MA 18: Functional Antiferromagnetism I

Time: Tuesday 15:00–17:15 Location: HSZ 02

MA 18.1 Tue 15:00 HSZ 02

Magnetization dynamics in hybrid $Mn_2Au/Ni_{80}Fe_{20}$ system — •Hassan Al-Hamdo[1], Tobias Wagner[2], Yaryna Lytvynenko[2], Gutenberg Kendzo[1], Sonka Reimers[2], Moritz Ruhwedel[1], Misbah Yaqoob[1], Philipp Pirro[1], Olena Gomonay[2], Vitaliy I. Vasyuchka[1], Mathias Kläui[2], Martin Jourdan[2], and Mathias Weiler[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Institute of Physics, Johannes Gutenberg-University Mainz, 55099 Mainz, Germany

We study the magnetization dynamics of $Mn_2Au/Ni_{80}Fe_{20}$ thin film bilayers. This system allows us to control the Mn_2Au Néel vector orientation with moderate external magnetic fields [1].Furthermore, Mn_2Au enables current pulse induced switching of the Néel vector via Néel spin-orbit torques [2] making this system intriguing for antiferromagnetic spintronics. By varying the thickness of the ferromagnetic layer, we investigated the effect of strongly exchange coupled $Mn_2Au/Ni_{80}Fe_{20}$ interface on the spin dynamics. Broadband ferromagnetic resonance and Brillion light scattering experiments reveal that interfacial exchange coupling causes an increase in the resonance frequency of $Ni_{80}Fe_{20}$. Our theoretical model based on the modification of the spin-wave wavevector due to interfacial coupling yields good agreement with the experimental observations.

[1] Bommanaboyena et al., Nature Communications **12**, 6539 (2021) [2] Y. Lytvynenko et al., arXiv:2208.04048v1 (2022).

MA 18.2 Tue 15:15 HSZ 02

Magnetization dynamics in hybrid ferromagnetic / antiferromagnetic systems — •Tobias Wagner[1], Hassan Al-Hamdo[2], Mathias Weiler[2], and Olena Gomonay[1] — [1]Institut für Physik, JGU Mainz, Germany — [2]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU in Kaiserslautern, Germany

Strong exchange coupling between Mn_2Au and thin layers of Permalloy ($Ni_{80}Fe_{20}$) has been shown [1]. As a consequence, the coercive field of $Mn_2Au/Ni_{80}Fe_{20}$ was reported to be 0.5 T, which is high compared to 0.02 T in CuMnAs/Fe [2]. Due to strong exchange coupling, the AFM Néel vector and the ferromagnetic (FM) magnetisation rotate coherently, when an external field is applied to the FM. Control of the Néel ordered state in Mn_2Au and the $Ni_{80}Fe_{20}$ spin dynamics has been studied by varying the $Ni_{80}Fe_{20}$ layer thickness [3]. Ferromagnetic resonance spectroscopy revealed two distinct frequencies for the coupled bilayer system, both of which lie above the resonance frequency of Permalloy [3]. We calculate the spectra of the magnons in the coupled FM/AFM system within micromagnetic model. Our model enables us to demonstrate how the interfacial exchange coupling enables tuning of the ferromagnetic resonance frequency by variation of the thickness of the ferromagnetic layer. We estimate the exchange coupling strength to be 5 T [3]. References: [1] Bommanaboyena, S. P. et al., Nat. Comm. 12, 6539 (2021), [2] Wadley, P. et al., Sci. Rep. 7, 11147 (2017), [3] Al-Hamdo, H. et al., unpublished.

MA 18.3 Tue 15:30 HSZ 02

Optically Triggered Néel Vector Manipulation of a Metallic Antiferromagnet Mn_2Au under Strain — Vladimir Grigorev[1], Mariia Filianina[1], Yaryna Lytvynenko[1], Sergei Sobolev[1], Amrit Raj Pokharel[1], •Amon P. Lanz[1], Alexey Sapozhnik[2], Armin Kleibert[3], Stanislav Bodnar[4], Petr Grigorev[5], Yurii Skourski[6], Mathias Kläui[1], Hans-Joachim Elmers[1], Martin Jourdan[1], and Jure Demsar[1] — [1]JGU, Mainz, Germany — [2]École Polytechnique, Lausanne, Switzerland — [3]PSI, Villingen, Switzerland — [4]TUM, Munich, Germany — [5]Aix-Marseille Université, Marseille, France — [6]HZDR, Dresden, Germany

The absence of stray fields, their insensitivity to external magnetic fields, and ultrafast dynamics make antiferromagnets promising candidates for active elements in spintronic devices. Here, we demonstrate manipulation of the Néel vector in the metallic collinear antiferromagnet Mn_2Au by combining strain and femtosecond laser excitation. Applying tensile strain along either of the two in-plane easy axes and locally exciting the sample by a train of femtosecond pulses, we align the Néel vector along the direction controlled by the applied strain. The dependence on the laser fluence and strain suggests the alignment is a result of optically triggered depinning of 90° domain walls and their motion in the direction of the free energy gradient, governed by the magneto-elastic coupling. The resulting, switchable state is stable at room temperature and insensitive to magnetic fields. Such an approach may provide ways to realize robust high-density memory device with switching time scales in the picosecond range.

MA 18.4 Tue 15:45 HSZ 02

Long-distance magnon spin transport in Orthoferrites. — •E.F. Galindez-Ruales[1], S. Das[1], X. X. Ma[2], G. Jakob[1], S. X. Cao[2], R. Lebrun[3], and M. Kläui[1] — [1]Institute of Physics, Johannes Gutenberg University Mainz, Staudingerweg 7, 55128 Mainz, Germany. — [2]Department of Physics, Materials Genome Institute, International Center for Quantum and Molecular Structures, Shanghai University, Shanghai 200444, China. — [3]Unité Mixte de Physique CNRS, Thales, Université Paris-Saclay, Palaiseau 91767, France.

Antiferromagnets have advantages over ferromagnets, such as terahertz-range magnetization dynamics and stability against external magnetic fields. The efficient transport of spin waves has until now only been observed in the insulating antiferromagnet hematite [1]. In this work [2], we report long-distance spin transport in the antiferromagnetic orthoferrite $YFeO_3$; although the magnetic damping order is in the same range as hematite, the spin transport is different. At zero magnetic field, the magnon modes in $YFeO_3$ are linearly polarized, which cannot transport the spin angular momentum. Nevertheless, under an external magnetic field and the presence of DMI, spin information is carried by elliptically polarized modes. We observe a strong anisotropy in the magnon decay lengths that we attributed to the role of the magnon group velocity in the transport of spin waves in antiferromagnets. This unique mode of transport identified in $YFeO_3$ opens up all the canted antiferromagnets for long-distance spin transport. [1] Lebrun, R., et al. Nat Commun. 11, 6332 (2020). [2] Das, S., et al. Nat. Commun. 13, 6140 (2022).

15 min. break

MA 18.5 Tue 16:15 HSZ 02

Coexistence of antiferromagnetism and ferrimagnetism in adjacent honeycomb layers — •Lilian Prodan[1,2], Viorel Felea[1,2,3], Yurii Skourskii[3], Sergei Zherlitsyn[3], Joachim Wosnitza[3], Alexander Tsirlin[4], Vladimir Tsurkan[1,2], and Istvan Kezsmarki[1] — [1]Experimental Physics V, Institute of Physics, University of Augsburg, D-86159, Augsburg, Germany — [2]Institute of Applied Physics, MD 2028, Chisinau, R. Moldova — [3]Hochfeld-Magnetlabor Dresden (HLD-EMFL), HZDR, 01328 Dresden, Germany — [4]Felix Bloch Institute for Solid-State Physics, Leipzig University, 04103 Leipzig, Germany

Recent theoretical and experimental studies of the honeycomb antiferromagnets $A_2Mo_3O_8$ ($A =$ Mn, Fe, Co, Ni, Zn) revealed a plethora of fascinating effects, such as strong linear and non-linear magnetoelectric effects, giant magnetoelectricity, hidden ferromagnetism, and topological magnons, being of interest for both fundamental and applied research. Here, we report a sequence of metamagnetic transitions in the polar antiferromagnet $Co_2Mo_3O_8$ based on magnetization, torque and ultrasound measurements in static and pulsed magnetic fields up to 65 T. Our studies reveal a novel spin state that is composed of an alternating stacking of antiferromagnetic and ferrimagnetic honeycomb layers. The strong intra-layer and the weak inter-layer exchange couplings together with competing anisotropies at octahedral and tetrahedral Co sites are identified as the key ingredients to stabilize antiferromagnetic and ferrimagnetic layers in such a close proximity [1]. [1]. D. Szaller et al., arXiv:2202.04700 (2022).

MA 18.6 Tue 16:30 HSZ 02

Anisotropic effects in antiferromagnetic curvilinear spin chains — •Oleksandr V. Pylypovskyi[1,2], Yelyzaveta A. Borysenko[3], Denys Y. Kononenko[4], Kostiantyn V. Yershov[4], Ulrich K. Roessler[4], Artem V. Tomilo[1,3], Jeroen van den Brink[4], Jürgen Fassbender[1], Denis D. Sheka[3], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [2]Kyiv Academic University, 03142 Kyiv, Ukraine — [3]Taras Shevchenko National University of Kyiv, 01601 Kyiv, Ukraine — [4]IFW

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Curvilinear spin chains are simplest antiferromagnetic systems revealing direct influence of their shape onto magnetic states via geometry-tracking anisotropies stemming from the dipolar interaction [1] or local surrounding [2]. Here, we show that in addition to the strongest effect onto magnetic state from exchange (biaxial anisotropy and chiral energy term) [1], the local break of the translational symmetry in curvilinear anisotropic antiferromagnets leads to (i) the longitudinal Dzyaloshinskii-Moriya energy term stemming from the single-ion anisotropy and (ii) the local weakly ferromagnetic response [2]. Furthermore, non-zero curvature κ can drive the helimagnetic phase transition in the spin-flop phase and enables the intermediate canted state for rings with large enough κ. [1] O. Pylypovskyi, D. Kononenko et al., Nano Lett. 20, 8157 (2020); [2] O. Pylypovskyi et al., Appl. Phys. Lett. 118, 182405 (2021); [3] Y. Borysenko et al., Phys. Rev. B, 106, 174426 (2022).

MA 18.7 Tue 16:45 HSZ 02

Spin-current driven Dzyaloshinskii-Moriya interaction in the multiferroic BiFeO3 from first-principles — •Sebastian Meyer[1], Bin Xu[2,3], Matthieu J. Verstraete[1], Laurent Bellaiche[3], and Bertrand Dupé[1,4] — [1]Université de Liège, Belgium — [2]Soochow University, China — [3]University of Arkansas, USA — [4]Fonds de la Recherche Scientifique (FRS-FNRS), Belgium

The electrical control of magnons opens up new ways to transport and process information for logic devices. In magnetoelectrical multiferroics, the Dzyaloshinskii-Moriya (DM) interaction directly allow for such a control and, hence, is of major importance [1]. We determine the origin and strength of the (converse) spin current DM interaction [2,3] in the *R3c* bulk phase of the multiferroic $BiFeO_3$ based on density functional theory. Our data supports only the existence of one DM interaction contribution originating from the spin current model. By exploring the magnon dispersion in the full Brillouin Zone, we show that the exchange is isotropic, but the DM interaction and anisotropy prefer any propagation and magnetization direction within the full (111) plane. Our work emphasizes the significance of the asymmetric potential induced by the spin current over the structural asymmetry induced by the anionic octahedron in multiferroics such as $BiFeO_3$.

[1] P. Rovillain, *et. al.*, Nature Materials **9**, 975 (2010)
[2] H. Katsura, *et. al.*, Phys. Rev. Lett. **95**, 057205 (2005)
[3] D. Rahmedov, *et. al.*, Phys. Rev. Lett. **109**, 037207 (2012)

MA 18.8 Tue 17:00 HSZ 02

Decoding Antiferromagnetism via Quadrupolar Far Fields — •Michael Paulsen[1], Michael Fechner[2], Julian Lindner[3], Ralf Feyerherm[3], Jörn Beyer[1], Bastian Klemke[3], Yuki Lino[4], Tsuyoshi Kimura[5], Klaus Kiefer[3], and Dennis Meier[6,7] — [1]Physikalisch-Technische Bundesanstalt, Berlin, Germany — [2]Max Planck Institute for the Structure and Dynamics of Matter, CFEL, Hamburg, Germany — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Germany — [4]Division of Materials Physics, Osaka University, Japan — [5]Department of Advanced Materials Science, University of Tokyo, Japan — [6]Department of Materials Science and Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway — [7]Center for Quantum Spintronics, NTNU, Trondheim, Norway

Antiferromagnets possess zero net dipole magnetization, whereas magnetic higher-order contributions are, in principle, allowed by symmetry. Such higher-order contributions are, however, usually extremely weak and hard to detect experimentally. Here, we present low-temperature magnetometry measurements of the higher-order far fields of the antiferromagnetic model systems Cr_2O_3 and $TbMnO_3$, using a dedicated SQUID setup. Our results reveal exterior quadrupolar magnetic fields specific to the emergent microscopic spin textures, providing new opportunities for the characterization of antiferromagnets and materials with ultra-small remanent magnetization in general.