MA 48: Magnonics II

Time: Thursday 15:00–18:00 Location: HSZ/0004

MA 48.1 Thu 15:00 HSZ/0004

Linear and nonlinear zero-field spin waves in transversally magnetised low-damping, half-metallic Co_2MnSi waveguides — •Anna Maria Friedel[1,2], Moritz Bechberger[1], Björn Heinz[1], Sébastien Petit-Watelot[2], Stéphane Andrieu[2], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Institut Jean Lamour, UMR CNRS 7198, Université de Lorraine, 54000 Nancy, France

We report on zero-field spin waves in the linear and nonlinear regime propagating over tens of micrometers in transversally magnetised Co_2MnSi waveguides. The remanent configuration is stabilised by the intrinsic cubic magnetocrystalline anisotropy of the $L2_1$-ordered Heusler compound, which enables an operation in the favourable Damon-Eshbach geometry, yielding large spin wave group velocities and propagation lengths associated with the large saturation magnetisation $M_s \approx 1000\,\text{kA/m}$ and the low Gilbert damping $\alpha \leq 10^{-3}$ in the half-metallic, $L2_1$-ordered Co_2MnSi. The cubic anisotropy not only allows for a reconfigurable remanent geometry and stable remanent operation, but also impacts the nonlinear magnetisation dynamics, yielding for instance a first order instability suppression range over several GHz. Investigating the linear and nonlinear dynamics in microstructured waveguides in remanence by Brillouin light scattering, this study consolidates the great interest in the half-metallic Co_2MnSi particularly for hybrid magnonic-spintronic applications at zero external bias fields.

MA 48.2 Thu 15:15 HSZ/0004

Long-range propagating paramagnon-polaritons in organic free radicals — •Sebastian Knauer[1], Roman Verba[2], Rostyslav O. Serha[1,3], Denys Slobodianiuk[2], David Schmoll[1,3], Andreas Ney[4], Sergej O. Demokritov[5], and Andrii V. Chumak[1] — [1]Faculty of Physics, University of Vienna, 1090 Vienna, Austria. — [2]V. G. Baryakhtar Institute of Magnetism of the NAS of Ukraine, 03142 Kyiv, Ukraine. — [3]Vienna Doctoral School in Physics, University of Vienna, 1090 Vienna, Austria. — [4]Institut für Halbleiter- und Festkörperphysik, Johannes Kepler Universität, 4040, Linz, Austria. — [5]Institute for Applied Physics, University of Münster, 48149 Münster, Germany.

Magnetic materials can host magnons below their Curie or Néel temperature, whereas in their paramagnetic phase, only short-range paramagnons are observed. We show that the organic free radical TEMPO supports long-range coherent spin dynamics well above its Néel temperature. Using all-electrical propagating spin-wave spectroscopy with on-chip microwave lines and external fields, we observe coherent excitations up to 23 GHz with group velocities above 100 km s^{-1} over 8 mm, exceeding calculated paramagnon velocities. Dispersion and pulse-propagation modelling identify these modes as paramagnon-polaritons, hybrid spin-photon excitations guided by the TEMPO column. This establishes organic free radicals as tunable paramagnetic magnonic media for microwave circuitry, spintronics, and high-frequency classical and quantum information processing [1].

[1] S. Knauer et al., RS, 2025 DOI: 10.21203/rs.3.rs-7990671/v1

MA 48.3 Thu 15:30 HSZ/0004

Nonlinear frequency mixing in spin-wave transducers — •Matthias Wagner, Felix Kohl, Björn Heinz, and Philipp Pirro — Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern- Landau, D-67663 Kaiserslautern, Germany

The demand for higher data transmission rates and high level of miniaturization has drawn attention to spin waves as a potential platform for building future radio frequency devices. So far, a lot of research has been carried out in optimizing prototype devices solely relying on continuous single-frequency operation. Nevertheless, the question how spin-wave transducers perform when real, multi-frequency signals are applied still is an open research subject that is especially relevant in the high-power regime where nonlinear spin-wave scattering leads to intermixing of frequency components within the passband. In this study, we quantify the nonlinear distortions caused by two-tone signals in spin-wave transducers by measuring relevant parameters, such as the 1-dB compression point and the third-order intercept point. Our results enable direct comparison between spin-wave based devices and conventional RF technology at the application level.

MA 48.4 Thu 15:45 HSZ/0004

Temperature-dependent characterization of spin-wave transducers — •Julien Schäfer, Björn Heinz, and Philipp Pirro — Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern- Landau, D-67663 Kaiserslautern, Germany

In radiofrequency technology, spin-wave-based (SW) communication building blocks, such as limiters and isolators, offer a low-energy alternative to traditional electronic devices. These magnonic communication devices consist of micrometer-sized antenna pairs that allow for tuning of the bandwidth and the frequency range through antenna shaping and adjustment of the applied magnetic field. Especially their compact size makes magnonic circuits attractive for on-chip integration, aiming to replace bulky electronic counterparts in crowded surroundings, such as cryostats and satellites. Following the objective to expand the SW transducer applicability to low-temperature environments, we study the propagation of SWs at various temperatures ranging from room temperature to 2 K. Understanding the impact of temperature-dependent variations in magnetic material parameters, including saturation magnetization and SW lifetime, on dispersive propagation characteristics is essential for engineering suitable devices. Our research provides insight into temperature-dependent insertion loss and isolation, consequently validating the applicability of SW transducers beyond room temperature conditions.

MA 48.5 Thu 16:00 HSZ/0004

Uniaxial strain response of antiferromagnetic magnons — •Manuel Knauft, Arthur von U.-S. Schwark, Matteo Minola, and Bernhard Keimer — Max Planck Institute for Solid State Research, Stuttgart, Germany

With the suggested paradigm shift away from conventional transistors towards lower loss devices, magnonics has attracted considerable attention in recent years. Generation, manipulation and detection of magnons are prerequisites for successful integration into microstructured chips. One potential phase space parameter to control magnon behavior is strain. In particular, in antiferromagnetic iridates with perovskite structure, it has recently been shown that the magnon energy can be varied by as much as 40% with small uniaxial strain of about 0.1% [1]. These ideas can also be extended to spatially inhomogeneous strain environments. We will demonstrate ideas of guiding magnons through bending single crystals and show results of finite element simulations and confocal Raman scattering.

[1] Kim *et al.*, Nat. Commun. **13**, 6674 (2022)

MA 48.6 Thu 16:15 HSZ/0004

Antiferromagnetic magnon condensation — •David Angster[1], Tobias Dannegger[1], Ulrich Nowak[1], and Verena Brehm[2] — [1]University of Konstanz, Germany — [2]Eindhoven University of Technology, Netherlands

The Bose-Einstein condensation (BEC) is a phase transition of a boson gas in which the ground state becomes macroscopically occupied below a critical temperature. BEC of bosonic quasiparticles, such as magnons, has been realised experimentally through active pumping of their density above a threshold value, since their number is not conserved in thermal equilibrium. This non-equilibrium magnon BEC was first demonstrated by Demokritov et al. [1]. Here, we present atomistic spin dynamics (ASD) simulations of antiferromagnetic hematite. The pumping of high-energy magnon modes triggers magnon redistribution via scattering processes that ultimately lead to condensation in the ground state, visible as an overproportional and non-thermal occupation of the low-frequency modes. Exploiting the non-linearity of ASD, we explore the key characteristics of BEC formation [2]: 1. a pumping threshold, 2. the spontaneous emergence of coherence, and 3. the shift of the magnon chemical potential.

[1] Demokritov et al., Nature 443, 430-433 (2006)
[2] Schneider et al., Nat. Nanotechnol. 15, 457-461 (2020)

MA 48.7 Thu 16:30 HSZ/0004

High-Resolution Field Mapping of Parametric-Instability Thresholds in YIG Films: Fine Structure and Magnon-

Phonon Hybridization — •Tamara Azevedo[1], Rostyslav O. Serha[2], Yannik Kunz[1], Matthias R. Schweizer[1], Vitaliy I. Vasyuchka[1], Mikhail Kostylev[3], Burkard Hillebrands[1], and Alexander A. Serga[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Faculty of Physics, University of Vienna, 1090 Vienna, Austria — [3]Faculty of Physics, University of Western Australia, 6009 Perth, Australia

Parametric electromagnetic pumping of magnons is a central technique for exciting and amplifying spin waves. Determining the parametric-instability threshold where the supplied energy compensates intrinsic magnon damping is essential for understanding and controlling this process. Using a highly sensitive automated measurement scheme based on quasi-continuous-wave excitation from a vector network analyzer and a microstrip resonator, we determined the instability threshold in tangentially magnetized yttrium-iron-garnet (YIG) films as a function of the external field $\mathbf{H}_0$ with unprecedented magnetic-field resolution. For parallel pumping, the threshold power exhibits distinct features originating from magnon hybridization with transverse and longitudinal phonons, as well as fine structure caused by the competitive excitation of thickness modes. These results highlight the dynamics specific to parallel parametric pumping that govern the onset of instability and provide crucial insight for efficient magnonic devices.

15 min break

MA 48.8 Thu 17:00 HSZ/0004

Stability of a magnon Bose-Einstein condensate under two-tone pumping — •Franziska Kühn[1], Lars Schiesser[1], Matthias R. Schweizer[1], Vitaliy I. Vasyuchka[1], Georg von Freymann[1,2], Mathias Weiler[1], Burkard Hillebrands[1], and Alexander A. Serga[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Fraunhofer Institute for Industrial Mathematics ITWM, Fraunhofer Platz 1, 67663 Kaiserslautern, Germany

In our work we investigate the stability of magnon Bose-Einstein condensates (BEC) in yttrium-iron-garnet films under two-tone pumping. First, to create a magnon BEC, the magnon gas is populated above the thermal level by external injection of magnons through parametric pumping. For flexible control of the excitation conditions, we employ a broadband microstrip antenna, allowing continuous tuning of the pumping frequencies. Second, after the magnon BEC is formed, its stability is tested by disturbing it with a second pumping pulse at a lower frequency. By shaking the magnon system without generating additional magnons, we aim to properly identify stability conditions of the magnon BEC in a time-varying environment. The measurements are performed using wave vector resolved Brillouin light scattering spectroscopy as an optical detection method for magnons. This research was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)-TRR 173/3-268565370 Spin+X (Project B04 and B13).

MA 48.9 Thu 17:15 HSZ/0004

Modelling spin-wave interference with electromagnetic leakage in micron-scaled spin-wave transducers — •Felix Kohl[1], Björn Heinz[1], Matthias Wagner[1], Christoph Adelmann[2], Florin Ciubotaru[2], and Philipp Pirro[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany — [2]imec, Kapeldreef 75, 3001 Heverlee, Belgium

Utilization of spin-wave transducers for radio-frequency signal processing provides significant potential due to intrinsic tunability, scalability and nonlinearity. However, such components can exhibit passband ripples, distortions in their transmission band, diminishing their operation and functionality. In this work, we experimentally identify the interference with the electromagnetic crosstalk (EM) as a major source of passband ripples and provide a simple analytic model to predict its impact on device operation. The results are in good agreement with the experimental observation. In addition, we test multiple transducer geometries to identify operational regimes and minimize the EM impact. Finally, the effect of nonlinear device operation on the interference with the EM is addressed, which is of relevance for the exploitation of the spin-waves intrinsic nonlinear traits.

MA 48.10 Thu 17:30 HSZ/0004

Avoided Crossings of Magnon Modes and Superconducting Lumped Element Resonator in YIG Microplatelet — •Seth W. Kurfman[1], Anoop Kamalasanan[1], Karl Heimrich[1], Philipp Geyer[1], Frank Heyroth[2], Kwangyul Hu[3], Tharnier Puel[3], Michael Flatté[3,4], and Georg Schmidt[1,2] — [1]Martin Luther Universität Halle-Wittenberg Institut für Physik, Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Halle, Germany — [3]University of Iowa Department of Physics and Astronomy, Iowa City, Iowa (USA) — [4]Eindhoven University of Technology Department of Applied Physics, Eindhoven, The Netherlands

Yttrium iron garnet (YIG) has been considered for decades as a gold standard material for magnonics due to its low-loss magnonic properties, and has successfully been used to demonstrate strong-coupling in macroscopic device geometries [1-4]. However, strong coupling of magnons in truly sub-10 micron YIG structures to date has not yet been realized. Here, we demonstrate the use of a YIG microplatelet placed on superconducting lumped element LC resonator to achieve strong coupling between numerous magnon modes and the LC resonator photons. These experimental findings are qualitatively backed by micromagnetic simulations and analytical calculations to identify the magnon modes corresponding to the experimentally observed anticrossings in the microwave transmission signal.

[1] Lachance-Quirion, et al., Appl. Phys. Express 12, 070101 (2019). [2] Zhang, et al. Phys. Rev. Lett. 113, 156401 (2014). [3] Tabuchi et al. PRL 113, 083602 (2014). [4] Huebl, et al., PRL 111, 127003 (2013).

MA 48.11 Thu 17:45 HSZ/0004

Auto-oscillations and directional magnonemission induced by spin current injection into large magnetic volumes — •R. Schlitz[1,2], V. E. Demidov[3], M. Lammel[1], S. O. Demokritov[3], and P. Gambardella[2] — [1]Department of Physics, University of Konstanz, Konstanz, Germany — [2]Department of Materials, ETH Zurich, Zurich, Switzerland — [3]Institute of Applied Physics, University of Muenster, Muenster, Germany

Magnons are quantized excitations of the magnetization texture in ordered magnets, which can be used to transport spin information. In magnetic insulator/heavy metal bilayers angular momentum conversion from the electrical to the magnonic domain allows to electrically generate and detect magnon spin currents in the magnetic layer [1]. Recent studies showed, that in the nonlinear regime the changes of the nonlocal transport allow to also obtain information on the transported magnon manifold [2,3]. We show that local modifications of the magnon dispersion in the nonlinear regime can sensitively affect nonlocal magnon transport, giving rise to a strong enhancement of the number of specific low energy magnons. Considering the role of nonlinear relaxation processes, the nonlocal transport can be understood in terms of the nonequilibrium modification of the magnon dispersion. Our results showcase that nonlocal transport measurements are a sensitive probe to unravel changes to the magnon manifold [4].

[1] L. J. Cornelssien et al., Nature Physics **11**, 1022-1026 (2015)
[2, 3] R. Kohno et al., Physical Review B **108**, 14410 and 14411 (2023)
[4] R. Schlitz et al., Nature Communications **16**, 8472 (2025)