MA 26: Non-Skyrmionic Magnetic Textures II

Time: Wednesday 9:30–11:30 Location: HSZ 401

Invited Talk MA 26.1 Wed 9:30 HSZ 401

The self-induced spin glass: the perplexing magnetism of elemental neodymium — •Alexander Khajetoorians — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

Spin glasses are a class of disordered magnetic materials characterized by a flat multi-well energy landscape that exhibits aging dynamics. Spin glass behavior is often described by two key ingredients: (a) competing spin interactions, and (b) external disorder. It was recently proposed that a special type of spin glass can be realized, solely by competing interactions (1). In 2020 (2), we discovered that the controversial and perplexing magnetic state of elemental Nd(0001) is a self-induced spin glass. Using spin-polarized scanning tunneling microscopy/spectroscopy (SP-STM/STS), we found that the zero-field state shows a multiplicity of favorable short-range ordered Q-states, but in the absence of long-range order. The magnetic state shows aging dynamics, and it stems from frustrated indirect exchange. More recently (3), we showed that with increasing temperature, frustration is broken leading to a long-range ordered multi-Q state. In this talk, I will review the concept of the self-induced spin glass in Nd. Moreover, I will discuss new results concerning the aging dynamics and magnetic phase diagram of the material, as well as perspectives to use such multi-well systems for new memory and computing applications. [1] A. Principi, M.I. Katsnelson, PRL, 117, 137201 (2016); [2] U. Kamber et al, Science, 368, 6494 (2020); [3] B. Verlhac, L. Niggli, et al, Nature Physics, 18, 905 (2022)

MA 26.2 Wed 10:00 HSZ 401

Low-temperature properties of single-crystal ErB_2 — •Christoph Resch, Georg Benka, Daria Nuzhina, Anh Tong, Andreas Bauer, and Christian Pfleiderer — Physik Department E51, Technische Universität München, 85748 Garching, Germany

We present a comprehensive study of single crystals of the hexagonal rare-earth diboride ErB_2 prepared by means of the optical floating-zone approach. Measurements of the specific heat, the ac susceptibility, the magnetisation, and the electrical transport at low temperatures and fields up to 18 T consistently establish magnetic order of the Er^{3+} moments below a second-order phase transition at $T_c = 14$ K with competing ferromagnetic and antiferromagnetic interactions. The magnetocrystalline anisotropies exhibit strong easy-plane characteristics with ⟨001⟩ being the magnetic hard axis.

MA 26.3 Wed 10:15 HSZ 401

Helitronics for unconventional computing — •Nicolai Timon Bechler[1] and Jan Masell[1,2] — [1]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]RIKEN CEMS, Wako, Japan

Non-trivial magnetic structures have been proposed to be a promising route to unconventional computing. The interplay between magnetic stiffness and Dzyaloshinskii-Moriya interaction can stabilize a helical order of the magnetisation which is often discarded as trivial. However, recent studies have shown that the orientation of these helical magnetisation structures can be manipulated by strong enough magnetic fields [1] and spin currents [2] which revealed their unexpectedly complex dynamics. Using micromagnetic simulations, we investigate novel magnetic memory devices such as MRAM-cells and memristors which use the orientation of the helical phase as an order parameter, dubbed helitronics. We propose a way to read-out said devices using the anisotropic magneto resistance and point out their use for unconventional computing purposes.

[1] A. Bauer, A. Chacon, M. Wagner, M. Halder, R. Georgii, A. Rosch, C. Pfleiderer, and M. Garst, Phys. Rev. B 95, 024429 (2017). [2] J. Masell, X. Z. Yu, N. Kanazawa, Y. Tokura, and N. Nagaosa, Phys. Rev. B 102, 180402(R) (2020).

15 min. break

MA 26.4 Wed 10:45 HSZ 401

Investigating a stable Bloch point in a magnetic disk comprising layers with two different chiralities — •Thomas Brian Winkler[1], Marijan Beg[2], Martin Lang[3,4], Mathias Kläui[1], and Hans Fangohr[3,4] — [1]Institute of Physics, Johannes Gutenberg University Mainz, Germany — [2]Department of Earth Science and Engineering, Imperial College London, United Kingdom — [3]Faculty of Engineering and Physical Sciences, University of Southampton, United Kingdom — [4]Max Planck Institute for the Structure and Dynamics of Matter Hamburg, Germany

Bloch points (BPs) are highly confined spin structures, that often occur in transient processes [1]. However, they can also be stabilized in specific systems. Beg et al. showed the existence of a stable Bloch point by stacking two cylindrical nanodisks of FeGe on top of each other, with opposite sign of the DMI vector [2]. In both layers a magnetic vortex is formed, with the same circularity, but opposite polarity, leading to a Bloch point at the interface. In this study we investigate the energetics of the system within the micromagnetic (MM) framework and validate results with atomistic simulations. Further, an in-plane field is applied to shift the BP out of the center of the disk. The dynamics of the system are analysed after the field switch-off. The BP does not show any precessional motion, which is different to a classical magnetic vortex [3]. We also find, that qualitatively, the MM framework produces the same results as atomistic simulation.

[1] T. B. Winkler et al., PRApplied 16, 044014 (2021). [2] M. Beg et al., Sci Rep 9, 7959 (2019). [3] K. Yu. et al., JAP 91, 8037 (2002).

MA 26.5 Wed 11:00 HSZ 401

Stability of Hopfions in Bulk Magnets with Competing Exchange Interactions — •Moritz Sallermann[1,2,3], Hannes Jónsson[3], and Stefan Blügel[1] — [1]PGI-1 and IAS-1, Forschungszentrum Jülich and JARA, Jülich, Germany — [2]Department of Physics, RWTH Aachen, Aachen, Germany — [3]Science Institute and Faculty of Physical Sciences, University of Iceland, Reykjavík, Iceland

Magnetic hopfions are three-dimensional topological solitons, characterised by the Hopf number. Based on a micromagnetic model, the existence of free moving hopfions has been predicted in certain magnets with competing exchange interactions [1]. However, physical realisations of free moving hopfions in bulk magnets have so far been elusive. Here, we consider an effective spin lattice Heisenberg model with competing exchange interactions and computationally study the stability of small toroidal hopfions with unity Hopf number by finding first-order saddle points representing the transition state for the decay of hopfions to the ferromagnetic ground state, via the formation of two coupled Bloch points. We show that the energy barriers can reach substantial heights and are largely determined by the size of the hopfions. The saddle point methods are discussed.

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[1] F. N. Rybakov *et al.*, Apl. Mater. **10**, 111113 (2022)

MA 26.6 Wed 11:15 HSZ 401

Blowing magnetic smoke rings (hopfions) — •Philipp Gessler[1] and Jan Masell[1,2] — [1]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]RIKEN CEMS, Wako, Japan

Hopfions are three-dimensional topological defects in magnetization, consisting of a closed skyrmion-string loop. Embedded in the field polarized phase, they are reminiscent of smoke rings in the air. In contrast to their two-dimensional counterparts, i.e. skyrmions, hopfions appear anything but ubiquitously in experiments. One reason is the lack of proposals for efficient ways to create these complex magnetic textures. Recently, ideas emerged for the creation of skyrmion-antiskyrmion pairs in two dimensions [1]. We generalize this idea to three dimensions. Using micromagnetic simulations, we show that spin-polarized currents can create hopfions at defects, similar to blowing smoke rings.

[1] K. Everschor-Sitte et al., New J. Phys. 19, 092001 (2017)