MA 34: Functional Antiferromagnetism

Time: Thursday 15:00–16:45 Location: H48

MA 34.1 Thu 15:00 H48

Giant and tunneling magnetoresistance in unconventional compensated magnets with nonrelativistic d-wave spin-momentum couplings — Libor Šmejkal[1,2], •Anna B. Hellenes[1], Rafael González-Hernández[3], Jairo Sinova[1,2], and Tomaš Jungwirth[2,4] — [1]Johannes Gutenberg Universität Mainz, Germany — [2]Czech Academy of Sciences, Prague, Czech Republic — [3]Universidad del Norte, Barranquilla, Colombia — [4]University of Nottingham, United Kingdom

The magnetoresistance effects used in commercial spintronics devices rely on spin current generated by the time-reversal broken band structure of ferromagnets. Realizing counterpart effects with all-antiferromagnetic electrodes has remained experimentally elusive, as conventional compensated antiferromagnets exhibit symmetries combining time-reversal with translation or inversion and thus prohibit nonrelativistic spin-polarized bands and spin currents. Recently, we have predicted large magnetoresistance effects in multilayers with an unconventional compensated magnetic phase[1]. It is characterized by zero magnetization and a time-reversal broken band structure[2], with d-wave spin-momentum coupling and alternating spin polarization [1,3] (thus also referred to as altermagnetism[3]). In the present contribution, we will describe mechanisms for giant and tunneling magnetoresistance relying on the anisotropic and valley-dependent forms of the d-wave spin-momentum coupling[1]. [1] L. Šmejkal, A. B. Hellenes et al., Phys. Rev. X 12, 011028, 2022. [2] L. Šmejkal et al., Sci. Adv. 6, eaaz8809, 2020. [3] L. Šmejkal et al., arXiv:2105.05820v2, 2021.

MA 34.2 Thu 15:15 H48

Exploring the magnetic ground states in different layers of Mn on Ir (111) by SP-STM — •vishesh saxena, arturo rodriguez sota, Roland Wiesendanger, and Kirsten von Bergmann — Institut für Nanostruktur- und Festkörperphysik, Hamburg

Conventional magnetic skyrmions are susceptible to unwanted phenomena such as the skyrmion Hall effect. This is a highly undesirable effect that hinders the application of such skyrmions in spintronic devices. An alternative are antiferromagnetic skyrmions which do not show a skyrmion Hall effect [1]. In the quest to explore systems that can host antiferromagnetic skyrmions, we have studied the magnetism of Mn on Ir (111) using spin-polarized scanning tunneling microscopy (SP-STM). Having an antiferromagnetic spin order on a periodic lattice can induce magnetic frustration. It has already been shown that the magnetic ground states of Mn monolayers on Re (0001) can be the row-wise antiferromagnetic state or the 3Q state depending on the stacking of Mn [2]. In the present work, the magnetic behavior of the monolayer, double layer, and the triple layer of Mn on Ir(111) is studied. Different magnetic ground states are observed depending on the Mn layer thickness.

[1] X. Zhang, Y. Zhou, and M. Ezawa, Antiferromagnetic Skyrmion: stability, creation and manipulation, Scientific Reports 6, 1 (2016). [2] J. Spethmann, S. Meyer, K. von Bergmann, R. Wiesendanger, S. Heinze, and A. Kubetzka, Discovery of magnetic single-and triple-q states in Mn/Re(0001), Physical Review Letters 124, 227203 (2020).

MA 34.3 Thu 15:30 H48

Identification of Néel vector orientation in antiferromagnetic NiO thin films — •Christin Schmitt[1], Luis Sanchez-Tejerina[2], Rafael Ramos[3], Eiji Saitoh[3,4], Giovanni Finocchio[2], Lorenzo Baldrati[1], and Mathias Kläui[1] — [1]Institute of Physics, Johannes Gutenberg-University Mainz, Germany — [2]Department of Mathematical and Computer Sciences, Physical Sciences and Earth Sciences, University of Messina, Italy — [3]WPI-AIMR, Tohoku University, Japan — [4]Department of Applied Physics, The University of Tokyo, Japan

Spintronics using antiferromagnets (AFM) is promising due to intrinsic dynamics in the THz range and the absence of stray fields. However, efficient writing and reading is necessary in terms of applications. Recently, current-induced writing of the Néel order in AFMs has been reported and different switching mechanisms have been put forward [1,2]. The mechanisms depend on the type of domains present. Here, we focus on antiferromagnetic NiO/Pt thin films, and image reversible electrical switching by photoemission electron microscopy (PEEM) employing the x-ray magnetic linear dichroism (XMLD) effect. By varying the x-ray polarization and sample azimuthal angle, we identify the crystallographic orientation of the domains that can be switched and quantify the Néel vector direction, showing that the switching occurs between different T-domains [3]. Finally, we characterize the domain walls showing that they are non-chiral and reveal a large anisotropy in the NiO thin films. [1] T. Moriyama, et al., Sci. Rep. 8, 14167 (2018). [2] P. Zhang, et al., Phys. Rev. Lett. 123, 247206 (2019). [3] C. Schmitt, et al., Phys. Rev. Appl. 15, 034047 (2021).

MA 34.4 Thu 15:45 H48

Magnon Hanle effect in easy-plane antiferromagnets — •Janine Gückelhorn[1,2], Akashdeep Kamra[3], Tobias Wimmer[1,2], Matthias Opel[1], Stephan Geprägs[1], Rudolf Gross[1,2,4], Hans Huebl[1,2,4], and Matthias Althammer[1,2] — [1]Walther-Meißner-Institut, BAdW, 85748 Garching, Germany — [2]Physik-Department, TUM, 85748 Garching, Germany — [3]IFIMAC and Departamento de Fisica Teorica de la Materia Condensaga, Universidad Autonoma de Madrid, 28049 Madrid, Spain — [4]Munich Center for Quantum Science and Technology, 80799 München, Germany

Antiferromagnets have drawn much attention due to their unique properties and potential for interesting device applications. In analogy to a spin-1/2 system, antiferromagnetic magnon pairs can be described in terms of a magnonic pseudospin. Recently, first experimental observations of the associated dynamics and the magnon Hanle effect have been reported and described using a 1D pseudospin transport model. Here, we discuss the effects of dimensionality on the magnon spin signal by studying insulating hematite (α-Fe_2O_3) films with varying thickness [1]. For both a thin and a thick film, we find a pronounced signal caused by the magnon Hanle effect. However, the magnonic spin signal exhibits clear differences in both cases. We extend the theoretical description by taking into account low-energy finite-spin magnons and use it to explain our observations. This provides deeper insight into the detailed understanding of magnonic pseudospin dynamics.
[1] J. Gückelhorn *et al.*, Physical Review B **150**, 094440 (2022)

MA 34.5 Thu 16:00 H48

Role of substrate clamping on anisotropy and domain structure in the canted antiferromagnet α-Fe_2O_3 — •Angela Wittmann[1], Olena Gomonay[1], Kai Litzius[2], Alexandra Churikova[3], Norman Birge[4], Felix Büttner[5], Sebastian Wintz[2], Mohamad Mawass[5], Markus Weigand[5], Florian Kronast[5], Jairo Sinova[1], Gisela Schütz[2], and Geoffrey Beach[3] — [1]Johannes Gutenberg Universität Mainz, Germany — [2]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [3]Massachusetts Institute of Technology, Cambridge, USA — [4]Michigan State University, East Lansing, USA — [5]Helmholtz-Zentrum für Materialien und Energie GmbH, Berlin, Germany

Antiferromagnets are at the forefront of research in spintronics and demonstrate high potential for revolutionizing memory technologies. For this, understanding the formation and driving mechanisms of the domain structure is paramount. In this work, we investigate the domain structure in a thin-film canted antiferromagnet α-Fe_2O_3 using x-ray linear dichroism (XMLD) and spin Hall magnetoresistance (SMR) measurements. We find that the internal destressing fields driving the formation of domains do not follow the crystal symmetry of α-Fe_2O_3 but fluctuate due to substrate clamping. This leads to an overall isotropic distribution of the Néel order with locally varying effective anisotropy in antiferromagnetic thin films. The insights gained from our work serve as a foundation for further studies of electrical and optical manipulation of the domain structure of antiferromagnetic thin films.

MA 34.6 Thu 16:15 H48

Correlation of Atomic Disorder and Anomalous Hall Effect in a Non-Collinear Antiferromagnet — •Berthold H. Rimmler[1], Binoy K. Hazra[1], Holger L. Meyerheim[1], Arthur Ernst[2], and Stuart S. P. Parkin[1] — [1]Max Planck Institute for Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Johannes Keppler University, Altenbergerstrβe 69, Linz 4040, Austria

Non-collinear antiferromagnets (NCAFs) such as the well-studied alloy Mn3Sn have compensated triangular magnetic structures with vanishing net magnetization. Due to magnetic symmetry breaking, they can display a large Anomalous Hall Effect (AHE). Measurement of the AHE requires an imbalance of antiferromagnetic domains. Domain structure control by magnetic field or spin torques is possible in Mn3Sn, because crystalline anisotropy induces weak canted moments. In contrast, these moments are not intrinsic to cubic NCAFs. In this work, we investigate the crystallographic, magnetic and magneto-transport properties of thin films of the cubic NCAF Mn3SnN. We find that the manganese atoms can be displaced from their high-symmetry positions. This atomic site disorder correlates with a finite AHE. We employ abinitio calculations to show that the manganese site displacement can induce canting. In analogy to Mn3Sn, these canted moments may allow for domain structure control leading to the observed AHE. This work provides new insight into the microscopic origin of canted moments in cubic NCAFs and their correlation with the AHE. Our findings have implications for other magneto-transport effects such as the anomalous Nernst effect or the spin Hall effect.

MA 34.7 Thu 16:30 H48

Spontaneous anomalous Hall effect arising from antiparallel magnetic order in a semiconductor — •Ruben Dario Gonzalez Betancourt[1,2,3,4], Jan Zubáč[3,4], Rafael Julian Gonzalez Hernandez[5], Kevin Geishendorf[3], Zbynek Šobáň[3], Gunther Springholz[6], Kamil Olejník[3], Libor Šmejkal[3], Tomas Jungwirth[3,7], Sebastian Tobias Benedikt Goennenwein[1,8], Andy Thomas[1,2], Helena Reichlová[3], Jakub Železný[3], and Dominik Kriegner[1,3] — [1]IFMP, TU Dresden — [2]IFW Dresden — [3]Institute of Physics, AV ČR, Prague — [4]Charles University, Prague — [5]Universidad del Norte, Barranquilla — [6]Semiconductor Physics, JKU Linz — [7]University of Nottingham — [8]University of Konstanz

It is known that collinear antiferromagnets cannot host a spin split band structure and therefore not show any anomalous Hall effect. Following the recent theory development [1], we experimentally show that this paradigm needs to be revised. We theoretically identify and experimentally confirm the symmetry components of the longitudinal and transversal anisotropic magnetoresistance in thin films of the compensated collinear antiferromagnet MnTe. We experimentally find a hysteretic signal odd in magnetic field in the transversal magnetoresistance, i.e. spontaneous anomalous Hall effect [2]. This effect can be rationalized considering nonmagnetic atoms at non-centrosymmetric lattice sites which break additional symmetries and cause a spin splitting in certain parts of the Brillouin zone.

[1] L. Šmejkal et al., Sci. Adv. 6, aaz8809(2020)
[2] R. D. Gonzalez Betancourt et al., (2021) *arXiv:2112.06805*