MA 37: Non-Skyrmionic Magnetic Textures

Time: Wednesday 15:00–17:15 Location: POT/0351

MA 37.1 Wed 15:00 POT/0351

Regularized micromagnetic theory for Bloch points — •Vladyslav M. Kuchkin[1], Andreas Haller[1], Andreas Michels[1], Thomas L. Schmidt[1], and Nikolai S. Kiselev[2] — [1]Department of Physics and Materials Science, University of Luxembourg — [2]Peter Grünberg Institute, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Magnetic singularities, known as Bloch points, pose a significant challenge for the micromagnetic theory due to the divergence of the effective field at these points. In this talk, we present a recently developed regularized micromagnetic model that does not assume a fixed magnetization length, but treats magnetization as an order parameter on the $\mathbb{S}^3$ sphere, thus allowing it to vary in length from zero up to a threshold value. Such an extension of micromagnetics respects the fundamental properties of local spin expectation values in quantum systems. Relying on the $\mathbb{S}^3$ order parameter, we derive Landau-Lifshitz-Gilbert and Thiele equations and apply them to the dynamics of several spin textures: domain walls in nanowires, chiral bobbers, and magnetic dipole strings. The results demonstrate how the extended formalism accounts for the dynamics of Bloch points observed experimentally and open up prospects for modeling complex spin structures, including the nucleation and annihilation of topological states such as skyrmions and hopfions.

MA 37.2 Wed 15:15 POT/0351

Magnetoelastic Fingerprints in Dysprosium Iron Garnet Thin Films: Inversion of Effective Local Anisotropy within Domain Walls — •Lukas D. Ćavar[1], Julian Skolaut[2], Olena Gomonay[1], Miela J. Gross[3], Khang Vi Becker[1], Simon J. Sochiera[1], Dirk Backes[4], Caroline A. Ross[3], and Angela Wittmann[1] — [1]Johannes Gutenberg Universität, Mainz, DE — [2]Christian-Albrechts-Universität zu Kiel, DE — [3]Massachusetts Institute of Technology, Cambridge, MA, USA — [4]Diamond Light Source, Oxfordshire, UK

A promising direction for future computing devices is to embed topological spin textures in compensated collinear magnetic systems. Yet in the absence of significant stray fields, these textures must be stabilized unconventionally. While we observe a wide variety of topological textures in magnetoelastic systems, including the altermagnet α-Fe2O3 ('hematite') and the ferrimagnet dysprosium iron garnet (DyIG), their specific origin is not clear. Here, we compare Néel vector mapping via x-ray magnetic linear dichroism photoemission electron microscopy and stray-field imaging by scanning nitrogen vacancy center magnetometry to show that the DyIG 360° domain wall profile exhibits significant deviations from the classical domain wall profile. These are consistent with an inversion of the effective local anisotropy, i.e. the easy and hard axes trading places within the domain wall body. Thereby we obtain quantitative insight into the mechanism, scale, and energetics of the magnetoelastic stabilization of topological textures in thin films with strong magneto-elastic coupling and uncover a new degree of straintronic freedom for next-generation spin devices.

MA 37.3 Wed 15:30 POT/0351

Hopfions in Symmetry-Transformed Magnetic Models — •Sandra Chulliparambil Shaju, Maria Azhar, and Karin Everschor-Sitte — Faculty of Physics and CENIDE, University of Duisburg-Essen

Three-dimensional (3D) topological spin structures continue to attract significant interest due to their rich physics and potential for future information technologies. We present a systematic framework of continuously transformed models that enables the stabilisation of topologically non-trivial 3D spin configurations. By applying this approach, we construct an effective model that hosts Hopfions embedded in a ferromagnetic background, with distinct energetic and dynamical characteristics. Our results provide new routes for investigating the formation, stability, and dynamics of three-dimensional topologically non-trivial textures.

MA 37.4 Wed 15:45 POT/0351

Fractional Hopfions in Composite Magnets — •Sanjay Ashok and Jan Masell — Karlsruhe Institute of Technology (KIT), Karlsruhe

Hopfions are three dimensional magnetization textures studied due to their unique physical-, topological properties and their functionalization prospects [1]. These textures are usually doughnut shaped and classified by their integer topological winding number called Hopf index. In our work, we demonstrate that hopfions with fractional Hopf index, called fractional hopfions [2, 3], can be stabilized in composite magnets. We identify a two-slab composite magnet with slab-dependent Dzyaloshinskii-Moriya interaction (DMI) as a suitable material platform for stabilizing fractional Hopfions. We further distinguish the role of Bloch-, Neel- and Antiskyrmion-type DMI in composite magnets and their effect on the winding of fractional hopfions [4]. By studying the phase diagram of fractional hopfions we predict the range of external magnetic field and uniaxial anisotropy where these textures can be found.

[1] Zheng et al., Nature 623, 7988 (2023); [2] Knapman et al., Comm. Phys. 7, 1 (2024); [3] Yu et al., Adv. Mat. 35, 20 (2023); [4] Ashok and Masell, *in preparation*

MA 37.5 Wed 16:00 POT/0351

Acoustically-driven manipulation of magnetic textures in epitaxial ferromagnetic thin-films — •João Pedro Leite Gomes, Jens Herfort, and Alberto Hernández-Mínguez — Paul-Drude-Institut für Festkörperelektronik - Leibniz-Institut im Forschungsverbund Berlin e.V., Hausvogteiplatz 5-7, 10117 Berlin, Germany

Recent advances in information technology have driven the research towards more reliable storage devices, while striving for ever higher memory densities. One drawback of current spintronic technologies for information recording is the need for large spin-polarized currents to access/write information in magnetic materials, leading to less energy-efficient devices. An alternative proposal to achieve controlled magnetization switching is to make use of the magnetoelastic (ME) interaction, for example, through the excitation of surface acoustic waves (SAW) in piezoelectric substrates.

In this contribution, we report SAW-driven manipulation of domain walls (DWs) in epitaxial ferromagnetic thin-films with both cubic and uniaxial magnetic anisotropies along well-defined crystalline directions. Micromagnetic simulations model the physical mechanism by which the tickling magnetic field generated by the strain modulation, via the ME interaction, can result in the local switching of the DWs. We discuss how much SAWs are a feasible approach to achieve magnetization switching and/or promote DW pinning in single crystal ferromagnetic thin-films.

MA 37.6 Wed 16:15 POT/0351

Control of helix orientation in chiral magnets via lateral confinement — •Maurice Colling[1], Mariia Stepanova[1], Mario Hentschel[2], Erik Lysne[1], Kasper Hunnestad[1], Naoya Kanazawa[3], Yoshinori Tokura[3,4], Jan Masell[4,5], and Dennis Meier[1] — [1]Department of Materials Science and Engineering, NTNU Norwegian University of Science and Technology, Trondheim, Norway — [2]Physics Institute and Research Center SCoPE, University of Stuttgart, Stuttgart, Germany — [3]Department of Applied Physics, University of Tokyo, Tokyo, Japan — [4]RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan — [5]Institute of Theoretical Solid State Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Helimagnetic materials offer a versatile platform for spin-based device concepts due to their long-range, tunable spiral order. This talk demonstrates control of the helimagnetic propagation vector q via geometrical confinement, using FeGe as a model DMI-driven chiral magnet. Micromagnetic simulations based on the nonlinear sigma model show that open boundaries generate a chiral surface twist that acts as an effective surface anisotropy selecting the helix orientation. This behavior is captured well by an analytical model derived from the DMI boundary condition. Magnetic force microscopy on focused ion beam structured FeGe confirms the predicted orientation and establishes geometry-controlled helimagnetic order as a robust mechanism for steering DMI-stabilized spin-spiral states. The concept provides a route to device-level control of chiral magnetic textures.

MA 37.7 Wed 16:30 POT/0351

Magnetization dynamics of twists in (anti-)ferromagnetic insulators — Patricia Oehrl[1,2], Mathew James[3], Luca Maranzana[4], Andreas Bauer[2], Denis Mettus[2], Christian

Pfleiderer[2], Christian Back[2], Sergey Artyukhin[4], Hans Huebl[1,2], and •Aisha Aqeel[3] — [1]Walther-Meißner-Institut, 85748 Garching, Germany — [2]Technical University of Munich, 85748 Garching, Germany — [3]University of Augsburg, 86159 Augsburg, Germany — [4]Quantum Materials Theory, Italian Institute of Technology, Via Morego 30, Genoa, Italy

Magnetic insulators hosting noncollinear spin textures display a remarkable variety of static and dynamic phenomena. In chiral systems such as Cu2OSeO3, the lack of inversion symmetry gives rise to helices and skyrmions stabilized by Dzyaloshinskii-Moriya interactions [1]. By contrast, in centrosymmetric compounds like CuSeO3, complex antiferromagnetic spiral states can emerge purely from competing symmetric exchange interactions, providing an intriguing platform to explore magnetism without intrinsic chirality. In this talk, I will present our preliminary results on dynamic excitation of these textures in chiral Cu2OSeO3 and centrosymmetric CuSeO3 magnets using magnetic resonance spectroscopy [2].

References: [1] S. Mehboodi, V. Ukleev, C. Luo, R. Abrudan, F. Radu, C. H. Back, A. Aqeel, Sci. Technol. Adv. Mater 26(1) 2532366 (2025) [2] Aisha Aqeel, Jan Sahliger,... Christian H Back, Phys. Rev. Lett. 126, 017202 (2021)

MA 37.8 Wed 16:45 POT/0351

Extraordinary return point memory in ferrimagnetic materials — •Tamer Karaman[1], Kai Litzius[1], Aladin Ullrich[1], Riccardo Battistelli[1], Manas Patra[1,2], Raluca Boltje[1], Miela Gross[2], Steffen Wittrock[2], Krishnanjana Joy[1], Daniel Metternich[2], Sebastian Hoffman[1], Timo Schmidt[1], Daniel Perez[3], Manuel Valvidares[3], Sebastain Wintz[2], Manfred Albrecht[1], and Felix Büttner[1,2] — [1]University of Augsburg, Germany — [2]Helmholtz-Zentrum Berlin, Germany — [3]ALBA Synchrotron Light Source, Spain

Magnetic domains and domain walls are promising information carriers, widely explored for racetrack memory [1] and other mobility applications [2]. In this study, we demonstrate deterministic magnetic-domain nucleation in rare-earth transition-metal (RE-TM) ferrimagnetic systems. Remarkably, the as-grown domain configuration serves as an intrinsic template that reappears with 100% return-point memory after repeated out-of-plane magnetic-field cycling. Even more surprisingly, the full domain pattern can be toggle switched using extremely small in-plane fields near 0 mT, while the overall domain morphology remains unchanged. These findings point to new opportunities in cryptography and other technologies requiring deterministic pattern reproducibility, and they highlight the importance of further exploring properties of RE-TM ferrimagnets. References: 1.Parkin, S. et al. Nat. Nano. 10, 195-198 (2015) 2.Venkat, G. et al. J. Phys. Appl. Phys. 57, 063001 (2024).

MA 37.9 Wed 17:00 POT/0351

Microscale coexistence of magnetic phases compatible with the Kagome spin-ice rule in HoAgGe — •Manuel Zahn[1,2], Kan Zhao[3], Philipp Gegenwart[1], Sándor Bordács[4], and István Kézsmárki[1] — [1]Center for Electronic Correlation and Magnetism, University of Augsburg, Augsburg, Germany — [2]Norwegian University of Science and Technology, Trondheim, Norway — [3]School of Physics, Beihang University, Beijing, China — [4]Department of Physics, Budapest University of Technology and Economics, Budapest, Hungary

HoAgGe realizes kagome spin-ice with a series of fractionalized magnetization plateau states for applied in-plane magnetic fields [1]. Corresponding magnetoresistance and Hall effect reveal a hysteresis at the plateau states, indicating field-history dependent occupation of magnetic domains with opposite chirality and Berry curvature [2].

In the presented study, we investigate the microscale magnetic patterns, using low-temperature atomic force microscopy to visualize possible phase coexistence. By studying different crystal cuts and varying magnetic fields using a vector magnet, we reconstruct the full 3D magnetic texture of phase coexistence. Our results provide insights into the interplay of geometrical, topological and frustrated properties of spin ice materials and demonstrate pathways for external manipulation of magnetic textures in highly-frustrated systems.

[1] K. Zhao *et al.*, Science **367**, 1218 (2020). [2] K. Zhao *et al.*, Nat. Phys. **20**, 442 (2024).