MA 12: Skyrmions II

Time: Tuesday 9:30–11:30 Location: HSZ 02

MA 12.1 Tue 9:30 HSZ 02

Coexistence of distinct skyrmionic spin textures — •Börge Göbel[1], Jagannath Jena[2], Stuart Parkin[2], and Ingrid Mertig[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle

The field of skyrmionics has attracted great research interest, as skyrmions – whirl-like nano-objects – are very stable which makes them potential carriers of information in future data storage devices. However, their integer topological charge causes two shortcomings of skyrmion-based racetrack storages: The skyrmions do not move parallel to a current and multiple skyrmions attract and repell each other.

In this talk, I present several alternative nano-objects that go beyond conventional skyrmions [1]. We discuss via simulations, Lorentz transmission electron microscopy measurements [2,3] and Hall transport measurements [4] that skyrmions, antiskyrmion and topologically trivial bubbles [5] can coexist. They can even appear fractionally near the sample's edges [6]. The interplay of Dzyaloshinskii-Moriya and dipolar interactions leads to interesting coexistence and deformation phenomena that may even be utilized for neuromorphic applications.

[1] BG et al. Physics Reports 895, 1-28 (2021), [2] Jena, BG et al. Nat. Com. 11, 1115 (2020), [3] Jena, BG et al. Science Advances 6, eabc0723 (2020), [4] Sivakumar, BG et al. ACS Nano 14, 13463 (2020), [5] BG et al. PRAppl. 15, 064052 (2021), [6] Jena, BG et al. Nat. Com 13, 2348 (2022) [7] Ribeiro de Assis, Mertig, BG arXiv: 2209.11017

MA 12.2 Tue 9:45 HSZ 02

Magnetic Néel Domain Walls and Skyrmions in La0.7Sr0.3Mn1-xRuxO3 Multilayers — •Arsha Thampi[1], Jörg Schöpf[2], Daniel Wolf[1], Ionela Lindfors-Vrejoiu[2], and Axel Lubk[1,3] — [1]Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [2]Physics Institute, University of Cologne, 50937 Cologne, Germany — [3]Institute of Solid State and Materials Physics, TU Dresden, 01069 Dresden, Germany

Magnetic domain walls (DWs) in ferromagnetic thin films exhibit a rich variety of configurations and corresponding dynamic properties depending on parameters like film thickness, defect density, magnetocrystalline anisotropy, exchange stiffness, and Dzyaloshinskii*Moriya interaction (DMI). Here, we study epitaxial ferromagnetic multilayer devices of La0.7Sr0.3Mn1-xRuxO3, consisting 8 nm thick manganite layers with varying Ru/Mn content, in order to engineer symmetric and antisymmetric exchange interaction and magnetic anisotropy across the multilayer stack. We particularly map the DW states as a function of temperature and external out-of-plane magnetic fields employing high-resolution magnetic imaging in the Transmission Electron Microscopy (TEM). Lorentz TEM and transport of intensity phase reconstruction is used to characterize the magnetic domains and DWs formed as a function of temperature and perpendicular magnetic field strength. High-resolution magnetic field mapping of La0.7Sr0.3Mn1-xRuxO3 multilayer system demonstrates the possibility to engineer chiral Néel domain walls and skyrmions.

MA 12.3 Tue 10:00 HSZ 02

In-situ correlation of the anomalous Hall effect with the occurence of topological and non-topological magnetic phases in $Mn_{1.4}PtSn$ — •Darius Pohl[1], Andy Thomas[2], Sebastian Schneider[1], Dominik Krieger[3], Yejin Lee[2], Praveen Vir[4], Claudia Felser[4], Moritz Winter[1,4], and Bernd Rellinghaus[1] — [1]Dresden Center for Nanoanalysis (DCN), cfaed, TU Dresden, D-01062 Dresden, Germany — [2]Leibniz Institute for Solid State and Materials Research Dresden, D-01062 Dresden, Germany — [3]Institute of Solid State and Materials Physics, TU Dresden, D-01062 Dresden, Germany — [4]Max Planck Institute for Chemical Physics of Solids, D-01187 Dresden, Germany

Topologically protected (anti-)skyrmions are potential future information carriers, since they can be electrically manipulated and detected, e.g., by measuring their Hall signature. Hall measurements are usually conducted on samples with different geometries as compared to those used for Lorentz TEM magnetic imaging. In magnetic phases which are strongly influenced by dipole-dipole interactions, such comparisons are problematic. We devised an experimental setup that bridges this gap and allows for the conduction of in-situ Hall measurements in a TEM. Besides proof-of-principle experiments on thin Ni films, our new setup allows us to follow in detail the field dependence of the Hall voltage while simultaneously monitoring the magnetic phases in $Mn_{1.4}PtSn$. This provides valuable insights into the existence and nature of an intensely debated electrical signature of skyrmionics structures. Financial support by DFG through SPP 2137 is gratefully acknowledged.

MA 12.4 Tue 10:15 HSZ 02

Room temperature stabilization of skyrmionic spin textures in synthetic antiferromagnets — •Mona Bhukta, Takaaki Dohi, M-A. Syskaki, Robert Frömter, and Mathias Kläui — Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Magnetic skyrmions [1] are twisted spin configurations, which show a non-zero skyrmion Hall angle when driven by current due to their topological nature[2], which is detrimental for applications. Skyrmions in synthetic antiferromagnet(SAFs), suppress this effect owing to an overall zero topological charge. Recent observations of skyrmions in SAFs have opened the possibility for using skyrmions as a candidate for logic operations in data storage devices [3]. Here, we investigate different, more exotic spin textures beyond skyrmions in a SAF consisting of CoFeB/Ir/CoFeB multilayers by using scanning electron microscopy with polarization analysis (SEMPA). The surface sensitivity of SEMPA is especially effective on SAFs enabling us to investigate the topological spin textures even in a fully compensated composition. We report merons and antimerons in the SAF that are stable at zero magnetic fields and room temperature. Micromagnetic simulations of the investigated SAF stacks have been carried out to understand the way of stabilization of these exotic spin textures as well as to explore the possible emergence of three-dimensional (3D) spin structures in the SAF multilayer system. [1] K. Everschor-Sitte et al., J. Appl. Phys. 124, 240901 (2018). [2] K. Litzius et al., Nat. Phys. 13, 170 (2017). [3] T. Dohi et al, Nat. Commun. 10, 5153 (2019)

MA 12.5 Tue 10:30 HSZ 02

Evidence for Chiral Soliton Lattice formation in the Antiskyrmion compound $Mn_{1.4}PtSn$ — •M. Winter[1,2,3], M. Rahn[4], D. Wolf[3], S. Schneider[2], M. Valvidares[5], C. Shekar[1], P. Vir[1], B. Achinuq[6], H. Popescu[7], T. Helm[8], G. van der Laan[9], T. Hesjedal[6], B. Rellinghaus[2], and C. Felser[1] — [1]MPI CPfS, Dresden, Germany — [2]DCN, TU Dresden, Germany — [3]IFW, Dresden, Germany — [4]IFMP, TU Dresden, Germany — [5]ALBA Synchrotron, Barcelona, Spain — [6]Clarendon Laboratory, University of Oxford, UK — [7]Synchrotron SOLEIL, Saint-Aubin, France — [8]HZDR,Dresden,Germany — [9]Diamond Light Source, Didcot, UK

The Antiskyrmion (aSks) compound $Mn_{1.4}PtSn$ has a rich magnetic phase diagram that strongly depends on strength and orientation of an external magnetic field as well as on the history of its application. We conducted combined experiments of resonant elastic x-ray scattering (REXS) and Lorentz transmission electron microscopy (LTEM) on an identical lamella of Mn1.4PtSn. Our complementary approach allows for an unambiguous correlation of the real space magnetic textures in Mn1.4PtS, i.e., helices, non-topological (NT) bubbles and aSks as determined by LTEM and transitions between them with their corresponding k space scattering patterns obtained by REXS. The octupole vector magnet of the REXS setup enabled us to gain extended information on the dependence of the phase diagram of $Mn_{1.4}PtSn$ on the direction of the external field, revealing the interplay of chiral soliton lattices, NT bubbles, the conical phase and aSks. Part of this work is gratefully supported by DFG within SPP 2137.

MA 12.6 Tue 10:45 HSZ 02

Spin dynamics of skyrmion lattices in a chiral magnet resolved by micro-focused Brillouin light scattering — Ping Che[1], •Riccardo Ciola[2], Markus Garst[2], Volodymyr Kravchuk[2], Arnaud Magrez[1], Helmuth Berger[1], Thomas Schönenberger[1], Henrik M. Rønnow[1], and Dirk Grundler[1] — [1]École Polytechnique Fédérale de Lausanne, Switzerland — [2]Karlsruhe Institute of Technology, Germany

Chiral magnets provide an innovative framework to study non-collinear spin textures and their associated magnetization dynamics. They include helical and conical magnetic textures that are spatially modulated with a wavevector k_h as well as the topologically non-trivial skyrmion lattice (SkL) phase. So far, different techniques have been used to probe the magnetization dynamics of the latter SkL phase in the small wavevectors limit, $k \ll k_h$, as well as for $k > k_h$. Here, we show that Brillouin light scattering (BLS) is ideally suited to probe the complementary range of wavevectors $k \lesssim k_h$. We analysed bulk spin waves in the SkL phase of Cu_2OSeO_3. We provide parameter-free predictions for the BLS cross section and compute both the resonances and their spectral weights. The theoretical results are compared to a BLS experiment in the backscattering geometry that probe magnons with a wavevector $k = 48 rad/\mu m < k_h = 105 rad/\mu m$. The clockwise, counterclockwise and breathing modes are clearly resolved. Due to the finite wavevector of the magnon excitations, finite spectral weight is theoretically predicted also for other resonances. Experimentally, at least one additional resonance is clearly identified.

MA 12.7 Tue 11:00 HSZ 02

Modelling thermal transport in spiral magnets — •Margherita Parodi[1,2] and Sergey Artyukhin[2] — [1]University of Genova, Italy — [2]Italian Institute of Technology, Genova, Italy

Magnetic memory and logic devices, including prospective ones based on skyrmions, inevitably produce heat. Thus, controlling heat flow is essential for their performance. Here we study magnon contribution to thermal conductivity in the most basic non-collinear magnet with a spin spiral ground state. Non-collinearity leads to anharmonic terms, resulting in magnon fusion and decay processes. These processes determine the magnon lifetime which can be used to estimate thermal conductivity in single mode approximation. However, by solving the full Boltzmann equation numerically, we find much higher thermal conductivity. This signifies that heat is carried not by individual magnons but by their linear combinations, called relaxons. The thermal conductivity is found to be increasing with the diminishing twist angle, consistent with recent experiments. The results pave the path to understanding magnetic thermal transport in other non-collinear magnets.

MA 12.8 Tue 11:15 HSZ 02

Enhanced Skyrmion Diffusion by Periodic Excitation — •Raphael Gruber, Maarten Brems, Jan Rothörl, Tobias Sparmann, Fabian Kammerbauer, Iryna Kononenko, Maria-Andromachi Syskaki, Peter Virnau, and Mathias Kläui — Institut für Physik, Johannes-Gutenberg Universität Mainz, 55099 Mainz, Germany

Magnetic skyrmions are chiral, quasi-particle spin structures that are considered as promising candidates for data storage, logic and non-conventional computing devices. When thermal excitation of the spins overcomes the variations in the energy landscape of a sample, skyrmions exhibit thermal motion as recently reported [1]. For non-conventional computing, diffusion is essential and its speed is key. Although pinning slows down diffusion, a finite effect of pinning is even required in order to ensure the system's complexity and non-linearity for non-conventional computing [2]. Using magneto-optical Kerr microscopy, we demonstrate that we can drastically increase the diffusion coefficient of micrometer-sized skyrmions in magnetic thin films by excitation with oscillating magnetic fields. The faster motion is traced back to a reduction of the effective pinning since the skyrmion pinning is strongly size-dependent [3]. Our findings thus pave the way to a significant increase of both performance and reliability of skyrmion devices, especially in non-conventional computing.

[1] Zázvorka, et al. Nat. Nanotechnol. 14, 658-661 (2019) [2] Raab et al. Nat Commun 13, 6982 (2022). [3] Gruber et al. Nat Commun 13, 3144 (2022).