MA 9: Magnonics I

Time: Monday 15:00–18:30 Location: HSZ/0004

MA 9.1 Mon 15:00 HSZ/0004

Non-reciprocal phonon propagation along skyrmion strings
— •Riccardo Ciola[1], Naofumi Matsuyama[2], Markus Garst[1], Lars Franke[1], Yoshimitsu Kohama[2], Toshihiro Nomura[3], Sergei Zherlitsyn[4], and Shinichiro Seki[2] — [1]Karlsruhe Institute of Technology (KIT), Germany — [2]University of Tokyo, Japan — [3]Shizuoka University, Japan — [4]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany

Non-centrosymmetric cubic chiral magnets host two-dimensional skyrmion textures that extend in the third direction, forming strings. In this work, we investigate the influence of magneto-elastic coupling on the collective excitations of the incommensurate skyrmion lattice phase. Within a microscopic theoretical framework that combines a Ginzburg-Landau description of the chiral magnet with a coupling to the underlying atomic crystal, we predict that magneto-elastic interactions give rise to a pronounced nonreciprocity in the propagation of acoustic phonons along the skyrmion strings. This directional asymmetry stems from the hybridisation between skyrmion lattice magnon modes and acoustic phonons, resulting in hybridized quasiparticles with strongly modified dispersions. Furthermore, our theory predicts the emergence of a phason gap, i.e., a gap of the translational Goldstone mode of the skyrmion lattice induced by a distortion of the atomic crystal. Altogether, our findings establish skyrmion-based topological superlattices as a theoretical platform for engineering chimeric magnon-phonon excitations, opening new directions in quasiparticle design and emergent material functionalities.

MA 9.2 Mon 15:15 HSZ/0004

Magnetically controllable phononic crystals experimentally investigated by combined μSNS-MOKE and μBLS
— •Philipp Knaus, Maximilian Alexander Thiel, and Mathias Weiler — Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern, Germany

Phononic crystals (PnCs) enable tailored elastic wave propagation and bandgap formation in the GHz range [1]. We present a pillar-type PnC made of gold on a $LiNbO_3$ substrate for controlling Rayleigh surface acoustic waves (SAWs). Using broadband interdigital transducers and nanoscale patterning, we demonstrate a phononic bandgap of 50 MHz at 1.6 GHz. The dispersion relation and spatially resolved SAW fields are measured with a combined micro-focused Super-Nyquist-Sampling Magneto-Optic Kerr Effect (μSNS-MOKE) [2,3] and micro-focused Brillouin Light Scattering (μBLS) setup, providing frequency-, phase-, time-, and space-resolved detection. Measurements reveal clear suppression of SAW propagation within the bandgap and allow direct reconstruction of the dispersion relation. We additionally study the impact of magnetic field on the bandstructrue of PnCs fabricated from CoFe pillars. Paving the way for reconfigurable SAW waveguides, tunable filters, and active phononic devices.

[1] M. Sledzinska et. al, Adv. Funct. Mater. 8, 30 (2020)
[2] G. I. Stegeman, J. Appl. Phys. 49, 5624-5637 (1978)
[3] R. Dreyer, PhD Thesis, Uni Halle (2021)

MA 9.3 Mon 15:30 HSZ/0004

Coherent Magnetoelastic Phonon Generation in CMOS-Compatible Ni/Si Microstructures
— •Mohammad Javad Kamali Ashtiani[1], Johan Sebastian Ramirez Amado[2], Abbas Koujok[1], Hanadi Mortada[1,2], Björn Heinz[1], Asma Mouhoub[2], Thibaut Devolder[2], Philipp Pirro[1], and Alexandre Abbass Hamadeh[2] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Center de Nanosciences et de Nanotechnologies, CNRS, Universite Paris-Saclay, 91120, Palaiseau, France

We investigate coherent phonon generation in a CMOS-compatible device using Ni micro-striplines fabricated on Si. Due to the coherent precession of the magnetization in Ni and its significant magnetostriction, the free energy oscillates at the drive frequency. Under appropriate conditions, this leads to oscillation of elastic forces on the Si substrate, which launches a propagating surface acoustic wave (SAW). By sweeping the excitation frequency and external magnetic field, we identify resonant conditions for magnon excitation in Ni stripes, which leads to coherent phonon generation.

Under this resonant excitation (e.g., 2.35 GHz, 10 mT), we observe strong phonon emission by micro-focused Brillouin light scattering. These results demonstrate that Ni/Si microstructures provide an efficient platform for studying field-tunable magnon-phonon interactions and magnetoelastic phonon generation in non-piezoelectric media. This research was supported by ANR-25-CE24-6700-01 (SAWSiX) and the DFG through TRR-173/3-268565370 Spin+X (Project-B01).

MA 9.4 Mon 15:45 HSZ/0004

Phase-resolved imaging of coherent phonon-magnon coupling
— •Yannik Kunz[1], Florian Kraft[1], Kevin Künstle[1], Matthias Küss[2], Stephan Glamsch[2], Manfred Albrecht[2], and Mathias Weiler[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU in Kaiserslautern, Germany — [2]Institute of Physics, University of Augsburg, Augsburg, Germany

The interaction between surface acoustic waves (SAWs) and spin waves (SWs) has become a major focus in magnetoacoustic research, as numerous studies have demonstrated the efficiency of SAW-driven SW excitation [1,2]. However, the coherence of the underlying magnetoelastic driving mechanism has so far only been inferred indirectly from microfocused Brillouin light scattering measurements [3].
We employ spatially resolved polarization-modulating optical detection [4] to directly visualize the resonant SAW-to-SW conversion with phase sensitivity. Hereby, $LiTaO_3$ provides a platform to excite shear-horizontal SAW modes in a magnetostrictive $Co_{40}Fe_{40}B_{20}$(5 nm) layer. Our technique enables direct imaging of the coherent driving of spin waves by surface acoustic waves, providing advanced insights into the dynamics of phonon-magnon coupling.

[1] Küß et al., Frontiers in Physics 10, 981257 (2022)
[2] Kunz et al., Phys. Rev. Appl. 24, 014043 (2025)
[3] Kunz et al., Appl. Phys. Lett. 124, 152403 (2024)
[4] Liensberger et al. IEEE Magn. Lett. 10, 5503905 (2019)

MA 9.5 Mon 16:00 HSZ/0004

Magnon-polaron control in a surface magnetoacoustic wave resonator
— •Kevin Künstle[1], Yannik Kunz[1], Tarek Moussa[1], Katharina Lasinger[1,2], Kei Yamamoto[3], Philipp Pirro[1], John F. Gregg[2], Akashdeep Kamra[1], and Mathias Weiler[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, Kaiserslautern, 67663, Germany — [2]Clarendon Laboratory, Department of Physics, University of Oxford, Parks Road, Oxford, OX1 3PU, United Kingdom — [3]Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, 319-1195, Japan

We demonstrate strong coupling between confined phonons and finite-wavelength magnons, forming a magnon-polaron cavity with field-tunable coupling strength [1]. Our platform combines a low-loss YIG film with a ZnO-based surface acoustic wave (SAW) resonator, enabling exceptionally low magnon-polaron dissipation rates below $\kappa/2\pi < 1.5$ MHz. The observed hybridization is accurately captured by a phenomenological model including the spatial mode profiles of SAWs and spin waves. We further observe Rabi-like oscillations in the coupled SAW spin-wave system, revealing time-domain magnon-polaron formation and establishing a platform for engineered hybrid spin-acoustic excitations.

[1] K. Künstle et al., Nat. Commun. 16, 10116 (2025)

MA 9.6 Mon 16:15 HSZ/0004

Understanding change in the sound wave frequency in a ferromagnet under magnetic field influence (Simon effect) in the low-field regime
— •Ievgeniia Korniienko[1], Pablo Nieves[2], and Dominik Legut[1] — [1]IT4Innovations, VSB-TU Ostrava, Ostrava, Czech Republic — [2]University of Oviedo, Oviedo, Spain

The Simon effect exhibits itself as the dependence of the ultrasonic wave velocity in a ferromagnetic crystal under applied magnetic field and it was explained using linear theory of magnetoelasticity in 1958. However, the recent research in the interaction of surface acoustic waves with spin waves in ferromagnetic films, as well as widespread use of the pulse echo technique for the study of various materials, has renewed interest in better understanding of the Simon effect. In our work, based on the example of bcc Fe, we propose a refined formula to describe the Simon effect, which contains terms related to dispersion effects associated with the exchange stiffness. We compare our analytical solutions with other alternative computational approaches and show that dispersion effects can be significant and cannot be neglected in the low field regime. As a result, we propose a more accurate analytical formula [1], which, due to its relative simplicity, can become a convenient tool to estimate the magnitude of the magnetic field effect on the sound wave speed propagation in a cubic ferromagnetic crystal, as well as it explains observed deviations from analytically expected results in Simon effect at low magnetic field.

[1] I. Korniienko, et al.: Results in Physics, **73**, 108264 (2025).

MA 9.7 Mon 16:30 HSZ/0004

Magnon-phonon interaction in non-Bravais lattices — •Meritxell Valls Boix[1,2] and Alexander Mook[1,2] — [1]Münster University — [2]Johannes-Gutenberg Universität, Mainz

Non-Bravais lattices with a multi-band magnon spectrum can host a variety of geometrical and topological effects, such as Dirac magnons and nonzero Chern numbers. In this project, we re-examine the magnon-phonon interaction in such systems. In particular, we investigate how the quantum geometry of the magnon bands enters in the theory of magnon-phonon interactions.

15 min break

MA 9.8 Mon 17:00 HSZ/0004

All-YIG based functional magnonic crystals — •Rouven Dreyer, Bikash Das Mohapatra, Seth Kurfman, Georg Schmidt, and Georg Woltersdorf — Martin Luther University Halle-Wittenberg, Institute of Physics, 06120 Halle, Germany

For novel magnon-based applications, such as neuromorphic or reservoir computing, so far metallic ferromagnets with large saturation magnetization and high magnonic damping are the material of choice in order to locally manipulate the amplitude and phase of a propagating spin wave in an Yttrium-Iron-Garnet (YIG) layer underneath. Such YIG-metal heterostructures allow for sufficient control of band gaps in spin-wave dispersion in magnon-based Fabry-Perot-resonators or magnonic crystals [1]. In this work, we demonstrate an all-YIG based heterostructure, which imprints phase shifts and amplitude suppression on propagating waves due to the coupling of the device to the chiral spin wave. Thus, the YIG structure acts as a chiral magnonic resonator (CMR). These CMRs can be combined to realize magnonic crystals and allow for active control of individual gaps. To achieve this, the micron-sized YIG CMRs may be initialized in a different field state with respect to the YIG layer. In particular, an antiparallel magnetization alignment allows for sufficient suppression of a propagating Damon-Eshbach spin wave, as demonstrated by using spatially- and frequency-resolved SNS-MOKE [2].

[1] H. Qin et al., Nat. Commun. 12, 2293 (2021)
[2] R. Dreyer et al., PRM 5, 064411 (2021)

MA 9.9 Mon 17:15 HSZ/0004

Exchange-dominated spin waves in Ga:YIG nanowaveguides — •Andrey Voronov[1], Khrystyna Levchenko[1], Roman Verba[2], Kristyna Davidkova[1,3], Carsten Dubs[4], Michal Urbanek[5], Qi Wang[6], Dieter Suess[1], Claas Abert[1], and Andrii Chumak[1] — [1]Faculty of Physics, University of Vienna, Vienna, Austria — [2]V.G. Baryakhtar Institute of Magnetism of the NAS of Ukraine, Kyiv, Ukraine — [3]Vienna Doctoral School of Physics, University of Vienna, Vienna, Austria — [4]INNOVENT e.V. Technologieentwicklung, Jena, Germany — [5]CEITEC BUT, Brno University of Technology, Brno, Czech Republic — [6]Huazhong University of Science and Technology, Wuhan, China

Spin-wave computing offers a path beyond CMOS scaling, but miniaturization to the 100 nm regime limits long-distance spin-wave transport. Gallium-substituted YIG (Ga:YIG) addresses this challenge through its reduced saturation magnetization, enabling excitation of exchange-dominated spin waves with superior transport properties. We report a combined experimental and theoretical study of spin-wave propagation in Ga:YIG waveguides down to 145 nm width and 73 nm thickness. Using micro-focused Brillouin light scattering, TetraX simulations, and analytical dispersion modeling, we show that Ga:YIG supports spin waves with group velocities up to 600 m/s, largely independent of waveguide width, resulting in enhanced propagation lengths compared to pure YIG. These results demonstrate that gallium substitution enables faster and longer-lived spin waves, establishing Ga:YIG as a promising platform for nanoscale magnonic devices.

MA 9.10 Mon 17:30 HSZ/0004

Spin Hall micro-bars: Near zero effective magnetization for low oscillation-onset thresholds — •Abbas Koujok[1], Hidekazu Kurebayashi[2], kei Yamamoto[3], Björn Heinz[1], Abbass Hamadeh[4], Takeshi Seki[5], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, Kaiserslautern, Germany — [2]London Centre for Nanotechnology, University College London, London, United Kingdom — [3]Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, Japan — [4]Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, Palaiseau, France — [5]Institute for Materials Research, Tohoku University, Sendai, Japan

Spin Hall devices, being promising building blocks in magnonic circuitry, are progressively being researched in the context of lowering required driving charge currents. Here, the impact of near zero effective magnetization on reducing oscillation-onset threshold in magnetic spin Hall micro-bars is studied using micro-focused Brillouin light scattering spectroscopy. We show that a threshold current density reduction of more than two orders of magnitude can be achieved in comparison to the lowest reported values from other studies in this regard. This reduction shows that controlling the effective magnetization can pave the way to employ spin Hall based devices as energy efficient elements in magnonic circuitry.

MA 9.11 Mon 17:45 HSZ/0004

Pinch points in the dynamical spin structure factor of dipolar ferromagnets — Michal Stekiel[1], Christoph Resch[2], •Konrad Scharff[3], Markus Garst[3], and Christian Pfleiderer[2] — [1]Jülich Center for Neutron Science at MLZ, Jülich, Germany — [2]School of Natural Sciences, Technical University Munich, Garching, Germany — [3]Karlsruhe Institute of Technology, Karlsruhe, Germany

The long-range dipolar interaction gives rise to a pinch-point nonanalyticity in the dynamical spin structure factor of a ferromagnet [1]. Its experimental observation is challenging because the strength of the pinch-point singularity at zero magnetic field scales both with the magnetic moment and the size of the easy-plane anisotropy. We demonstrate that suitable materials for its detection are the rare-earth diborides, ErB2 and HoB2, as they possess a large magnetic moment on the order of 10 Bohr magneton and a pronounced easy-plane anisotropy two orders of magnitude larger than their direct exchange. In both materials, we were able to resolve pinch-point singularities in energy-momentum space using inelastic neutron scattering. The experimental signatures are quantitatively reproduced by a Heisenberg model with exchange, anisotropy and dipolar interaction.

[1] Jensen, J. and Mackintosh, A.R. Rare Earth Magnetism. Clarendon Press - Oxford (1991)

MA 9.12 Mon 18:00 HSZ/0004

Spin-wave emission with current-controlled frequency by a PMA-based spin-Hall oscillator — •Moritz Bechberger[1], David Breitbach[1], Abbas Koujok[1], Björn Heinz[1], Carsten Dubs[2], Abbass Hamadeh[3], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany — [2]INNOVENT e.V. Technologieentwicklung, D-07745 Jena, Germany — [3]Université Paris-Saclay, Centre de Nanosciences et de Nanotechnologies, CNRS, 91120, Palaiseau, France

Spin-Hall oscillators (SHOs) are of particular interest for neuromorphic computing, as they are able to synchronize via spin waves. We demonstrate a SHO based on low-damping gallium-substituted yttrium-iron-garnet (Ga:YIG) with perpendicular magnetic anisotropy (PMA). In-plane magnetized Ga:YIG allows for the operation at a high efficiency level while also enabling resonant spin-wave emission by exploiting the positive nonlinear frequency shift. Via micro-focused Brillouin light scattering spectroscopy, we investigate the properties of auto-oscillation and emission. Multiple modes are excited and compete internally, with two emitted modes detected up to distances larger than 10 μm. Their frequencies combine to an extended bandwidth of approximately 1.6 GHz. The observed two-mode system and its transition to a single mode at higher currents are reproduced via micromagnetic simulations, which account for spatial variation of the PMA arising due to the microstructures on Ga:YIG. Our results propose a promising platform for SHOs with long-range coupling via spin waves.

MA 9.13 Mon 18:15 HSZ/0004

Dispersion-tunable low-loss implanted spin-wave waveg-

uides — •Jannis Bensmann[1], Robert Schmidt[1], Kirill O. Nikolaev[3], Dmitrii Raskhodchikov[1,2], Shraddha Choudhary[1], Richa Bhardwaj[1], Shabnam Teheriniya[1,2,4], Akhil Varri[1,2], Sven Niehues[1], Ahmad El Kadri[1], Johannes Kern[1], Wolfram H. P. Pernice[1,2,4], Sergej O. Demokritov[3], Vladislav E. Demidov[3], Steffen Michaelis de Vasconcellos[1], and Rudolf Bratschitsch[1] — [1]University of Münster, Institute of Physics and Center for Nanotechnology, Münster, Germany — [2]University of Münster, Center for Soft Nanoscience, Münster, Germany — [3]University of Münster, Institute of Applied Physics, Münster, Germany — [4]Heidelberg University, Kirchhoff-Institute for Physics, Heidelberg, Germany

Spin waves offer a promising pathway toward energy-efficient information processing. Here, we present an etchless fabrication method for low-loss spin-wave waveguides in thin yttrium iron garnet (YIG) films using maskless silicon ion implantation. Focused Si-ion irradiation locally amorphizes YIG to create a low-magnetization cladding, effectively confining spin waves while preserving the pristine magnetic properties of the waveguide core. Spin-wave propagation is directly imaged via Faraday rotation microscopy, revealing decay lengths exceeding 100 μm even for submicron waveguides. By tuning the implantation dose and waveguide width, we achieve precise dispersion control. Our approach enables large spin-wave networks, offering a promising route toward magnonic integrated circuits.