MA 30: Functional Antiferromagnetism

Time: Wednesday 9:30–12:45 Location: POT/0151

MA 30.1 Wed 9:30 POT/0151

Electric Current Control of Helimagnetic Chirality from a Multidomain State — •Yuta Kimoto[1], Hidetoshi Masuda[1], Jun-ichiro Ohe[2], Shoya Sakamoto[1], Takeshi Seki[1,3], and Yoshinori Onose[1,3] — [1]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan — [2]Department of Physics, Toho University, Funabashi 274-8510, Japan — [3]Center for Science and Innovation in Spintronics (CSIS), Core Research Cluster, Tohoku University, Sendai 980-8577, Japan

In helimagnets, magnetic moments form a helical spin order possessing chirality. In centrosymmetric crystals, two helical states with opposite handedness are degenerate; thus, chiral domains can coexist and form domain walls. Here, we study the domain wall dynamics under electric current in the helimagnet $MnAu_2$. We found that the threshold current required for the transition from the multidomain state to a single-chiral domain state in a magnetic field is much lower than that for chirality reversal from a single-chiral domain within certain ranges of temperature and magnetic field. The chirality after the transition depends on whether the magnetic field and electric current were parallel or antiparallel. Numerical calculations based on the Landau-Lifshitz-Gilbert equation reproduce our observations. These results indicate that the domain walls are highly mobile in the helimagnet, reflecting a pinning potential much smaller than the domain-nucleation energy. They also suggest that helimagnetic domain walls could serve as efficient information carriers, opening new avenues for spintronic applications, such as racetrack-type memory devices.

MA 30.2 Wed 9:45 POT/0151

Multistate probabilistic computing in the chiral kagome antiferromagnet Mn3Sn — •Prajwal Rigvedi[1], Jae-Chun Jeon[1], Kevin Callahan-Coray[2], Kerem Y. Camsari[2], and Stuart S.P Parkin[1] — [1]Max-Planck Institute of Microstructure Physics, Halle (Saale), Germany — [2]Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA, USA

Chiral kagome antiferromagnets such as Mn3Sn are promising candidates for spintronic applications due to their ultrafast spin dynamics and negligible stray fields. Their magnetic ground state exhibits six-fold degeneracy, which naturally supports multistate information processing. In this work, we investigate ultra-thin W/Mn3Sn bilayers and demonstrate spin-orbit torque-driven multistate probabilistic switching. Above a critical current density, stochastic fluctuations in the anomalous Hall resistance (Rxy) emerge, and their probability distribution can be continuously tuned with nanosecond electrical pulses. This tunability results in a sigmoidal response of Rxy to the applied current, enabling electrically controlled antiferromagnetic probabilistic bits with multiple accessible states. Leveraging experimentally obtained state statistics, we implement a graph coloring task, an NP-hard optimization problem. These results constitute the first experimental realization of multistate probabilistic switching in an antiferromagnet and demonstrate its applicability to non-deterministic computing tasks. Our findings position non-collinear antiferromagnets as a promising material platform for multibit spintronics, highlighting their potential for unconventional computing architectures.

MA 30.3 Wed 10:00 POT/0151

Antiferromagnetic Writing by Magneto-electric Field in Cr_2O_3 — Nikolai Khokhlov[1], •Aleksandr Buzdakov[2], Timur Gareev[1], Anatoly Zvezdin[3], Sergey Artyukhin[2], and Aleksei Kimel[1] — [1]Radboud University Nijmegen, Institute for Molecules and Materials, Nijmegen 6525 AJ, The Netherlands — [2]Istituto Italiano di Tecnologia, Via Morego 30, Genova 16163, Italy — [3]Moscow, Russia

Antiferromagnetic (AFM) spintronics is a promising platform for next-generation storage, offering high domain wall velocities and immunity to stray fields. However, a bottleneck remains: the lack of a low-power method to write arbitrary domains without high-density currents and Joule heating. Here, we demonstrate full, non-volatile control of AFM domains in magnetoelectric Cr_2O_3 at room temperature. Utilizing an electrically charged needle to "draw" domains under a magnetic bias, we find that approaching the Néel temperature is critical. In this regime, domain walls lose their elastic "rubber band" behavior, allowing complex shapes to stabilize. We rationalize this via the Larkin length, establishing that reliable storage requires a Larkin length smaller than the bit size. Our findings provide a model for domain writability in insulating antiferromagnets, paving the way for low-energy, electrically controlled AFM memory.

MA 30.4 Wed 10:15 POT/0151

Magnetic-phase-entangled orbital anisotropy in the van der Waals antiferromagnet $CrPS_4$ revealed by resonant inelastic X-ray scattering — •Zhijia Zhang[1], Yuan Wei[1], Carlos William Galdino[1], Cedomir Petrovic[2], and Thorsten Schmitt[1] — [1]Centre for Photon Science, Paul Scherrer Institut, Villigen PSI 5225, Switzerland — [2]Shanghai Advanced Research in Physical Sciences, Shanghai 201203, P.R. China

The emergence of exfoliable magnetic van der Waals (vdW) materials with weak inter-layer correlations enables physicists to study magnetism directly in two dimensions (2D). Their sustained magnetic order and other novel magnetic properties down to the 2D limit make them promising candidates for spintronic applications. $CrPS_4$ is an A-type antiferromagnetic vdW material with strong correlations between spin, orbital, and structural degrees of freedom, and its highly unusual magnetic properties has been the subject of considerable scientific and practical interests. In this talk, I will present our temperature-dependent X-ray absorption spectroscopy (XAS) and resonant inelastic X-ray scattering (RIXS) measurements on bulk $CrPS_4$ crystals. Both the XAS and RIXS spectra display significant linear dichroism. In particular, the linear-dichroic RIXS intensity of one of the orbital excitations shows an order-parameter-like temperature dependence below the Néel temperature; and the dichroism entirely disappears in the paramagnetic phase. This evidence strongly supports the role of the orbital anisotropy as the shaping agent of the magnetic states in $CrPS_4$.

MA 30.5 Wed 10:30 POT/0151

Impact of deposition parameters on magnonic properties of α-Fe_2O_3 thin films. — •Katharina Müller[1,2], Tobias Herrlich[1,2], Monika Scheufele[1,2], Matthias Opel[1], Hans Huebl[1,2,3], Rudolf Gross[1,2,3], Akashdeep Kamra[4], Matthias Althammer[1,2], and Stephan Geprägs[1] — [1]Walther-Meißner-Institut, BAdW, Garching, Germany — [2]TUM School of Natural Sciences, Munich, Germany — [3]Munich Center for Quantum Science and Technology, Munich, Germany — [4]Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, Kaiserslautern, Germany

Magnons in magnetic insulators are promising spin information carriers in future spintronic devices. For such applications, investigating and understanding the magnonic properties of thin films is crucial. Among the antiferromagnetic insulators, α-Fe_2O_3 is a prime example to study. Upon cooling, it features a Morin transition at 263 K from an antiferromagnetic easy-plane to an easy-axis phase below the Néel temperature. We obtain the magnetic anisotropy, the Dzyaloshinskii-Moriya interaction, as well as the magnon decay length from the magnon Hanle effect in all-electrical magnon transport experiments [1]. We study the dependence of these properties on the deposition parameters of α-Fe_2O_3 thin films grown on differently oriented Al_2O_3-substrates. Starting from a multi-domain state and driving the system with an external magnetic field, we use spin Hall magnetoresistance measurements to assess how the monodomainization field is influenced by the deposition parameters. [1] M.Scheufele *et al.*, APL Mater. **11**, 091115 (2023).

MA 30.6 Wed 10:45 POT/0151

Investigation of magnetic symmetries and domain imaging in antiferromagnetic Mn_2As via methods of electron microscopy — •Oleksandr Zaiets[1,2], Kamil Olejník[3], Filip Křížek[3], Jose Angel Castellanos-Reyes[4], Jan Rusz[4], Darius Pohl[2], and Axel Lubk[1,2] — [1]IFW Dresden, Germany — [2]TU Dresden, Germany — [3]Institute of Physics of the Czech — [4]Uppsala University, Sweden

Antiferromagnets are promising candidates for spintronic applications due to their ultrafast dynamics, low magnetic susceptibility, and lack of stray fields. Their switching behaviour is determined by the undisturbed antiferromagnetic ordering, the distribution of magnetic defects (notably domain walls) and their pinning to structural defects of the underlying crystal structure.

In this work we investigate antiferromagnetic Mn_2As thin films epitaxially grown on GaAs via methods of transmission electron microscopy, in particular high resolution imaging and electron diffraction. The antiferromagnetic ordering of Mn_2As entails a doubled magnetic unit cell compared to the structural one. This allows us to study purely magnetic Bragg reflections. The analysis of these reflections suggests the presence of a previously unknown antiferromagnetic phase. We furthermore reveal the presence of an antiferromagnetic domain structure by mapping the intensity of these reflections. We discuss stabilization mechanisms of this new AF ordering with the help of ab-initio methods. The strength of the antiferromagnetic signal is sufficient for domain mapping with sub-nanometer scale.

15 min break

MA 30.7 Wed 11:15 POT/0151

Creation of antiferromagnetic skyrmions by edge manipulation — •Aleksey Berg, Tim Matthies, and Elena Vedmedenko — University of Hamburg

Novel magnetic storage technologies rely on ferromagnetic topological objects to represent information. These objects can be created, propelled and annihilated by electric currents in racetracks. We have recently demonstrated theoretically that arbitrary sequences of coexisting ferromagnetic skyrmions and antiskyrmions can be processed via local rotations of magnetic moments at the edge of a rectangular slab, eliminating the need for global charge or spin currents [1]. This local manipulation can be achieved experimentally using rotating local magnetic fields or currents. Here, we demonstrate that edge rotation can be effectively applied to antiferromagnetic skyrmions, too. Furthermore, antiferromagnetic quasiparticles can be created and propelled without rotating the edge magnetisation, but rather by switching the local magnetisation at the racetrack edge. This low-energy manipulation of stable antiferromagnetic topological quasiparticles via local excitation would be highly advantageous in the field of antiferromagnetic spintronics. 1. P. Siegl et al., Phys. Rev. B 106, 014421 (2022)

MA 30.8 Wed 11:30 POT/0151

Field-induced spin-reorientation transitions in collinear antiferromagnet Cr_2O_3 — •Paulina J. Prusik[1,2], Igor Veremchuk[1], Florin Radu[3], Pavlo Makushko[1], Jürgen Fassbender[1,2], Kirill D. Belashchenko[4], Denys Makarov[1], and Oleksandr V. Pylypovskyi[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany — [2]Dresden University of Technology, Dresden 01062, Germany — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin 12489, Germany — [4]University of Nebraska-Lincoln, Lincoln, NE 68588, USA

We classify collinear antiferromagnets (AMFs) by presence in their σ-model of a term of exchange origin that couples the external magnetic field and gradients of the Néel vector. One representative material is the magnetoelectric, room-temperature, collinear AFM Cr_2O_3, which is promising for spintronics applications [1,2] as well as for fundamental research [3,4]. In Cr_2O_3 this term leads to a texture-induced magnetization with a finite component along the crystallographic c axis. By analyzing the field-induced spin-reorientation transitions, we find the appearance of a phase in which a field-induced domain wall lies in the basal plane at fields below the spin-flop field. The theoretical predictions are supported by X-ray magnetic linear dichroism measurements, which show that the transition field in thin films is reduced by nearly half compared to the single crystal. [1] Hedrich et al., Nat. Phys. 17, 574 (2021) [2] Rickhaus, Prusik et al., Nano Letters 24, 13172 (2024) [3] Makushko et al., Nat. Comm. 13, 6745 (2022) [4] Pylypovskyi et al., Phys. Rev. Lett. 132, 226702 (2024)

MA 30.9 Wed 11:45 POT/0151

Direct Observation of Hidden Excitonic States via Exciton-Magnon Coupling in CrSBr — Sophie Bork[1], •Richard Leven[1], Vincent Wirsdörfer[1], Alessandro Ferretti[2], Rafael Rojas Lopez[1], Mattia Benini[1], David Maximilian Janas[1], Umut Parlak[3], Alberto Brambilla[2], Alexey Scherbakov[1], and Mirko Cinchetti[1] — [1]Department of Physics, TU Dortmund University, 44227 Dortmund, Germany — [2]CNR-IFN Dipartimento di Fisica, Politecnico di Milano, 20133 Milan, Italy — [3]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany

Two-dimensional van der Waals magnets exhibit strong exciton binding and intrinsic magnetic order, enabling exciton-magnon coupling that links collective spin excitations with excitonic states. However, detecting dark excitons and their coupling remains challenging. Here we employ broadband transient reflectivity on CrSBr, a quasi-two-dimensional antiferromagnetic semiconductor, to probe excitonic structures across 1.25 - 1.65 eV under varying magnetic fields. We identify two excitonic resonances: a bright 1s exciton at 1.36 eV and a dark exciton near 1.46 eV, the latter revealed solely through exciton-magnon interactions. The detected GHz magnon mode exhibits magnetic-field-dependent frequency shifts and coupling signatures with both excitons. High-energy excitation modifies magnon dispersion and enhances exciton-magnon hybridization. These findings provide direct insight into exciton-magnon coupling in CrSBr and demonstrate that ultrafast optical probes can uncover hidden excitonic states, advancing understanding of hybrid quasiparticles in van der Waals magnets.

MA 30.10 Wed 12:00 POT/0151

Rocket-like dynamics of ferrimagnetic domain walls in graded magnets — •Pietro Diona[1,2], Sergey Artyukhin[2], and Luca Maranzana[2,3] — [1]Scuola Normale Superiore di Pisa, Pisa, Italia — [2]Istituto Italiano di Tecnologia, Genova, Italia — [3]Università di Genova, Genova, Italia

The domain wall motion underpins emerging spintronic technologies, such as high-speed racetrack devices and THz logic. Spatially nonuniform magnetic exchange and anisotropy in ferromagnets can pin or accelerate domain walls [1,2]. In ferrimagnets, where Walker breakdown is suppressed, domain walls can therefore approach the magnon speed [3]. Here we show that in non-uniform ferrimagnets such gradients not only exert a net force on the ferrimagnetic domain walls, but also modify the effective mass of the wall, enabling an entirely new acceleration mechanism. As a domain wall travels through regions of varying exchange or anisotropy, it can shed or gain effective mass leading to a "rocket effect" as in variable-mass systems. This phenomenon becomes increasingly pronounced as the wall approaches the magnon velocity [3], providing a natural route to ultrafast domain-wall propulsion. Our analytical theory, supported by micromagnetic simulations, suggests strategies for mass control in racetrack devices. These results establish variable-mass domain walls as a new paradigm for efficient, high-velocity spintronics and THz-frequency magnetic technologies.

[1] F. N. Tan et al., Scient. Rep., 9, 7369 (2019).
[2] P. Diona et al., IEEE Trans. on Elec. Dev., 69(7), 3675 (2022).
[3] P. Diona et al., Adv. Func. Mat., e22549 (2025).

MA 30.11 Wed 12:15 POT/0151

Revealing Magnetic Chirality in Non-Collinear Kagome Antiferromagnets through Spin-Seebeck Measurements — •Feodor Svetlanov Konomaev, Mithuss Tharmalingam, and Kjetil Magne Dørheim Hals — Department of Engineering Sciences, University of Agder, 4879 Grimstad, Norway

Non-collinear antiferromagnets (NCAFMs) are appealing for antiferromagnetic spintronics, as they combine the advantages of collinear antiferromagnets with novel emergent phenomena stemming from their complex spin structures. These phenomena are often associated with the intrinsic spin chirality, which characterizes the handedness of the ground-state spin configuration. Here, we investigate a kagome NCAFM interfaced with a normal metal and demonstrate that the groundstate vector spin chirality can be probed through measurements of the spin Seebeck effect (SSE). Starting from a microscopic spin Hamiltonian, we derive the corresponding bosonic Bogoliubov-de-Gennes Hamiltonians for the two chiral configurations. Using linear response theory, we obtain a general expression for the spin current thermally pumped into the normal metal by the SSE. We show that a sizable in-plane spin current emerges exclusively in the negative-chiral state, providing a direct signature for real-time detection of chirality switching in kagome NCAFMs. In addition, we find a field-dependent out-of-plane spin current whose magnitude differs between the two chiralities, reflecting their distinct magnon band structures

MA 30.12 Wed 12:30 POT/0151

Strain engineering of antiferromagnetic $LaFeO_3$ films for magneto-optical investigations — •Antonia Rieche, Wolfgang Hoppe, Chis Körner, Aurora Diana Rata, Andreas Herklotz, and Kathrin Dörr — Martin-Luther-Universität Halle-Wittenberg

$LaFeO_3$ is a representative member of the orthoferrites. This antiferromagnet exhibits a high Néel temperature of 740 K. A weak net magnetization is created due to a small tilting of the magnetic moments. $LaFeO_3$ is considered to be a promising candidate for antiferromagnetic spintronics.

While the magneto-optical Kerr effect (MOKE) has been used to investigate bulk crystals, only a single study has reported MOKE data for $LaFeO_3$. [1]

Our work demonstrates the magnetic switching behavior of coherently strained $LaFeO_3$ films. The strain states were generated using different substrates and helium implantation. [2] The films were grown using pulsed laser deposition (KrF 248 nm), and their strain state was analyzed by X-ray diffraction.

Longitudinal MOKE hysteresis and microscopy measurements revealed a strain-dependent orientation of the magnetization axis, which is consistent with predictions from density functional theory. [3] Further single-domain remanence has been confirmed.

[1] J. Alaria et al., Chem. Sci. 5, 1599 (2014)
[2] A. Herklotz et al., Adv. Science, 5, 1800356 (2018)
[3] A. J. Mao et al., RSC Adv. 6, 100526 (2016)