MA 46: Magnonics II

Time: Thursday 15:00–18:00 Location: H 0110

Topical Talk MA 46.1 Thu 15:00 H 0110

Topological spin textures as spin-wave emitters — •Sebastian Wintz — Paul Scherrer Institut, Villigen PSI, Switzerland — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The investigation of propagating spin waves is a key topic of magnetism research [1]. For the excitation of short wavelengths, it was typically necessary to either use patterned transducers with sizes on the order of the desired wavelengths (striplines or point-contacts) or to generate such spin waves parametrically by a spatially uniform double-frequency microwave signal [2]. Recently, we found a novel mechanism for the local excitation of spin waves, which overcomes the lower wavelength limit given by the minimum patterning size. This method utilizes the translation of natural topological spin textures, e.g. the gyration of spin vortex cores, to generate spin waves [3]. Yet in terms of signal transfer, spin waves excited by a 0D defect, propagating isotropically in a 2D matrix suffer from a geometry induced amplitude decay. This decay is prevented when the dimensionality difference between source and host matrix is reduced to one. Here we will show that this can be achieved in vortex pair systems with moderate uniaxial intrinsic anisotropy, where domain walls may act both as 1D channels for directional wave propagation and as emitters for 2D plane waves [4]. Finally, we will address vortex core induced spin-wave excitation in single layer films [5]. [1] A.V. Chumak et al., Nat. Phys. 11, 453 (2015). [2] A.G. Gurevich, G.A. Melkov, Magnetization Oscillations and Waves. New York CRC, 1996. [3] S. Wintz et al., Nat. Nanotechnol. 11, 948 (2016). [4] V. Sluka et al. (unpublished). [5] G. Dieterle et al. (unpublished).

MA 46.2 Thu 15:30 H 0110

Tunable short-wavelength spin wave emission and confinement in anisotropy-modulated multiferroic heterostructures — Sampo J. Hämäläinen[1], Florian Brandl[2], Ben Van de Wiele[3], Kévin J. A. Franke[1], Dirk Grundler[2], and •Sebastiaan van Dijken[1] — [1]Department of Applied Physics, Aalto University, Finland — [2]Institute of Materials, EPFL, Switzerland — [3]Department of Electrical Energy, Ghent University, Belgium

Excitation of short-wavelength spin waves from a precise location is essential for the downscaling of magnonic devices. Here, we report on the generation and confinement of short-wavelength spin waves in a continuous film with periodically modulated magnetic anisotropy. The concept, which is demonstrated for strain-coupled CoFeB/$BaTiO_3$ heterostructures, relies on abrupt rotation of magnetic anisotropy at the boundaries of magnetic stripe domains. In combination with an external bias field, this produces a lateral variation of the effective magnetic field, leading to local spin wave excitation when irradiated by a microwave magnetic field. In domains with small effective field, spin waves are perfectly confined by the spin gap in neighboring domains. In contrast, standing spin waves in domains with large effective field radiate into neighboring domains. Using micromagnetic simulations, we show that the wavelength of emitted spin waves is tunable from a few micrometers down to about 100 nm by rotation of the bias field. We also demonstrate that dynamic fluctuations of the effective magnetic field and microwave spin-polarized currents can be used to excite exchange-dominated spin waves in multiferroic heterostructures.

MA 46.3 Thu 15:45 H 0110

Two-dimensional wave vector resolved transport measurements of magneto-elastic bosons — •Pascal Frey, Dmytro A. Bozhko, Alexander A. Serga, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Macroscopic quantum states—Bose-Einstein condensates (BECs) can be created in overpopulated gases of bosonic quasiparticles as excitons, polaritons or magnons. However, interactions between quasiparticles of a different nature, for example, between magnons and phonons in a magnetic medium, can significantly alter the properties of these gases and thus modify the condensation scenarios. Recently, we reported on the discovery of a novel condensation phenomenon mediated by the magnon-phonon interaction: an accumulation of hybrid magneto-elastic bosons. Unlike a BEC, the accumulated magneto-elastic bosons possess a nonzero group velocity, making them promising data carriers in prospective magnon spintronic circuits. Here, we present the results of two-dimensional transport measurements of magneto-elastic bosons in a single-crystal yttrium iron garnet film. Due to the strong magnetically induced anisotropy the curvature of the magnon-phonon spectrum is changed in the hybridization area and therefore we observe several spatially localized beams with different group velocities for the magnon-phonon hybrid states. The nature of the observed beams and their relations with caustic effects is discussed. This work is supported by the European Research Council within the ERC Advanced Grant "Supercurrents of Magnon Condensates for Advanced Magnonics".

MA 46.4 Thu 16:00 H 0110

Spin waves along domain walls in magnetic dots — Antonio Lara[1], Konstantin Y. Guslienko[2,3], Jose Luis Prieto[4], and •Farkhad G Aliev[1] — [1]Universidad Autonoma de Madrid, 28049 Cantoblanco-Madrid, Spain — [2]Universidad del País Vasco, 20018 San Sebastián, Spain — [3]IKERBASQUE, 48013, Bilbao, Spain — [4]Universidad Politécnica de Madrid, 28031, Spain

We discuss quasi one-dimensional spin waves in Permalloy dots of different geometries and in different magnetic states. Recent studies allowed observation of spin waves along domain walls in rectangular, circular [1] and triangular dos in the ground or metastable states. Triangular dots could also present edge pinned inhomogeneous magnetic states, depending on the direction of the external magnetic field. These edge domain walls yield the interesting, and potentially applicable in real devices property of broadband spin waves confinement to the edges of the structure [2,3] with capabilities to be redirected at angles exceeding 100 degrees. We also show how these waves could be generalized for arbitrary shapes and propose few devices (such as interferometers, controllers or splitters) where edge spin waves could be implemented. [1] F.G. Aliev, et al., Phys. Rev. B 84, 144406 (2011); [2] A. Lara, V. Metlushko, F. G. Aliev, J. Appl. Phys. 114, 213905 (2013); [3] A. Lara, J. Robledo, K.Y. Guslienko, F. G. Aliev, Sci. Reports, 7: 5597 (2017).

MA 46.5 Thu 16:15 H 0110

Optical effects in photonic-magnonic crystals — Yulia Dadoenkova[1,2,3], Nataliya Dadoenkova[1,3], Jaroslaw Klos[4], Maciej Krawszyk[4], and •Igor Lyubchanskii[3] — [1]Ulyanovsk State University, Ulyanovsk, Russian Federation — [2]Institute of Electronics and Information Systems, Novgorod State University, Veliky Novgorod, Russian Federation — [3]Donetsk Physical and Technical Institute of the National Academy of Sciences of Ukraine, Ukraine — [4]Faculty of Physics, Adam Mickiewicz University in Poznan, 61-614 Poznan, Poland

In this communication we present the results of theoretical investigation of Faraday and Goos-Haenchen (GH) effects in one-dimensional photonic-magnonic crystals (PMC) consisting of periodically distributed magnetic layers spaced by finite size dielectric photonic crystals. We found that the Faraday rotation of p-polarized incident light is increasing in the transmission band with the number of magnetic supercells. The increase of Faraday rotation is observed also in vicinity of the band-gap modes localized in magnetic layers but the maximal polarization plane rotation angles are reached at minimal transmittivity. We studied the GH effect, i.e., the lateral shift of the light beam transmitted through PMC and show that the increase of the number of periods in the photonic-magnonic structure leads to increase of the GH shift in the vicinity of the frequencies of defect modes located inside the photonic band gaps. We also investigated an influence of the linear magnetoelectric coupling in the magnetic layers on the Faraday rotation and GH effect in PMC.

MA 46.6 Thu 16:30 H 0110

Temperature dependent relaxation of magnons in yttrium iron garnet films — •Laura Mihalceanu[1], Vitaliy I. Vasyuchka[1], Dmytro A. Bozhko[1], Thomas Langner[1], Alexey Yu. Nechiporuk[2], Vladislav F. Romanyuk[2], Burkard Hillebrands[1], and Alexander A. Serga[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Germany — [2]Taras Shevchenko National University of Kyiv, Ukraine

The lifetime of magnons is of high relevance for the fields of magnonics, magnon spintronics and quantum computing. When approaching cryogenic temperatures, quantum phenomena in spin-wave systems pave the path towards quantum information processing. Also, an elongated magnon lifetime at low temperatures will allow to investigate the dynamics of a magnon Bose-Einstein condensates at long-time intervals. Here, the relaxation behavior of parametrically excited magnons was experimentally investigated in the temperature range from 20 K to 340 K in single crystal yttrium iron garnet (YIG) films epitaxially grown on gallium gadolinium garnet (GGG) substrates as well as in an ultrapure bulk YIG crystal. As opposed to the bulk YIG crystal in YIG films we have found a significant increase in the magnon relaxation rate below 150 K up to 10.5 times the reference value at 340 K in the entire range of probed wavenumbers. This increase is associated with rare-earth impurities contaminating the YIG samples with a slight contribution caused by coupling of spin waves to the spin system of the paramagnetic GGG substrate at the lowest temperatures. (arXiv:1711.07517) The work is supported by the DFG within the SFB/TR 49.

MA 46.7 Thu 16:45 H 0110

A spin waves optical pumping in reconfigurable magnonic crystal — Chia-Lin Chang[1], Szymon Mieszczak[2], Ronnie Tamming[1], Mateusz Zelent[1], Julius Janusonis[1], Piotr Graczyk[2], •Jarosław W. Kłos[2,3], and Raanan I Tobey[1] — [1]Zernike Institute for Advanced Materials, University of Groningen, Groningen, The Netherlands — [2]Faculty of Physics, Adam Mickiewicz University in Poznan, Poznań, Poland — [3]Ernst Moritz Arndt University, Greifswald, Germany

The laser interference pattern is used here to generate a transient magnonic crystal in Ni layer by the reduction of magnetization in periodically heated regions. The heat transferred by laser pulse produces also dynamic strain in the form of phase-locked elastic wave capable of preferentially driving precessional magnetization motion in different regions of the Ni layer. The magnetization dynamics is probed with the aid of time resolved Faraday effect. The observed spin wave dynamics is anisotropic with respect to the angle of in-plane applied magnetic field. We found that the anomalies in the angular dependence of the resonance field reveal spin wave localization effects. Calculations of the spin wave normal modes in a laterally varying magnetization landscape elucidate the localization tendencies, while an estimation of the elastic to spin wave mode excitation cross section qualitatively explains the experimental findings. Financial support from NCN Poland grants No. UMO-2012/07/E/ST3/00538 and No. UMO-2016/21/B/ST3/00452 and the EU's Horizon 2020 grant No. 644348 (MagIC).

MA 46.8 Thu 17:00 H 0110

Efficient excitation of perpendicular standing spin waves in nanometer-thick yttrium iron garnet films — •Huajun Qin, Sampo J. Hämäläinen, and Sebastiaan van Dijken — NanoSpin, Department of Applied Physics, Aalto University School of Science, P.O.Box15100, FI-00076Aalto, Finland

Spin waves in ferrimagnetic yttrium iron garnet (YIG) films are promising for low-power wave-like computing and magnon-based spintronics. The excitation frequency of spin waves in YIG is rather low because of its small saturation magnetization. For high-frequency magnonic devices, spin waves at higher frequencies are required. Here we demonstrate the efficient excitation of high-frequency exchange-dominated perpendicular standing spin waves (PSSWs) in nanometer-thick YIG films with a thin CoFeB capping layer. Using global microwave excitation fields, we measure intense PSSWs up to 10th order. We also observe strong hybridization between the PSSW modes in YIG and the FMR mode of CoFeB, causing characteristic anti-crossing behavior in the spin-wave spectra. We explain the excitation of PSSWs by a dynamic exchange torque at the YIG/CoFeB interface. The highly localized torque originates from exchange coupling between two forced magnetization oscillations of different amplitude in the YIG and CoFeB layers. As a consequence, spin waves are launched into both layers and a PSSW forms when the wave vector matches a confinement condition. No PSSWs are excited when the exchange coupling between YIG and CoFeB is suppressed by a nonmagnetic insertion layer.

MA 46.9 Thu 17:15 H 0110

Spin-wave transport in hexagonal nanotubes — Michael Zimmermann[1], Jorge Otálora[2], Sebastian Wintz[3], Elisabeth Josten[4], Tobias Schneider[4], Helmut Schultheiss[4], Jürgen Lindner[4], Christian Back[1], Jürgen Fassbender[4], and •Attila Kákay[4] — [1]Physics Department, University of Regensburg, 93040 Regensburg, Germany — [2]Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Institute for Metallic Materials, 01069 Dresden, Germany — [3]Paul Scherrer Institut, Villigen PSI, Switzerland — [4]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany

Spin-wave propagation in ferromagnetic nanotubes is fundamentally different than in flat thin films as shown recently[1]. In particular, the dispersion relation is asymmetric regarding the sign of the wave vector. As a consequence, spin waves traveling in opposite directions have different wavelengths. This purely curvature induced effect originates from the dipole-dipole interaction. Such non-reciprocal spin-wave propagation[2] is known for flat thin films with interfacial Dzyalonshiinsky-Moriya interaction. In this work we investigate spin-wave transport in nanotubes with hexagonal cross section using micromagnetic simulations and Scanning Transmission X-ray Microscopy. In contrast to round tubes the hexagonal tubes provide more channels - reciprocal and non-reciprocal ones - for spin-wave transport. [1] J.A. Otálora, et. al., Phys. Rev. Lett. 117, 227203 (2016). [2] K. Zakeri, et. al., Phys. Rev. Lett. 104, 137203 (2010).

MA 46.10 Thu 17:30 H 0110

Phonon-pulse-induced magnetization dynamics in magnetic tunnel junctions — •Hangfu Yang, Xiukun Hu, Sibylle Sievers, Mark Bieler, and Hans W. Schumacher — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany.

Manipulating the angular momentum of spins with external stimulus is a key issue in the field of spintronic with the aim to boost logic and memory applications. Here, we report time-domain measurements of magnetization dynamics in magnetic tunnel junctions (MTJs) driven by femtosecond-laser-induced phonon pulses through the inverse magnetostriction effect. The precession frequency is strongly dependent on amplitude and angle of the applied magnetic field. We find that the phonon-induced precession frequency differs from the precession frequency triggered by spin transfer torque. Most likely this is due to a spatially nonuniform precession mode excitation of the MTJ by the phonon pulses. Furthermore, we demonstrate coherent control of magnetization precession using two laser pulses at various magnetic fields and heating positions.

MA 46.11 Thu 17:45 H 0110

Controlling chiral domain walls in antiferromagnets using spin-wave helicity — •Alireza Qaiumzadeh, Lars Kristiansen, and Arne Brataas — Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

In antiferromagnets, the Dzyaloshinskii-Moriya interaction lifts the degeneracy of left- and right-circularly polarized spin waves. This relativistic coupling increases the efficiency of spin-wave induced domain-wall motion. In this talk, we report a fast all-magnonic helicity-dependent antiferromagnetic domain wall motion in the presence of the Dzyaloshinskii-Moriya interaction.