation, motion and device concept. For technological applications – especially as a promising building block for future information technology – it is essential to determine those materials in which skyrmions assume a typical radius of 10 nm or even less.

We studied the energy contributions of the circular domain wall profile [1] in thin, infinite films of magnetic materials, employing the continuous, micromagnetic approximation. Notably, we also include the exact contribution of the magnetostatic interactions and thus go beyond the commonly applied thin-film approximation. We confirm our findings by comparing them with exact micromagnetic calculations that do not depend on any choice of trial functions. We provide an easy to use and fast online tool, the Skyrmion Radius Calculator [2], which computes an approximation to the skyrmion radius in fractions of a second. It is based on the minimization of the energy of the ansatz profile. The agreement with full micromagnetic simulations can be estimated from the resulting profile parameters and is excellent as long as the skyrmions are of domain-wall character.

Acknowledgement: DFG through SPP-2137 & SFB-1238 (project C1).

[1] F. Büttner, I. Lemesh and G.S. Beach, Sci.Rep., 8(1) (2018)
[2] https://juspin.de/skyrmion-radius/

MA 5.4 Tue 10:00 P

Modification of the DMI by He$^+$ ion bombardment characterized by high-resolution optical Kerr microscopy — •Sapida Akhundzada[1], Florian Ott[1], Maxwell Li[2], Tim Mewes[3], Arno Ehresmann[1], Vincent Sokalski[2], and Michael Vogel[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Kassel, Germany — [2]Department of Materials Science and Engineering, Carnegie Mellon University, Pittsburgh, USA — [3]Department of Physics and Astronomy, University of Alabama, Tuscaloosa, USA

The Dzyaloshinkii-Moriya interaction (DMI) is an antisymmetric exchange interaction arising, e.g., from interfaces between ferromagnets and heavy metals with large spin-orbit coupling [1]. The DMI is topologically stabilizing chiral spin-structures like skyrmions which are promising candidates for nonvolatile magnetic memory technologies [2]. It has been recently demonstrated that the DMI can be tuned by bombardment with accelerated ions [3]. While altering the interfaces between the different material layers in total, the sign and magnitude of the DMI can be manipulated [3]. In a systematic study, we modified the DMI by keV He ion bombardment in perpendicularly magnetized ferromagnetic/heavy metal multilayer system. In order to characterize the interfacial DMI, we characterized the field-driven, asymmetric growth of the magnetic domains by high-resolution Kerr microscopy.

[1] T. Moriya, Phys. Rev. Lett. 4, 228 (1960)
[2] A. Fert, V. Cros and J. Sampaio, Nat. Nanotechnol. 8, 152 (2013)
[3] H. T. Nembach, et al., arXiv:2008.06762 (2020)

MA 5.5 Tue 10:00 P

Stability of the skyrmion lattice in $Fe_{1-x}Co_xSi$ — •Carolina Burger[1], Andreas Bauer[1], Alfonso Chacon[1], Marco Halder[1], Jonas Kindervater[1], Sebastian Mühlbauer[2], André Heinemann[2], and Christian Pfleiderer[1] — [1]Physik-Department, Technische Universität München, D-85748 Garching, Germany — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, D-85748 Garching, Germany

We report measurements of the magnetization, susceptibility, and electrical transport on single-crystal $Fe_{1-x}Co_xSi$, complemented by small-angle neutron scattering. In small magnetic fields, this compound hosts a hexagonal lattice of topologically non-trivial skyrmions that may persist metastably down to lowest temperatures when field-cooled. We show that signatures characteristic of the skyrmion lattice survive field values up to the field-polarized regime as well as field inversion. At low temperatures, the Hall effect is dominated by the anomalous contributions, with additional contributions emerging in the vicinity of the magnetic phase transitions hinting towards complex processes associated with the unwinding of the skyrmion lattice.

References: [1] A. Bauer, C. Pfleiderer, and M. Garst, Phys. Rev. B 93 (23), 235144 (2016), [2] A. Bauer, A. Chacon, M. Halder, C. Pfleiderer, Springer Series in Solid-State Sciences 192 (2018), [3] H. Oike, A. Kikkawa, N. Kanazawa, Y. Taguchi, M. Kawasaki, Y. Tokura, and F. Kagawa, Nature Phys. 12, 62 (2016)

MA 5.6 Tue 10:00 P

Topological Hall effect in thin films of noncollinear magnets — •Rebeca Ibarra[1,2], Anastasios Markou[1], Aleksandr Sukhanov[2], Dmytro Inosov[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Technical University Dresden, Germany

Topological spin textures in quantum materials are of great interest, along with the associate transport signatures, for next-generation spintronic applications. Recently, the tetragonal (t) Heusler compounds show to host elliptical skyrmions and antiskyrmions [1], and the hexagonal (h) half-Heusler compound MnPtGa displays noncollinear magnetism [2]. Spin chirality in metallic materials with noncoplanar spin structure gives rise to a Berry phase-induced topological Hall effect. In addition, neutron diffraction is a powerful technique to study the magnetic structure of these chiral materials.

Here, we study the noncollinear spin textures in high-quality epitaxial thin films of the t-Mn_2RhSn and h-MnPtGa compounds. In t-Mn_2RhSn, we observe topological Hall signatures of two distinct chiral spin textures. Interestingly, we show with single-crystal neutron diffraction that the h-MnPtGa undergoes a magnetic phase transition from ferromagnetic to in-plane canted antiferromagnetic. With our thin film method, we can access a novel and fundamental understanding of these compounds not possible with other methods.

[1] J. Jena *et al.*, Nat. Commun. **11**, 1115 (2020).
[2] J. A. Cooley *et al.*, Phys. Rev. Mater. **4**, 044405 (2020).

MA 5.7 Tue 10:00 P

Spin-transfer torque driven motion, deformation, and instabilities of magnetic skyrmions at high currents — •Jan Masell[1], Davi R. Rodrigues[2], and Karin Everschor-Sitte[2] — [1]RIKEN CEMS, Wako, Japan — [2]University of Duisburg-Essen, Duisburg, Germany

Magnetic skyrmions are whirls which are characterized by a topological winding number. They have gained massive attention due to this real-space topological property and other features like possible nanometer size, extraordinary stability, or easy manipulation by electrical currents or other means. Therefore, various proposals emerged how skyrmions might serve as mobile information carriers in future information technology.

When considering skyrmions driven by spin-transfer torque (STT), it is usually assumed that distortions due to the current are small.

We have simulated STT-driven skyrmions with ultra high precision and quantitatively studied the distortion by STT in the entire stability regime up to the ferromagnetic instability. We find analytical expressions for the distortion of skyrmions, which is quadratic in the current, as well as for the STT-induced elliptical instability which destroys the skyrmion. We show numerically that for large enough Gilbert damping, however, stable but distorted "shooting star" skyrmion solutions are possible in regimes even above the elliptical instability. [1]

[1] J. Masell, D. R. Rodrigues, B. F. McKeever & K. Everschor-Sitte, Phys. Rev. B **101**, 214428 (2020)

MA 5.8 Tue 10:00 P

Skyrmion movement in Ta/CoFeB/MgO-trilayers — •Hauke Lars Heyen[1], Jakob Walowski[1], Christian Denker[1], Malte Römer-Stumm[2], Markus Münzenberg[1], and Jeffrey McCord[2] — [1]Institut für Physik, Universität Greifswald, Felix-Hausdorff-Straße 6, 17489 Greifswald, Germany — [2]Christian-Albrechts-Universität zu Kiel, Institute for Materials Science, Nanoscale Magnetic Materials and Magnetic Domains, 24143 Kiel, Germany

Skyrmion manipulation and dynamics control are promising tools for the realization of racetrack memory devices to increase data storage densities.

We use current pulses to experimentally investigate skyrmion dynamics in Ta/CoFeB/MgO-trilayers. Layer thickness control in CoFeB layers in the picometer range generated by very small thickness gradients allows to produce layers exhibiting a transition region from inplane to out-of-plane magnetic anisotropy along the sample. This enables fine adjustment for optimal skyrmion nucleation. Skyrmions are created in the demagnetized CoFeB layer using magnetic field pulses tilted slightly out of the plane direction. Afterwards stabilized by a small out-of-plane field, skyrmion dynamics are generated with microsecond current pulses and recorded by Kerr-microscopy.

By using a specially developed tracking software to follow the motion after each current pulse, we analyze the skyrmion dynamics. The movement shows a Skyrmion-Hall-effect and a superdiffusive distribution. Further the skyrmions seem to get stuck, generated or annihilated at pinning centers.

MA 5.9 Tue 10:00 P

Ab-initio investigation of intrinsic antiferromagnetic skyrmions in magnetic thin films — •Amal Aldarawsheh[1,2], Imara Fernandes[1], Sascha Brinker[1], Moritz Sallersmann[1], Muayyad Abusaa[3], and Samir Lounis[1,2] — [1]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany — [2]Faculty of Physics, University of Duisburg-Essen, 47053 Duisburg, Germany — [3]Physics Department, Arab American University, Jenin, Palestine.

Skyrmions are topologically protected spin textures that are envisioned to be the next generation of bits. However, conventional ferromagnetic (FM) skyrmions are deflected when an electric field is applied, which limits their use in spintronic devices. In contrast, antiferromagnetic (AFM) skyrmions, which consist of two FM solitons coupled antiferromagnitically, are predicted to have zero net magnus force [1], and this makes them promising candidates for spintronic racetrack memories. So far these have been stabilized in synthetic AFM structures [2], i.e. multilayers hosting FM skyrmions, which couple antiferromagnetically through a non-magnetic spacer. Using *ab initio* calculations in conjunction with atomistic spin dynamics, we investigate systematically and predict the presence of chiral intrinsic AFM structures in specific and realistic combination of thin films deposited on heavy substrates.

[1] X. Zhang *et al.* Sci. Rep. **6**, 24795 (2016), [2] Legrand *et al.* Nat. Mat., **19**, 34 (2020). Work funded by the PGSB (BMBF–01DH16027) and Horizon 2020–ERC (CoG 681405–DYNASORE).

MA 5.10 Tue 10:00 P

First-principles study of DMI mechanisms and exchange frustration in Rh/Co/Fe/Ir multilayers — •Felix Nickel, Sebastian Meyer, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel

Magnetic skyrmions are promising for the usage in data storage and logic devices. Materials, which can host small diameter skyrmions in zero magnetic field at room temperature, are suitable for such applications. Recently, it has been shown that ultrathin Rh/Co films on Ir(111) exhibit skyrmions with diameters below 10 nm at zero magnetic field [1]. On the other hand, room temperature skyrmions with diameters of 30 nm - 90 nm have been found in magnetic multilayers [2].The Dzyaloshinskii-Moriya Interaction (DMI), exchange frustration and magnetocrystalline anisotropy are the main characteristics that make materials capable of hosting such complex spin structures. We performed density functional theory calculations for different transition-metal multilayer systems consisting of Co, Fe, Ir and Rh and determined those magnetic interactions to investigate if properties of ultra thin film systems, like in Ref. [1], can be transferred to multilayer systems. We present how the magnetic interactions depend on the structural properties of the multilayer systems. Further we predict multilayers which are very promising for the stabilisation of magnetic skyrmions.

[1] Meyer *et al.*, Nat. Commun. **10**, 3823 (2019)
[2] Moreau-Luchaire *et al.*, Nat. Nanotechnol. **11**, 444 (2016)

MA 5.11 Tue 10:00 P

Skyrmion braids — Fengshan Zheng[1], Filipp N. Rybakov[2], •Nikolai S. Kiselev[3], Dongsheng Song[1,4], András Kovács[1], Haifeng Du[5], Stefan Blügel[3], and Rafal E. Dunin-Borkowski[1] — [1]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Gr\"unberg Institute, Forschungszentrum J\"ulich, 52425 J\"ulich, Germany — [2]Department of Physics, KTH-Royal Institute of Technology, Stockholm, SE-10691 Sweden — [3]Peter Gr\"unberg Institute and Institute for Advanced Simulation, Forschungszentrum J\"ulich and JARA, 52425 J\"ulich, Germany — [4]Institutes of Physical Science and Information Technology, Anhui University, Hefei 230601, China — [5]High Magnetic Field Laboratory, Chinese Academy of Science (CAS), Hefei, Anhui Province 230031, China

Skyrmions are vortex-like spin textures that form strings in magnetic crystals. Due to the analogy to elastic strings, skyrmion strings are naturally expected to braid and form complex three-dimensional patterns, but this phenomenon has not been explored yet. We found that skyrmion strings can form braids in cubic crystals of chiral magnets [1]. Our finding is confirmed by direct observations of skyrmion braids in B20-type FeGe using transmission electron microscopy. The theoretical analysis predicts that the discovered phenomenon is general for a wide family of chiral magnets. These findings have important implications for skyrmionics and propose a solid-state framework for applications of the mathematical theory of braids.

[1] F. Zheng et al., arXiv:2104.01682.

MA 5.12 Tue 10:00 P

Antiskyrmions and sawtooth surface textures in an S4 symmetric magnet — Kosuke Karube[1], Licong Peng[1], •Jan Masell[1], Xiuzhen Yu[1], Fumitaka Kagawa[1,2], Yoshinori Tokura[1,2], and Yasujiro Taguchi[1] — [1]RIKEN CEMS, Wako, Japan — [2]University of Tokyo, Tokyo, Japan

Magnetic skyrmions are vortex-like textures in the magnetization. By now, skyrmions are found in many systems ranging from bulk chiral magnets to thin films and monolayers. Their anti-vortex-like anti-particles, consequently dubbed "antiskyrmions", were theoretically predicted to exist in magnets with D_{2d} or S_4 symmetry [1], but were observed only in a family of D_{2d}-symmetric Heuslers. [2]

We report the first observation of antiskyrmions in a magnet with S_4 symmetry. We prepared Pd-doped Schreibersite which shows a weak uniaxial anisotropy and weak antisymmetric DMI. Thus, domain walls with opposite handedness are stabilized along two orthogonal directions. In thin films, LTEM reveals square-shaped antiskyrmions, elliptical skyrmions, and trivial bubbles, as a consequence of dipolar interactions. For thicker systems, MFM shows that the domain wall textures fractalize with sawtooth patterns. These novel patterns arise from the weak antisymmetric DMI in combination with dominant dipolar interactions, as shown by our micromagnetic simulations. [3]

[1] A.N. Bogdanov & D.A. Yablonskii, JETP **68,** 101-103 (1989)
[2] A.K. Nayak *et al.*, Nature **548,** 561-566 (2017)
[3] K. Karube, L.C. Peng, J. Masell, *et al.*, Nature Materials **20,** 335-340 (2021)

MA 5.13 Tue 10:00 P

Real-Space Observation of Topological Defects in Extended Skyrmion-Strings — •Jan Masell[1], Xiuzhen Yu[1], Fehmi S. Yasin[1], Kosuke Karube[1], Naoya Kanazawa[2], Kiyomi Nakajima[1], Takuro Nagai[3], Koji Kimoto[3], Wataru Koshibae[1], Yasujiro Taguchi[1], Naoto Nagaosa[1,2], and Yoshinori Tokura[1,2] — [1]RIKEN CEMS, Wako, Japan — [2]University of Tokyo, Tokyo, Japan — [3]National Institute for Materials Science, Tsukuba, Japan

Skyrmions are whirls in the magnetization which are characterized by a 2d topological winding number. Due to their topology, large skyrmions are protected by a high energy barrier [1] which makes them interesting objects for potential future applications. However, in 3d bulk materials or thin films, skyrmions are strings (SkS) which can have singular topological defects [2], known as Bloch points.

We use Lorentz Transmission Microscopy (LTEM) on thin films of chiral magnets to obtain a sideview of SkS that extend in the film plane. We obtain high resolution images of various defects, including Bloch points which terminate SkS or fuse them, but also SkS which annihilate smoothly by escaping through the surface. These objects can be discerned by comparing them to the results of micromagnetic simulations. [3]

[1] B. Heil, A. Rosch & J. Masell, Phys. Rev. B **100,** 134424 (2019)
[2] P. Milde *et al.*, Science **340**, 1076-1080 (2013)
[3] X.Z. Yu*, J. Masell* *et al.*, Nano Lett. **20,** 7313-7320 (2020)

MA 5.14 Tue 10:00 P

Mode following method for magnetic systems — •Stephan von Malottki[1,2], Moritz A. Goerzen[2], Hendrik Schrautzer[1,2], Pavel F. Bessarab[1], and Stefan Heinze[2] — [1]Science Institute, University of Iceland, Reykjavík — [2]ITAP, University of Kiel, Germany

The average lifetime of metastable magnetic states is commonly determined by harmonic transition state theory (HTST) [1] or the related Langer's theory [2], resulting in an Arrhenius-law depending on the thermal energy, the energy barrier and the pre-exponential factor. The latter contains information about the dynamics and entropic effects of the transition and is often challenging to obtain. In the past, the application of HTST calculations to magnetic skyrmions has been limited to cases in which the harmonic and zero-mode approximations are justified [1-3]. Other cases, such as the collapse of magnetic skyrmions via the chimera transition [2-4] or the collapse of antiskyrmions [4] were not always accessible. Here, we present a numerical method to evaluate the entropic contribution of individual Eigenmodes beyond the harmonic approximation. With this method, not only the quality of the harmonic and zero-mode approximations can be evaluated, but also the direct numerical calculation of the entropic contributions becomes feasible, which allows access to intermediate temperature regimes that could not be treated with conventional HTST.

[1] P. Bessarab *et al.* Sci. Rep. **8**, 3433 (2018) [2] L. Desplat *et al.* PRB **99**, 174409 (2019) [3] F. Muckel *et al.* Nat. Phys. **17**, 395-402 (2021) [4] S. Meyer *et al.* Nat. Commun. **10** 3823, (2019)

MA 5.15 Tue 10:00 P

Single-Crystal Growth and Low-Temperature Properties of Er_2 — •Christoph Resch[1], Georg Benka[1,2], Andreas Bauer[1], and Christian Pfleiderer[1] — [1]Physik Department E51, Technische Universität München, 85748 Garching, Germany — [2]Kiutra GmbH Rupert-Mayer-Str. 4481379 Munich, Germany

Single crystals of the hexagonal rare-earth diboride ErB_2 were synthesized by means of the self-adjusted flux travelling solvent optical floating zone technique. The magnetic phase diagram was inferred from measurements of the magnetization and the ac susceptibility as a function of magnetic field and temperature for fields up to 14 T applied along major crystallographic axes. We find behavior characteristic of a hard-axis-easy-plane antiferromagnet. Magnetoresistivity and hall effect measurements up to 20 T exhibit a field dependence that may not be accounted for by standard normal and anomalous contributions, suggesting non-collinear antiferromagnetic order as potential origin.

MA 5.16 Tue 10:00 P

Topological-chiral magnetic interactions in ultrathin films at surfaces — •Soumyajyoti Haldar[1], Sebastian Meyer[2], André Kubetzka[3], and Stefan Heinze[1] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel, Leibnizstr. 15, 24098 Kiel, Germany — [2]Nanomat/Q-mat/CESAM, Université de Liège, B-4000 Sart Tilman, Belgium — [3]Department of Physics, University of Hamburg, 20355 Hamburg, Germany

Non-collinear spin structures are of fundamental interest in magnetism since they allow to obtain insight into the underlying microscopic interactions and are promising for spintronic applications [1,2]. Here, we demonstrate that recently proposed topological-chiral magnetic interactions [3] can play a key role for magnetic ground states in ultrathin films at surfaces [4]. Based on density functional theory we show that significant chiral-chiral interactions occur in hexagonal Mn monolayers due to large topological orbital moments which interact with the emergent magnetic field. Due to the competition with higher-order exchange interactions superposition states of spin spirals such as the 2Q state or a distorted 3Q state can arise. Simulations of spin-polarized scanning tunneling microscopy images suggest that the distorted 3Q state could be the magnetic ground state of a Mn monolayer on Re(0001).

[1] A. Fert *et al.*, Nat. Rev. Mater. **2**, 17031 (2017). [2] J. Grollier *et al.*, Nat. Electron. **3**, 360 (2020). [3] S. Grytsiuk *et al.*, Nat. Commun. **11**, 511 (2020). [4] S. Haldar *et al.*, arXiv:2106.08622 (2021).

MA 5.17 Tue 10:00 P

Creation of reconfigurable stray field landscapes in synthetic antiferromagnets via focused ion beam irradiation — •Fabian Samad[1,2], Gregor Hlawacek[1], Sri Sai Phani Kanth Arekapudi[2], Xiaomo Xu[1], Leopold Koch[2], Miriam Lenz[1], and Olav Hellwig[1,2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Institute of Physics, Chemnitz University of Technology, Chemnitz, Germany

Synthetic antiferromagnets (SAFs) with perpendicular magnetic anisotropy (PMA) can exhibit different magnetic phases depending on the magnetic history and energy balance [1]. By using focused He^+ ion beam (FIB) irradiation, the antiferromagnetic (AF) interlayer exchange coupling (IEC) and PMA can be reduced on a lateral (sub-)micron scale, such that different magnetic textures can be "written" with FIB [2,3]. Due to the depth-dependent ion damage, AF domains are stabilized at low fluences, typically around 10 ions/nm^2. When using a fluence gradient, the AF domains can be further manipulated in a directional fashion by applying external magnetic fields. Thus, a well-defined and reconfigurable stray field landscape is created, which can act on a suitable functional overlayer, such as a spin wave conducting or superconducting layer.

[1] Hellwig et al., J. Magn. Magn. Mater. 319, 13 (2007)
[2] Koch et al., Phys. Rev. Applied 13, 024029 (2020)
[3] Samad et al., Appl. Phys. Lett. 119 (2021)

MA 5.18 Tue 10:00 P

Ab initio exploration of hopfion hosting magnets — •Imara Lima Fernandes, Roman Kováčik, and Stefan Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, D-52425 Jülich, Germany

Topological magnetic textures are currently of great interest in condensed matter physics due to their rich science and potential applications in information technology. In contrast to two-dimensional magnetic skyrmions, which are currently under intense scrutiny both theoretically and experimentally, their three-dimensional (3D) counterpart, known as Hopfions, were only recently observed experimentally [1]. Hopfions are stable solutions of the magnetization field with a knotted topological structure. In particular, their simplest spin texture can be described as a closed torus with a topologically nontrivial spin texture in the cross-section profile.

In the current work, using *ab initio* calculations, we explore suitable classes of materials to host magnetic hopfions based on analytical conditions of Heisenberg exchange parameters derived in Ref. [2]. We address systematically the case of chemical disorder and temperature in order to approach the optimal magnetic parameter field. The present study may give a guidance to identify suitable materials.

– Funding is provided by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant 856538 – 3D MAGiC).

[1] Kent, N. *et al*, Nat. Commun. **12**, 1562 (2021).
[2] Rybakov, F. N. *et al*, arXiv:1904.00250

MA 5.19 Tue 10:00 P

Combing the helical phase of chiral magnets with electric currents — •Jan Masell[1], Xiuzhen Yu[1], Naoya Kanazawa[2], Yoshinori Tokura[1,2], and Naoto Nagaosa[1,2] — [1]RIKEN CEMS, Wako, Japan — [2]University of Tokyo, Tokyo, Japan

In chiral magnets, the competition between the ferromagnetic exchange interaction and the small Dzyaloshinskii-Moriya interaction can form long-ranged helical modulations as the ground state. This helical phase has been extensively studied and chiral magnets gained extra attention when the skyrmion lattice was discovered in the chiral magnet MnSi a decade ago. However, in contrast to particle-like skyrmions, the helical phase seemed useless for spintronic applications as it is strongly pinned and hard to manipulate.

We have recently managed to unpin the helical phase in thin films of the chiral magnet FeGe by using electrical currents. Our theoretical analytical and numerical analysis predicts that the unpinned helical phase shows a variety of interesting dynamical phenomena, including distinct reorientation processes which can be driven by defects deep in the bulk or by the edge of the material, and predict numerous instabilities. Our results pave the way for "helitronics" and potential application in memory devices or unconventional computing.

[1] J. Masell, X.Z. Yu, N. Kanazawa, Y. Tokura & N. Nagaosa, Phys. Rev. B **102,** 180402(R) (2020)

MA 5.20 Tue 10:00 P

Magnetic ordering in $CePdAl_3$ and $CePtAl_3$ — •Michal Stekiel[1], Petr Cermak[4,5], Wolfgang Simeth[1,2], Martin Meven[4,3], Christian Franz[1,4], Stefan Weber[1], Rudolf Schönmann[1], Vivek Kumar[1], Kirill Nemkovskiy[4], Hao Deng[4,3], Andreas Bauer[1], Christian Pfleiderer[1], and Astrid Schneidewind[4] — [1]Technische Universität München, Garching, Germany — [2]Paul-Scherrer-Institut, Villigen, Switzerland — [3]RWTH Aachen at MLZ, Garching, Germany — [4]JCNS at MLZ, Garching, Germany — [5]Charles University, Praha, Czech Republic

In cerium-based intermetallic compounds the interplay of localized 4f electrons with itinerant d electrons may result in a wide range of magnetic and electronic ordering phenomena. Here, we report a comprehensive neutron diffraction study on single crystals of the noncentrosymmetric compounds $CePdAl_3$, crystallizing in the orthorhombic space group $Cmc2_1$, and $CePtAl_3$, crystallizing in the tetragonal space group $I4/mmm$. In $CePdAl_3$, a collinear antiferromagnetic structure is observed below $T_N = 5.3$ K with an ordered moment of 1.64 μ_B/Ce pointing along the a direction. In $CePtAl_3$, an amplitude-modulated cycloidal structure with an ordering vector $(\frac{2}{3}00)$ emerges below $T_N = 3.2$ K. A symmetry analysis and its connection to the magnetic structures of measured compounds will be presented.

MA 5.21 Tue 10:00 P

Spin and orbital texture of the Weyl semimetal $MoTe_2$ studied by spin-resolved momentum microscopy — •Kenta Hagiwara[1], Xin Liang Tan[1], Philipp Rüssmann[1], Ying-Jiun Chen[1,2], Koji Fukushima[3], Keiji Ueno[3], Vitaliy Feyer[1], Shigemasa Suga[1,4], Stefan Blügel[1], Claus M. Schneider[1,2], and Christian Tusche[1,2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich — [2]Fakultät für Physik, Universität Duisburg-Essen, 47057 Duisburg — [3]Saitama University, 338-8570, Saitama, Japan — [4]Osaka University, 567-0047, Osaka, Japan

Weyl semimetals host chiral fermions in solids as a pair of nondegenerate linear dispersions with band crossing points in their bulk electronic structure. These Weyl points are protected by topology, forming a Fermi arc, which is a connection between a pair of Weyl points with opposite chirality at the surface. Momentum microscopy provides two dimensional photoelectron maps of the in-plane crystal momentum over the whole Brillouin zone, simultaneously. Together with an imaging spin filter, we have revealed the spin-resolved electronic structure of the type-II Weyl semimetal $1T_d$ $MoTe_2$ in the full Brillouin zone. Supported by first-principles calculations, we clarified the spin texture and the orbital texture of the Weyl cones, which reflect the chirality of the Weyl points. We give evidence that a pair of Weyl cones exhibits a strong circular dichroism with reversed sign, indicating the different charge of the respective Weyl points in the Fermi surface.

MA 5.22 Tue 10:00 P

Giant anomalous Hall and Nernst eff ect in magnetic cubic Heusler compounds — •Jonathan Noky[1], Yang Zhang[2], Claudia Felser[1], and Yan Sun[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Massachusetts Institute of Technology, Cambridge, USA

There is an ongoing search for materials with large anomalous Hall and Nernst effects. These effects can be utilized in applications for data storage, thermoelectric power generation, and a high temperature quantum anomalous Hall effect, when preparing them as thin films. A promising class of materials for this purpose are the Heusler compounds because they can be grown in thin films and have a high Curie temperature. In these systems, the interplay between magnetism and topological band structures leads to a strongly enhanced Berry curvature. This can consequently create large anomalous Hall and Nernst effects.

In this work, we provide a comprehensive study of the intrinsic anomalous transport properties for magnetic cubic full Heusler compounds and we illustrate that several Heusler compounds outperform the best so far reported materials. Additionally, the results reveal the general importance of mirror planes in combination with magnetism for giant anomalous Hall and Nernst effects, which should be valid for all linear responses (spin Hall effect, spin orbital torque, etc.) dominated by intrinsic contributions.