MA 28: Cooperative Phenomena: Spin Structures and Magnetic Phase Transitions

Time: Wednesday 15:00–17:30 Location: H19

MA 28.1 Wed 15:00 H19

Correlations of short-range environment and hyperfine parameters in disordered FeV thin-films — •Simon Rauls[1], Benedikt Eggert[1], Jürgen Fasbender[2], Kay Potzger[2], Rantej Bali[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf

The binary alloy $Fe_{1-x}V_x$ shows a variety of interesting properties, ranging from antiparallel coupling of induced V magnetic moments up to 1 μ_B per V atom to the positive vibrational entropy in the disorder/order transition from the A2 to the B2 bcc-crystalline phase. Furthermore, around equiatomic composition, the structurally complex σ-phase might develop. To understand these effects, the local atomic environment as well as both structural and chemical disorder need to be considered. Using Mössbauer spectroscopy, the local environment of ^{57}Fe atoms and different aspects of disorder can be investigated through careful analysis of the distribution of hyperfine parameters, i.e.. the hyperfine field splitting and the isomer shift. In this talk, the conversion electron Mössbauer spectra of the entire concentration range of $Fe_{1-x}V_x$ thin film samples are presentedd. Enrichment with 95% ^{57}Fe results in a very high signal to noise ratio, which allows for comparison of Hesse-Rübartsch fits with a model, in which the hyperfine parameters are described by a binomial distribution of the first three nearest-neighbor shells. We acknowledge funding by the DFG through project No. 322462997.

MA 28.2 Wed 15:15 H19

Simulating magnetostriction in skyrmion-hosting $MnSc_2S_4$ — •Justus Grumbach[1], Mahmood Deeb[1], Sergey Granovsky[1], Lilian Prodan[2], Vladimir Tsurkan[2], Martin Rotter[3], and Mathias Doerr[1] — [1]Institut für Festkörper- und Materialphysik, TU Dresden, 01062 Dresden — [2]Experimentalphysik V, Universität Augsburg, 86135 Augsburg — [3]*McPhase* Projekt, 01159 Dresden

Measurements of neutron scattering on $MnSc_2S_4$ explored an antiferromagnetic skyrmion state [1]. We measured the magnetostriction and found curves with characteristic anomalies. To find out which is linked to skyrmions, we performed mean field Monte Carlo simulations with the *McPhase* program package using the hamiltonian introduced earlier [1].

We could resemble main properties of the experimental outcome. The exact location of the skyrmionic state in the phase diagram and the discovery of a new $2\boldsymbol{q}$ structure between the skyrmion state and saturation in field were new informations gained by these simulations.

Simulations and experimental results introduce a link of magnetostriction and skyrmions by a plateau-like non-distorted region, which could also be found in other compounds.

[1] S. Gao et al.: Fractional antiferromagnetic skyrmion lattice induced by anisotropic couplings. Nature, 586:37, 2020.

MA 28.3 Wed 15:30 H19

Tilted spin state near the spin reorientation of the topological kagome magnet Fe_3Sn_2 — •Lilian Prodan[1], Donald M. Evans[1,2], Aleksandr S. Sukhanov[1], Stanislav E. Nikitin[3], Alexander A. Tsirlin[4], Lukas Puntingam[1], Marein C. Rahn[1], Liviu Chioncel[1], Vladimir Tsurkan[1,5], and Istvan Kezsmarki[1] — [1]University of Augsburg, Augsburg, Germany — [2]Department of Sustainable Energy Technology, SINTEF Industry, Oslo, Norway — [3]Paul Scherrer Institut, Switzerland — [4]Leipzig University, Germany — [5]Moldova State University, Chisinau, Moldova

Spin reorientation due to competing magnetic anisotropies can have drastic effects on various physical properties in itinerant magnets with topologically nontrivial band structure. Therefore, understanding the mechanism of spin reorientation provides an efficient tool for engineering the properties of topological magnets [1]. Our target material is the topological kagome ferromagnet Fe_3Sn_2 [2], where we investigated the temperature-driven spin reorientation using a number of experimental techniques and numerical modeling. We reveal that the crossover from the high-temperature state with uniaxial easy-axis anisotropy to the low-temperature state with easy-plane anisotropy take place at ∼120 K through an intermediate tilted easy-cone state. Our MFM study highlights significant changes in the magnetic patterns emerging on the mesoscale across all three states, including the formation of magnetic bubbles on the surface of bulk centrosymmetric Fe_3Sn_2 crystals. [1] A. Kimel et.al, Nature 429, 850-853 (2004). [2] F. Schilberth et al., Phys. Rev. B 106, 144404 (2022).

MA 28.4 Wed 15:45 H19

High-field/high-frequency Ferromagnetic Resonance Studies on the van-der-Waals ferromagnet Fe_3GeTe_2 — •Birte Beier[1], Martin Jonak[1], Eva Brücher[2], Reinhard K. Kremer[2], and Rüdiger Klingeler[1] — [1]Kichhoff Institute for Physics, Heidelberg University, Germany — [2]Max Planck Institute for Solid State Research, Stuttgart, Germany

Long-range ferromagnetic order develops down to the monolayer in Fe_3GeTe_2 and is particularly robust both in the monolayer and in the bulk as compared to other van-der-Waals ferromagnets. In the bulk, T_C amounts to about 220 K as compared to, e.g., 61 K in CrI_3 and 65 K in $Cr_2Ge_2Te_6$. In order to elucidate the origin of robust long-range ferromagnetism, we have investigated low-energy magnon excitations in Fe_3GeTe_2 by high-field/high-frequency ferromagnetic resonance studies. Our data reveal the size and temperature dependence of the anisotropy gap and also show the evolution of short-range magnetic order well above T_C. The frequency- and field-dependence of magnon excitation is discussed and compared with our recent findings on CrI_3 [1].

[1] M. Jonak *et al.*, Phys. Rev. B **106**, 214412 (2022)

MA 28.5 Wed 16:00 H19

Derivation of spin-orbit generated relativistic symmetric and antisymmetric exchange interactions — •Hiroshi Katsumoto[1], Yuriy Mokrousov[1,2], and Stefan Blügel[1] — [1]Peter Grünberg Institut, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

It has become clear that the higher-order exchange interactions beyond the Heisenberg interaction can promote very complex magnetic structures. Moriya derived the Dyzaloshinskii-Moriya interaction (DMI) for spin-1/2 systems, including spin-orbit coupling (SOC). We derived an expression that generates the DMI according to a systematic algorithm for any higher-order antisymmetric exchange interaction. Applying this expression to particular spin models consistently provides all recently suggested DMIs extended to higher-order exchange interactions [1]. In addition, it is found that in the second-order perturbation of SOC, not only the antisymmetric higher-order terms but also the symmetric spin-nematic term is obtained. The spin-nematic term is known to produce electromagnetic effects [2], and in this study, its microscopic derivation is given.

We acknowledge funding from the ERC grant 856538 (project "3D MAGIC") and DFG through SPP-2137 and SFB-1238 (project C1).

[1] A. Lászlóffy *et al.*, PRB **99**, 184430 (2019); S. Brinker *et al.*, NJP **21**, 083015 (2019); S. Grytsiuk *et al.*, Nat. Commun. **11**, 511 (2020); S. Mankovsky *et al.*, PRB **101**, 174401 (2020).
[2] M. Soda *et al.*, PRL **112**, 127205 (2014)

MA 28.6 Wed 16:15 H19

magnetism and electronic dynamics in CuCr1-xSnxS4 — •Elaheh Sadrollahi[1], Cynthia P. C. Medrano[2], Magno A.V. Herling[2], Elisa M. Baggio Saitovitch[2], Lilian Prodan[3,4], Vladimir Tsurkan[3,4], and F. Jochen Litterst[5] — [1]IFMP, TU Dresden, 01069 Dresden, Germany — [2]CBPF, Rio de Janeiro, 22290-180, Brazil — [3]EKM, Inst. of Physics, University Augsburg, 86135 Augsburg, Germany — [4]IAP, Moldova State University, MD 2028, Chisinau, Republic of Moldova — [5]IPKM, TU Braunschweig, 38106 Braunschweig, Germany

Magnetization, muon spin rotation and relaxation(muSR), and 119Sn Mössbauer spectroscopy have been performed on the metallic ferromagnetic CuCr1-xSnxS4 (x=0.03-0.08) cubic spinel (Tc=360 K-343 K). Magnetization and muSR results reveal the same low-temperature magnetic transitions around 80 K and 40 K as found for the undoped material with a magnetic ground state deviating from a simple collinear ferromagnet [1] and proposed charge ordering [2]. The changes in Mössbauer hyperfine spectra are less pronounced and are discussed in view of the different positions of the local probes mu+ and 119Sn and their different magnetic coupling to the magnetic Cr lattice. Above 70 K, both muSR and Mössbauer spectra show temperature-dependent inhomogeneous broadening either due to structural or charge disorder and changing spin and charge dynamics that can be related to a precursor magnetic phase above the well-defined static low-temperature phase. References: [1] E. Sadrollahi, et al., Phys. Rev. B 110, 054439 (2024). [2] K. Oda, et al., J. Phys. Soc. Jpn. 70, 2999 (2001).

15 min. break

MA 28.7 Wed 16:45 H19

Ground state magnetization in superstable graphs — •Fabio Pablo Miguel Méndez-Córdoba[1,2,3], Joseph Tindall[4], Dieter Jaksch[1,2,5], and Frank Schlawin[1,2,3] — [1]Universität Hamburg, Luruper Chaussee 149, Gebäude 69, D-22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, Hamburg D-22761, Germany — [3]Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]Center for Computational Quantum Physics, Flatiron Institute, 162 5th Avenue, New York, NY 10010 — [5]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, UK

Much of our understanding of ground state magnetic properties rests on analytical results on bipartite lattices. However, few exact results are known in non-bipartite graphs with frustrated couplings. We determine the ground state magnetization of strongly correlated systems on non-bipartite graphs displaying superstability. Superstability allows reinterpreting non-bipartite graphs as a collection of bipartite-connected components, providing magnetic properties of important lattices, such as the triangular ladder. Numerical evidence suggests further generalizations are feasible.

MA 28.8 Wed 17:00 H19

Magneto-optical spectroscopy on cubic noncollinear antiferromagnet HoCu — •Felix Schilberth[1,2], Marein Rahn[3], Andreas Bauer[4], Christian Pfleiderer[4], Sándor Bordács[2], and István Kézsmárki[1] — [1]Lst. für Experimentalphysik V, Universität Augsburg — [2]Dept. of Physics, BME Budapest — [3]Lst. für Experimentalphysik VI, Universität Augsburg — [4]Lst. für Experimentalphysik zur Topologie korrelierter Systeme, TU München

Giant anomalous Hall effect (AHE) and magneto-optical Kerr-effect (MOKE) can emerge in magnets with topologically non-trivial electronic bands. Besides extrinsic contributions from scattering of electrons by impurities, two intrinsic contributions are considered. In momentum space, the Berry curvature generated by non-trivial band features like Weyl points or nodal lines can produce resonances in the optical conductivity, leading to AHE in the static limit. On the other hand, noncollinear magnetic texture in the real space can induce topological Hall effect (THE). The separation of all three contributions is a remarkable experimental challenge which typically cannot be solved by magnetotransport experiments alone. Here, we address this question in the itinerant cubic antiferromagnet HoCu where a remarkably large AHE on the order of $10^6\ \Omega^{-1}\text{cm}^{-1}$ was observed. By measuring reflectivity and MOKE, we determine the optical Hall effect spectrum, the finite frequency analog of the AHE. In this quantity, the energy scales provided by the scattering rate or the energy of band degeneracies allow to disentangle the AHE contributions by free carriers from interband resonances, decomposing this remarkable transport response.

MA 28.9 Wed 17:15 H19

Investigating the soft X-ray-induced spin-state switching in the room temperature regime of a Fe(II) spin-crossover complex — •Lea Kämmerer[1], Carolin Schmitz-Antoniak[2,3], Tobias Lojewski[1], Damian Günzing[1], Torsten Kachel[4], Florin Radu[4], Radu Abrudan[4], Katharina Ollefs[1], Senthil K. Kuppusamy[5], Mario Ruben[5,6], and Heiko Wende[1] — [1]University of Duisburg-Essen and CENIDE — [2]Forschungszentrum Jülich — [3]University of Applied Sciences Wildau, — [4]Helmholtz-Zentrum Berlin — [5]Karlsruhe Institute for Technology — [6]Institut de Science et d'Ingénierie Supramoléculaires

Spin-crossover complexes exhibit two distinct spin-states, designated as low-spin and high-spin, which are contingent upon the ligand field surrounding the central metal ion. It is possible to induce a switching of the spin state in these complexes through the use of soft X-rays. The complex $Fe(1-bpp-COOC_2H_5)_2(BF_4)_2CH_3CN$ exhibits an abrupt spin-state switching with an open thermal hysteresis around room temperature. Static X-ray absorption spectroscopy was performed at the synchrotron BESSY II, which allows for the analysis of the two spin states at the Fe $L_{2,3}$ absorption edges due to the presence of different fine structures. We gained insight into the cooperative mechanism that occurs during the soft X-ray-induced spin-state switching at room temperature. It was observed that once the effect was initiated in a thin film, a chain reaction led to further switching, even in the absence of soft X-rays. We thank the Deutsche Forschungsgemeinschaft for their financial support of the SFB 1242.