MA 55: Non-Skyrmionic Magnetic Textures

Time: Thursday 15:00–17:15 Location: POT 6

MA 55.1 Thu 15:00 POT 6

Hall effects in non-collinear kagome antiferromagnets. — •Oliver Busch[1], Börge Göbel[1,2], and Ingrid Mertig[1] — [1]Institut für Physik, Martin-Luther-Universität, D-06120 Halle — [2]Max-Planck-Institut für Materialforschung, D-06120 Halle

By the end of the 19^{th} century E. Hall discovered the anomalous Hall effect that usually occurs in metals in the ferromagnetic phase. The transversal electric conductivity exists without an external magnetic field and often scales with the magnetization.

In non-collinear antiferromagnets that do not have a net magnetization an anomalous Hall effect has been predicted as well and it has been measured in Mn_3Sn recently [1,2]. Furthermore it has been shown that in such materials the spin-Hall effect can exist even without spin-orbit coupling.

We examine a 2D kagome lattice considering a double-exchange *s*-*d*-tight-binding model. Our Hamiltonian includes the interaction of *s* electrons with non-collinear magnetic moments of a magnetic texture and spin-orbit coupling. Based on this we apply Kubo formalism to calculate the intrinsic contribution to the anomalous and spin-Hall conductivities. Furthermore we vary the magnetic moments' in-plane and out-of-plane orientation and show the impact on both Hall conductivities.

[1] A.H. MacDonald *et al.*, Phys. Rev. Lett., **112**, 017205 (2014)
[2] S. Nakatsuji *et al.*, Nature, **527**, 212-215 (2015)

MA 55.2 Thu 15:15 POT 6

Topological Hall signatures of electrons in magnetic hopfions — •Börge Göbel[1,2], Collins Akosa[3,4], Gen Tatara[3,5], and Ingrid Mertig[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle (Saale), Germany — [3]RIKEN Center for Emergent Matter Science (CEMS), Hirosawa, Wako, Saitama, Japan — [4]Department of Theoretical and Applied Physics, African University of Science and Technology (AUST), Galadimawa, Abuja F.C.T, Nigeria — [5]RIKEN Center for Pioneering Research (CPR), Hirosawa, Wako, Saitama, Japan

Magnetic hopfions are topologically protected three-dimensional solitons that are constituted by a tube which exhibits a topologically non-trivial spin texture in the cross-section profile and is closed to a torus. We show that the topological Hall effect of electrons in such spin textures vanishes on the global level. However, in a local measurement, where the hopfion is located asymmetrically between two leads, a purely topological Hall signature arises due to the locally uncompensated emergent field. This fundamental effect can be exploited to electrically detect hopfions in experiments and to distinguish them from skyrmion tubes. Furthermore, it can potentially be utilized in spintronic devices. We propose a hopfion-based racetrack storage device and discuss switching of currents by tilting the stabilizing magnetic field.

MA 55.3 Thu 15:30 POT 6

Manipulation of the helical phase of chiral magnets with spin-transfer torque — •Jan Masell and Naoto Nagaosa — Center for Emergent Matter Science RIKEN, Wako, Saitama, Japan

The small Dzyaloshinskii-Moriya interaction in chiral magnets can lead to long-range modulations of the magnetization which can stabilize skyrmion lattices or a helical phase. While skyrmion lattices are well-known to be highly mobile and manipulable by electric currents, the helical phase is often strongly pinned. In thin films of chiral magnets, however, the current density can be large enough to depin the helix. We study the dynamics of the helical phase under spin transfer torques by combining analytics and numerical simulations of the micromagnetic model, and reveal how a reorientation of the helical phase can be achieved and exploited for memory devices.

MA 55.4 Thu 15:45 POT 6

Non-local symmetry breaking effects, induced by magnetostatics in curvilinear ferromagnetic shells — Denis D. Sheka[1], •Oleksandr V. Pylypovskyi[1,2], Pedro Landeros[3], Yuri Gaididei[4], Attila Kákay[2], and Denys Makarov[2] — [1]Taras Shevchenko National University of Kyiv, Kyiv, Ukraine — [2]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [3]Universidad Técnica Federico Santa María, Avenida España Valparaíso, Chile — [4]Institute for Theoretical Physics, Kyiv, Ukraine

We present a micromagnetic theory of curvilinear ferromagnetic shells [1]. We show the appearance of new chiral effects, originating from the magnetostatic interaction. They manifest themselves even in statics and are essentially nonlocal. This is in contrast to conventional Dzyaloshinskii–Moriya interaction (material intrinsic or curvature-induced, stemming from the exchange). The physical origin is in a non-zero mean curvature of a shell and non-equivalence between the top and bottom surfaces of the shell. To describe the new effects, we split a conventional volume magnetostatic charge into two terms: (i) magnetostatic charge, governed by the tangent to the sample's surface, and (ii) geometrical charge, given by the normal component of magnetization and the mean curvature. We classify the interplay between the symmetry of the shell, its local curvature and magnetic textures and apply the proposed formalism to analyse magnetic textures in corrugated shells with perpendicular anisotropy.

[1] D. D. Sheka et al. arXiv:1904.02641

15 min. break.

MA 55.5 Thu 16:15 POT 6

Magnetic Domain States in Synthetic Antiferromagnets with Perpendicular Magnetic Anisotropy — •Ruslan Salikhov[1], Fabian Samad[1], Benny Böhm[2], and Olav Hellwig[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Chemnitz University of Technology, Chemnitz, Germany

Magnetic multilayers (MLs) with perpendicular magnetic anisotropy (PMA), such as Co/Pt or Co/Pd, are the host materials for a variety of magnetic domain structures, e.g. aligned or labyrinth stripe domains, bubble domains and their mixtures [1]. Interleaving the Co/Pt (or Co/Pd) blocks by Ru or Ir layers tuned to promote antiferromagnetic (AF) interlayer coupling between adjacent PMA ML blocks, results in synthetic antiferromagnets (SAFs) with PMA [2]. The AF interlayer exchange energy alters the typical energy balance and is the source of newly evolving metamagnetic domain states in the corresponding magnetic-phase diagram [3]. Here we demonstrate the stabilisation of metamagnetic bubble domains in the $[Co/Pt]_8Co/Ru_{18}$ SAFs at zero fields and ambient temperature.

[1] K. Chesnel, et al., Phys. Rev. B 98 224404 (2018) [2] O. Hellwig, et al., JMMM 319, 13-55 (2007) [3] N. S. Kiselev, et al., Phys. Rev. B 81, 054409 (2010)

MA 55.6 Thu 16:30 POT 6

Domain formation and domain wall motion in synthetic antiferromagnets controlled by focused ion beam irradiation — •Fabian Samad[1,2], Leopold Koch[2], Gregor Hlawacek[1], Sri Sai Phani Kanth Arekapudi[2], Miriam Lenz[1], and Olav Hellwig[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Chemnitz University of Technology, Chemnitz, Germany

By tuning the energy landscape of layered synthetic antiferromagnets (SAFs) with perpendicular anisotropy, a great variety of magnetic phases can be stabilized, as was shown previously by changing the layer thicknesses and repetition numbers [1]. Here, in contrast, we use focused He+ ion beam irradiation in order to controllably and locally change the energy balance, giving rise to laterally coexisting magnetic textures. Using intermediate He+ ion fluences, we achieve a phase transition to ferromagnetic stripe domains. For low He+ ion fluences, an antiferromagnetic (AF) remanent domain is nucleated, stabilized with an inverse magnetization structure as compared to the naturally preferred non-irradiated AF remanent state, thus allowing us to write well defined AF domains on the nanoscale into our SAF system. When exposed to an external out-of-plane magnetic field, structures irradiated with a fluence gradient exhibit a continuous domain annihilation from the high to the low fluence region. This could be utilized for engineering a controllable and local stray field landscape within the stray field free environment provided by the as prepared SAF ground state. [1] Hellwig et al., J. Magn. Magn. Mater. 319, 13-55 (2007).

MA 55.7 Thu 16:45 POT 6

Few-nm tracking of vortex orbits in the presence of disorder

using Ultrafast Lorentz Microscopy — •Marcel Möller, John H. Gaida, Sascha Schäfer und Claus Ropers — 4th Physical Institut, Goettingen, Germany

Static Lorentz Transmission Electron Microscopy presents itself as a viable method for the mapping of nanoscale magnetic textures, offering a resolution down to one nanometer. In this contribution, we demonstrate its adaptation to time-resolved imaging, offering fascinating prospects for studying ultrafast magnetization dynamics. The Göttingen Ultrafast Transmission Electron Microscope (UTEM) is a newly developed instrument, which allows for studies of ultrafast magnetization and demagnetization dynamics induced by radio-frequency currents or optical pulses. This is facilitated with an electron source which can deliver electron pulses with a duration down to 200 fs.

Here, we focus on the investigation of the gyrotropic motion of a magnetic vortex confined within a 26 nm thick 2.1μm x 2.1μm permalloy nanoisland [1]. We demonstrate that we can track the vortex core position with an accuracy below 5 nm, measured by the deviation form an ideal elliptical trajectory and the deviation between identical acquisitions, respectively. Furthermore, using a sinusoidal current pulse which only lasts for a cycles, we can trace the build-up and relaxation of the vortex gyration, which reveals a temporal hardening of the free oscillation frequency and an increasing orbital decay rate attributed to local disorder in the vortex potential.

[1] M. Möller, et al., arXiv:1907.04608 (2019)

MA 55.8 Thu 17:00 POT 6

Unidirectionally tilted domain walls in chiral biaxial stripes
— •Oleksandr V. Pylypovskyi[1,2], Volodymyr P. Kravchuk[3], Oleksii M. Volkov[1], Jürgen Fassbender[1], Denis D. Sheka[2], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [2]Taras Shevchenko National University of Kyiv, 01601 Kyiv, Ukraine — [3]Karlsruher Institut für Technologie

The orientation of a chiral magnetic domain wall in a racetrack determines its dynamical properties. In equilibrium, magnetic domain walls are expected to be oriented perpendicular to the stripe axis. We demonstrate the appearance of a unidirectional domain wall tilt in an out-of-plane magnetized stripes with biaxial anisotropy (the firsrt easy axis is perpendicular to the plane and the second one is tilted with respect to the stripe axis) and interfacial Dzyaloshinskii–Moriya interaction (DMI). The tilt is a result of the interplay between the in-plane easy-axis anisotropy and DMI. We show that the additional anisotropy and DMI prefer different domain wall structure: anisotropy links the magnetization azimuthal angle inside the domain wall with the stripe main axis in contrast to DMI, which prefers the magnetization perpendicular to the domain wall plane. Their balance with the energy gain due to domain wall extension defines the equilibrium magnetization and domain wall tilt angles. We demonstrate that the Walker field and the corresponding Walker velocity of the domain wall can be enhanced in the system supporting tilted walls.