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).