MA 50: Magnetic Domain Walls (non-skyrmionic)

Time: Friday 9:30–11:15 Location: POT 6

MA 50.1 Fri 9:30 POT 6

Geometrically controlled domain wall dynamics in curved 3D nanostructures — •Sandra Ruiz-Gomez[1], Pamela Morales[1], Claudia Fernandez-Gonzalez[1], Aurelio Rodriguez-Hierro[2], Michael Foerster[3], Miguel Angel Nino[3], Ewa Madej[4], Dorota Wilgocka-Slezak[4], Anna Mandziak[4], Amalio Fernandez-Pacheco[5], and Claire Donnelly[1] — [1]MPI-CPfS, Dresden, Germany — [2]Nothnitzer strasse 40 — [3]Alba Synchrotron, Barcelona, Spain — [4]Solaris synchrotron, Krakow, Poland — [5]INMA, Zaragoza, Spain

Three dimensional nanomagnetic systems, with novel and unconventional spin textures, represent an exciting platform to explore new magnetic phenomena for the development of more efficient, capable and multifunctional technologies. In particular, the 3D geometry is predicted to have a significant influence on the dynamics of magnetic domain walls through the introduction of curvature and torsion, where new physics and functionalities can be realised.

Here, we experimentally explore the influence of 3D geometry on the energetics of domain walls by introducing curvature using focused electron beam induced deposition. We probe the behaviour of DWs within 3D curved systems with soft x-ray magnetic microscopy, that allows us to directly observe the magnetic state and the domain walls, and determine their response to the application of magnetic fields . This insight into the control that can obtained via complex geometries will help pave the way to the next generation of 3D spintronic devices.

MA 50.2 Fri 9:45 POT 6

Geometry-induced effects in domain wall dynamics in stripes with spatially varying cross section — •Kostiantyn V. Yershov[1,2] and Denis D. Sheka[3] — [1]Leibniz Institute for Solid State and Materials Research, Dresden, Germany — [2]Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine — [3]Taras Shevchenko National University of Kyiv, Ukraine

Here we study both analytically and numerically the influence of curvature and cross section deformation effects on the motion of a domain wall in curved stripes which corresponds to geometry of recent experiments [1]. We base our study on a phenomenological Landau–Lifshitz–Gilbert equations using collective variable approach based on a $q-\Phi$ model. We show that (i) curvature and nonzero gradient of cross-section deformation result in a modification of a ground state and can be interpreted as an effective magnetic field. (ii) The presence of a nonzero gradient of cross section deformation also results in a pinning potential for domain walls in addition to the curvature-induced potential [2]. In effective equations of motions the spatially varying cross section and curvature appear as a driving forces which can suppress or reinforce the action of each other. The eigenfrequency oscillations of domain wall in vicinity of the pinning potential is obtained as a function of curvature and cross section deformation and their gradients. All analytical predictions are well confirmed by full scale micromagnetic simulations. [1] L. Skoric et al, ACS Nano **16**, 8860 (2022); [2] K. V. Yershov et al, PRB **92**, 104412 (2015).

MA 50.3 Fri 10:00 POT 6

Domain wall tilt in thin CrOx/Co/Pt corrugated stripes — •Jose A. Fernandez-Roldan[1], Mikel Quintana[1,2], Shahrukh Shakeel[1], Oleksii Volkov[1], Oleksandr Pylypovskyi[1], Eduardo Sergio Oliveros-Mata[1], Florian Kronast[3], Mohamad-Assaad Mawass[3], Claas Abert[4], Dieter Suess[4], Denise Erb[1], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]CIC nanoGUNE BRTA, Donostia-San Sebastian, Spain — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — [4]Physics of Functional Materials, University of Vienna, Vienna, Austria

Curvilinear magnetism is a flourishing field of interest for applications in flexible magnetoelectric devices, microrobots, sensors and nanoelectronics [1-2]. Curvilinear phenomena often result in magnetization patterning, symmetry breaks and Domain Wall (DW) pinning. However, these phenomena have remained so far unexplored in stripes. Here, spin-orbit torques allow the manipulation of DWs [3] with a low power consumption. A recent approach permits the estimation of Dzyaloshinskii-Moriya interaction from DW tilt in thin stripes [4]. Here we provide first results on 100 nm wide 2 nm thin corrugated CrOx/Co/Pt stripes with a mean curvature of 0.06 nm^{-1}. Our results open a perspective for the design of curvature-induced effects with application prospects in current challenges of nanoelectronics. [1] D. Makarov et al., Adv.Mater. 34(3), 2101758 (2022); [2] D. Sheka et al., Small 18, 2105219 (2022); [3] O. Pylypovskyi et al. Sci.Rep. 6, 23316 (2016); [4] O. M. Volkov et al., Phys.Rev.Appl. 15, 034038 (2021).

MA 50.4 Fri 10:15 POT 6

Get in Shape - Closed Magnetoelastic Domain Wall Loops in Antiferromagnets — •Bennet Karetta and Olena Gomonay — Johannes-Gutenberg Universität Mainz

Antiferromagnets are new candidates to be used as active spintronics elements as they are faster and more stable than the ferromagnets in current devices. However, their lack of a net magnetization introduces the challenge to manipulate the magnetic state. Recent studies suggested that the magnetoelastic coupling can be used for this task. Thus, understanding the interaction between strain and Néel vector is of high priority. We study the orientation in different antiferromagnetic domain walls which is influenced by magnetostriction. We show how the energy of the domain wall depends on its orientation on the antiferromagnet. Further, we apply the results to a system of a closed domain wall loops. The anisotropy of the energy significantly changes the shape of the closed loop to an anisotropic form. The exact shape is given by the type of domain wall and magnetoelastic coupling strength. For its determination we finally present a method to quantify the change of the domain wall shape from the zero magnetoelastic coupling case.

MA 50.5 Fri 10:30 POT 6

Magneto-Optic Effects and Domain Imaging in EuO film and EuO/Co Heterostructure — •Seema Seema[1], Henrik Jentgens[1], Paul Rosenberger[1,2], and Martina Müller[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Fakultät Physik, Technische Universität Dortmund, 44221 Dortmund, Germany

Ferromagnetic semiconductors and stable half-metallic ferromagnets with Curie temperatures (Tc) equal to or more than room temperature have been sought for their applications in novel spintronic devices. Europium oxide (EuO) is one of the potential candidates as it possesses strong ferromagnetism (FM) of 7 μB with a Tc of 69 K. The present work focuses on the magnetization reversal mechanisms and domain images in EuO probed using magneto-optic Kerr microscopy. We aimed to visualize magnetic proximity effect induced changes in the coercivity of hysteresis loops as well as magnetic domains in EuO film and in a EuO/3d-FM heterostructure. We synthesized EuO/Co heterostructure sample using molecular beam epitaxy on Nb:STO and observed the differences in the domain saturation behavior as well as the Kerr rotation below Tc. This had been performed by magnetic hysteresis measurement along with simultaneous domain imaging using a Kerr microscope. To explore the temperature-dependent magneto-optic effects in EuO in the proximity of Co, we measured hysteresis at various temperatures below and above Tc. This study of proximity effect-induced changes in magnetic domains in EuO due to Co can provide insights into achieving room-temperature FM in EuO.

MA 50.6 Fri 10:45 POT 6

Electric field induced magnetic swicthing in spin-spiral multiferroics — Francesco Foggetti[1,2] and •Sergey Artyukhin[1] — [1]Italian Institute of Technology, Genova, Italy — [2]Uppsala University, Sweden

Switching in magnetic materials gives rise to rich physical phenomena and lies at the heart of their technological applications. Although domain wall motion in ferro- and antiferromagnets has been studied, in spiral magnets it is still poorly understood despite 20 years of active research since the discovery of spiral multiferroics. The problem of the domain wall motion in a spiral magnet is a compelling one, the more so the magnetic domain walls in cycloidal spiral phase are also ferroelectric, thus enabling electric control of magnetism, i.e. domain wall motion under the action of an external electric field. Phase transition to a spiral phase leads to a formation of chiral domains with opposite spin rotation senses, that are separated by chiral domain walls. Spiral order breaks inversion symmetry and induces a ferroelectric polarization, whose sign is determined by the chirality of the domain. Thus the spiral order allows for the manipulation of spins via an external electric field. Here we study domain wall motion in magnets with spiral ground state, that are the most basic non-collinear magnets. We formulate a simplified variational model and derive the equation of motion for the domain wall driven by an external electric field. The results are corroborated with atomistic spin dynamics simulations. The results suggest a linear dependence of the wall speed on the external electric field, and a peculiar dependence on the system geometry and domain structure.

MA 50.7 Fri 11:00 POT 6

Visualisation of an 4f-antiferromagnetic domain pattern in multiferroic $Dy_{0.7}Tb_{0.3}FeO_3$ — •Yannik Zemp[1], Mads C. Weber[1,2], Ehsan Hassanpour[1,3], Thomas Lottermoser[1], Yusuke Tokunaga[4], Yasujiro Taguchi[5], Yoshinori Tokura[5,6], and Manfred Fiebig[1] — [1]Department of Materials, ETH Zurich — [2]IMMM, Le Mans Université — [3]UDEM Inselspital, University of Bern — [4]Department of Advanced Materials Science, University of Tokyo — [5]RIKEN CEMS, Japan — [6]Department of Applied Physics, University of Tokyo

We visualize the antiferromagnetic (AFM) domain pattern of the 4f-rare-earth subsystem in $Dy_{0.7}Tb_{0.3}FeO_3$. To do so, we exploit the unique order-parameter interaction in the multiferroic phase of this material, where the magnetic rare-earth- and iron subsystems induce ferroelectricity. By magnetic-field cooling into the multiferroic phase, we force the 4f-rare-earth- and ferroelectric domain pattern to be identical. We can then access the former by imaging the latter using optical second harmonic generation, which is very sensitive to a breaking of inversion symmetry. The 4f-AFM domains form stripes with a thickness of several $10\,\mu m$ along the antiferromagnetic easy axis. As a consequence, the ferroelectric domains are forced to form energetically unfavourable head-to-head and tail-to-tail domain walls. Also, the domain pattern is very dissimilar to the weakly ferromagnetic bubble-domain structure of the iron sublattice that is present at higher temperatures. These observations show that the rare-earth system orders independently from the other magnetic- and electric influences.