MA 59: Magnonics III

Time: Friday 9:30–12:30 Location: POT/0361

MA 59.1 Fri 9:30 POT/0361

Magnetization dynamics in RMn_6Sn_6 crystals investigated by broadband ferromagnetic resonance spectroscopy — •Philipp Schwenke[1], David Weffling[1,3], Kyle Fruhling[2], Vitaliy Vasyuchka[1], Fazel Tafti[2], and Mathias Weiler[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Department of Physics, Boston College, Chestnut Hill, MA 02467, USA — [3]Present address: Department of Physics and Materials Science, University of Luxembourg, L-4362 Esch-sur-Alzette, Luxembourg

The RMn_6Sn_6-material family is known for hosting complex magnetic orders [1]. Their Kagome and triangular lattices give rise to an unconventional band structure forming flat bands and Dirac cones leading to significant anomalous Hall- and Nernst-effects [2,3]. In this study, we investigate the magnetization dynamics of $ErMn_6Sn_6$ and $YbMn_6Sn_6$. We track characteristic phase transitions of the materials and the accompanying signatures in the magnetization dynamics over temperature. We find that the phase transitions are in agreement with previous results, while the spin dynamical signatures have not been discussed before. This study highlights the potential of using broadband ferromagnetic resonance spectroscopy to investigate the magnetic properties in RMn_6Sn_6

[1] L. Nil, *et. al*, Phys. Rev. B **111**, 054410 (2025)
[2] A. Bolens and N. Nagaosa, Phys. Rev. B **99**, 165141 (2019)
[3] K. Fruhling, *et. al*, Phys. Rev. Mat. **8**, 094411 (2021)

MA 59.2 Fri 9:45 POT/0361

Anisotropic magnon transports in van der Waals altermagnetic and ferromagnetic insulators — •Qirui Cui — Department of Applied Physics, School of Engineering Sciences, KTH Royal Institute of Technology, AlbaNova University Center, SE-10691 Stockholm, Sweden

Based on state-of-the-art first-principles calculations and model analysis [Nat. Rev. Phys. 5, 43-61 (2023)], we report the spin Seebeck effect (SSE) and spin Nernst effect (SNE) in vdW altermagnetic and ferromagnetic insulators, which are entirely independent of magnetic fields and spin-orbit coupling [Phys. Rev. B 108, L180401 (2023)]. In altermagnetic monolayers Cr2Te2O and Cr2Se2O, the breaking of combined symmetries of space inversion P, time reversal T, and translation τ, while preserving the combined symmetry of mirror M and τ, renders magnons with anisotropic spin-momentum locking, i.e., altermagnetic magnons. Interestingly, this spin-momentum locking gives rise to the SSE and SNE, with very efficient generation of longitudinal and transverse spin currents when the thermal gradient is aligned with and deviates from the main crystal axes, respectively. Moreover, anisotropic magnon dispersions are also realized in synthesized ferromagnetic monolayers CrPS4 and CrSBr, arising from C4 symmetry breaking-induced anisotropic exchange couplings [Adv. Funct. Mater. 35, 2407469 (2025)]. Consequently, without the magnetic field, the anisotropic SSE and the SNE emerge. These nontrivial magnonic transports can be further manipulated by the temperature and gate current.

MA 59.3 Fri 10:00 POT/0361

Magnon Shake-Up Enabling Quantum Features and Devices — •Vahid Azimi Mousolou — Department of physics and astronomy, Uppsala University

Shake-up effects, based on the sudden approximation and many-body quantum dynamics, reveal fundamental aspects of quantum systems and have broad applications in molecular spectroscopy and electronic structure analysis. Here, we present magnon shake-up patterns within magnetic systems [1], highlighting their significance in generating and detecting magnon entanglement and squeezing. This study offers new insights into shake-up phenomena in quantum magnonics and paves the way for novel developments in quantum technology.

[1] V. Azimi-Mousolou, A. Delin, E. Sjöqvist, O. Eriksson, Magnon Shake-up: Entanglement Generation and Sensing, arXiv:2503.20063 (2025).

MA 59.4 Fri 10:15 POT/0361

Optical vortex generation by magnons with spin-orbit-coupled light — •Ryusuke Hisatomi[1,2], Alto Osada[3], Kotaro Taga[1], Haruka Komiyama[1], Takuya Takahashi[1], Shutaro Karube[1,2], Yoichi Shiota[1,2], and Teruo Ono[1,2] — [1]Institute for Chemical Research, Kyoto University, Uji, Japan — [2]Center for Spintronics Research Network, Institute for Chemical Research, Kyoto University, Uji, Japan — [3]Center for Quantum Information and Quantum Biology (QIQB), Osaka University, Toyonaka, Osaka, Japan

Magneto-optic effects are generally described as the interaction between spin systems and collimated light (paraxial light). However, in many real-world systems studied in magneto-optics research, light focused by an objective lens (non-paraxial light) is utilized, which inherently exhibits optical spin-orbit coupling. Such spin-orbit-coupled light possesses a longitudinal electric-field component. Recently, we found that the interaction between spin-orbit-coupled light and collective spin dynamics (i.e., magnons) leads to optical vortex scattering, and we developed a theoretical framework to reproduce this phenomenon. The result provides the first step toward a comprehensive magneto-optics study incorporating optical vortices.

MA 59.5 Fri 10:30 POT/0361

Magnetization dynamics in YIG optomechanical crystals — •Matthias Grammer[1,2], Jonny Qiu[3], Sebastian Sailler[4], Sebastian T.B. Goennenwein[4], Matthias Althammer[1,2], Stephan Geprägs[1], Michaela Lammel[4], Eva Weig[3], and Hans Huebl[1,2] — [1]Walther-Meißner-Institut, BAdW, Garching, Germany — [2]School of Natural Sciences, TUM, Garching, Germany — [3]School of Computation, Information and Technology, TUM, Garching, Germany — [4]Department of Physics, University of Konstanz, Konstanz, Germany

Efficient transduction between microwave and optical photons is a key requirement for future quantum network applications. Recent studies have focused on freestanding magnetic nanostructures such as optomechanical crystals (OMC) based on yttrium iron garnet (YIG). These devices allow for co-localizing magnonic, elastic and photonic exitations in a single nanostructure. While the optical properties of a YIG OMC have already been experimentally shown [1], its magnonic and phononic modes have so far only been explored through simulations. In this talk, we present an experimental investigation of the magnetic modes in a YIG OMC. For our proof of principle study, we fabricated a non-suspended YIG OMC on a GGG substrate using sputtering and lift-off techniques. We investigate the collective magnon modes using spacially resoved micro-focused magneto-optical Kerr effect measurements and categorize the observed modes using micromagnetic simulations.

[1] A. Rashedi et al., Phys. Rev. Applied 24, 054017(2025).

MA 59.6 Fri 10:45 POT/0361

Direct observation of magnetic vortex resonances on curvilinear surfaces — •Sabri Koraltan[1], Takeaki Gokita[1], Michal Krupinski[2], Sebastian Wintz[3], and Amalio Fernández-Pacheco[1] — [1]Insitute of Applied Physics, TU Wien, Vienna, Austria — [2]Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland — [3]Institute for Nanospectroscopy, Helmholtz-Zentrum Berlin, Berlin, Germany

Spin waves in magnonic systems offer energy-efficient alternatives to conventional electronics [1], with low-frequency magnetic vortex resonances being particularly relevant for microwave applications [2]. While planar magnetic vortices have been extensively studied [2], their dynamics in three-dimensional curvilinear architectures remain largely unexplored. Here, we present the direct experimental observation of vortex core gyration on a 3D curvilinear surface [3]. Using a stripline antenna on a SiN membrane, we excite self-assembled polystyrene spheres coated with NiFe, which host a vortex lattice state at remanence. Time-resolved scanning transmission X-ray microscopy (TR-STXM) at BESSY II [4] captures real-space, time-resolved dynamics, revealing complex spin-wave modes due to curvature-induced field gradients. Our results highlight the potential of curvilinear magnetic architectures for next-generation magnonic devices.

[1] Chumak, Andrii V., et al. Nature physics 11.6 (2015): 453-461. [2] Yu, Haiming, et al. Physics Reports 905 (2021): 1-59. [3] Koraltan, Sabri, et al. In Preparation (2026). [4] Koraltan, Sabri, et al. Science Advances 10.39 (2024): eado8635.

15 min break

MA 59.7 Fri 11:15 POT/0361

Direction Selective Spin Waves Imaging in Microstructures
— •Roméo Beignon[1], Chris Köerner[2], Rouven Dreyer[2], Zeling Xiong[3], Katrin Schultheiss[3], Helmut Schultheiss[3], Vincent Jacques[1], Georg Woltersdorf[2], and Aurore Finco[1] — [1]Laboratoire Charles Coulomb, Université de Montpellier, CNRS, Montpellier, France — [2]Martin Luther University Halle-Wittenberg, Halle, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, Dresden, Germany

Spin waves can be generated and manipulated at the nanoscale using patterned microstructures and magnetization features. Harnessing these effects is key to the development of magnonic devices. With scanning NV microscopy, we are able to image spin waves with a spatial resolution of about 50 nm. Simultaneously, we probe the stray field produced by non-uniform static magnetic textures hosted in the microstructures and explore their interactions with spin wave modes.

Here, we apply this technique to observe spin waves in Permalloy microstructures. We first investigate spin waves generated via scattering and measure their dispersion relation. Then, we show that the NV center is sensitive to the handedness of the circularly polarized field emitted by spin waves. We can thus selectively image spin waves propagating in different directions and study how they interact with the edges of the Py structure. Finally, we observe discrete magnon modes with high azimuthal indices in disks featuring a vortex state. These measurements open the way to understanding complex nonlinear dynamic phenomena in magnetic microstructures.

MA 59.8 Fri 11:30 POT/0361

Time domain correlation spectroscopy of thermal and nonequilibrium magnons
— •F. S. Herbst[1], M. A. Weiss[1], C. Runge[1], N. Beaulieu[2], J. B. Youssef[2], A. Leitenstorfer[1], M. Lammel[1], R. Schlitz[1], and S. T. B. Goennenwein[1] — [1]Department of Physics, University of Konstanz, Germany — [2]LabSTICC, CNRS, Université de Bretagne Occidentale, France

Yttrium iron garnet (YIG) is a prototypical material for spintronics and magnonics due to its low magnetic damping and high spin wave propagation velocities. The properties of coherently excited, standing spin waves are well understood. However, much less is known about the interplay between coherently excited magnons and incoherent fluctuations, as schemes simultaneously resolving both coherent and incoherent contributions in a single measurement are scarce. In this work, we probe bismuth doped YIG with femtosecond noise correlation spectroscopy (FemNoC), an optical technique probing magnetization dynamics in the time domain. This method enables us to simultaneously investigate both the thermal magnon noise background and the coherent magnon response induced by microwave excitation. Using a phenomenological model, we can fit both the waveform and amplitude of the experimental data. This step allows us to quantify and disentangle the respective contributions by their correlation signature. Consequently, FemNoC gives access to the absolute magnon number of a magnetic system in the time domain.

MA 59.9 Fri 11:45 POT/0361

Nonlinearly controllable magnonic mode-converter in a synthetic antiferromagnet
— •Mujin You[1,2], Moojune Song[2], Jun Seok Seo[2], Sanghoon Kim[3], Yoichi Shiota[4], Teruo Ono[4], Se Kwon Kim[1], Albert M. Park[2], Kab-Jin Kim[2], Mathias Weiler[1], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserlautern-Landau, Germany — [2]Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Korea — [3]Department of Nano-semiconductor Engineering, University of Ulsan, Korea — [4]Institute for Chemical Research, Kyoto University, Uji, Japan

Exploring and controlling nonlinear regimes enables new functionalities in hybrid magnonic systems, including phenomena such as nonlinear anticrossing gap closure and bistability in magnon dispersion. In this work, we observe mode hopping between acoustic and optic modes in a SAF, occurring at the magnetic field where the optic frequency becomes twice the acoustic frequency-consistent with a three-magnon interaction process. Based on this nonlinear mode-hopping behavior, we demonstrate an electrically tunable, nanoscale GHz-range mode-converter. These findings reveal a promising application via nonlinear coupling between acoustic and optic magnons in SAFs, paving the way for energy-efficient, reconfigurable magnonic devices.

MA 59.10 Fri 12:00 POT/0361

$\mathbb{Z}$ Topological Index for 3D Hamiltonians based on Lattice Gauge Theory
— Nastaran Salehi and •Manuel Pereiro — Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

The characterization of topological phases in three-dimensional (3D) systems often requires extending concepts well-established in two dimensions (2D). We propose a robust method for calculating an integer topological invariant, akin to the Chern number, for 3D Hamiltonians with periodic boundary conditions. This approach utilizes conceptual elements derived from lattice gauge theory, defining the invariant over a discretized Brillouin zone (a 3-torus, T^3). By constructing U(1) link variables from the Bloch wavefunctions, we define a gauge-invariant quantity from Wilson loops over elementary 3D plaquettes (cubes) in k-space. The resulting topological index is an integer, reflecting the classification of principal fiber bundles $T^3 \times U(1)$ and related to the homotopy group $\pi_3(\mathbb{P}^2(\mathbb{R})) \cong \mathbb{Z}$. This method is general and computationally efficient, avoids issues with band degeneracies, and provides a unique integer invariant for each band. We adapt the method for magnetic Hamiltonians and showcase its effectiveness with two examples: firstly, a 3D Kagome lattice model, and secondly, a realistic material, Mn_3Se, for which the magnon spectra is obtained by employing electronic structure first-principles calculations.

MA 59.11 Fri 12:15 POT/0361

Second-Chern Topology of 3D Magnon Bands via a Field-Angle Pump
— •Nastaran Salehi and Manuel Pereiro — Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

We present a general framework to realize second-Chern topology in three-dimensional (3D) bosonic Bogoliubov-de Gennes (BdG) bands by augmenting the Brillouin zone with a slow, cyclic control parameter, yielding a 4D manifold $\mathbf{T}^3 \times S^1$. Using the bosonic metric Σ_3 and paraunitary gauge, we define the non-Abelian Berry connection/curvature for isolated positive-norm band bundles and an integer invariant $C_2 \in \mathbf{Z}$. We prove that C_2 quantizes an adiabatic transport: across a slab, the pumped conserved quantity (spin for magnons) per 2π cycle is an *integer* set by C_2, and the corresponding current is proportional to $\dot{\phi}$. We introduce a stable lattice algorithm, based on Σ_3-polar link variables, that is gauge covariant and robust in the presence of degeneracies. For the sake of concreteness and pedagogical clarity, we carry out the full derivation in a kagome-based 3D magnet, where a field-angle cycle drives a topological spin flow detectable via inverse spin Hall voltages in Pt contacts on opposing faces. Although illustrated for magnons, the construction applies broadly to quadratic bosonic BdG systems, including phononic and photonic analogues.