MA 45: Focus Session: Magnon Transport in Metallic Spin Textures

Organizer: J. Fassbender (Helmholtz-Zentrum Dresden-Rossendorf e.V.)

While prototypes of magnonic logic gates have been demonstrated already on macroscopic length scales, magnonics going beyond wave-based information processing remains to be exploited to full extent. One of the current hot topics is magnon transport in and the interaction with magnetic spin textures such as domain walls, vortices and skyrmions. Both, magnons and spin textures, have common ground set by the interplay of dipolar-, spin-orbit- and exchange energies rendering them perfect interaction partners. Magnons are fast, sensitive to the spin directions and easily driven far from equilibrium. Spin textures are robust, non-volatile and still reprogrammable on ultrashort timescales.

Time: Wednesday 15:45–18:00 Location: HSZ 04

Invited Talk MA 45.1 Wed 15:45 HSZ 04

Manipulating Room Temperature Magnetic Skyrmions — •Axel Hoffmann — Materials Science Division, Argonne National Laboratory, Lemont, Illinois 60439, U.S.A.

Magnetic skyrmions are topologically distinct spin textures and can be stable with quasi-particle like behavior, where they can be manipulated with very low electric currents. Using magnetic multilayers we demonstrated that inhomogeneous charge currents allow the generation of skyrmions at room temperature in a process that is remarkably similar to the droplet formation in surface-tension driven fluid flows [1]. Micromagnetic simulations reproduce key aspects of this transformation process and suggest a possible second mechanism at higher currents that does not rely on preexisting magnetic domain structures [2]. Indeed, we demonstrated this second mechanism experimentally using non-magnetic point contacts. Using this approach, we demonstrated that the topological charge gives rise to a transverse motion on the skyrmions, i.e., the skyrmion Hall effect [3], which is in analogy to the ordinary Hall effect, which is due to the motion of electrically charged particles in the presence of a magnetic field.

This work was supported by the U.S. Department of Energy, Office of Science, Materials Sciences and Engineering Division.

[1] W. Jiang, et al., Science 349, 283 (2015).
[2] O. Heinonen, et al., Phys. Rev. B 93, 094407 (2016).
[3] W. Jiang, et al., Nature Phys., doi:10.1038/nphys3883 (2016).

Invited Talk MA 45.2 Wed 16:15 HSZ 04

Spin wave caustics and channelling in chiral spin systems — •Joo-Von Kim — Centre for Nanoscience and Nanotechnology (C2N), CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91405 Orsay, France

Spin waves are elementary excitations in magnetic systems and have attracted renewed attention due to possible applications in information processing. In ultrathin films and nanostructures, the presence of chiral interactions of the Dzyaloshinskii-Moriya form can lead to a number of interesting phenomena such as nonreciprocal propagation and channelling. We will present some recent theoretical work in this area, namely the appearance of caustics and interference patterns generated by a point source in continuous films [1], nonreciprocal channelling along chiral domain walls [2], and edge channelling states in nanostructured media [3]. These results may benefit future device development by illustrating how unidirectional flow of spin wave power can be achieved in realistic material systems.

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[1] J.-V. Kim *et al.*, Phys. Rev. Lett. **117**, 197204 (2016).
[2] F. Garcia-Sanchez *et al.*, Phys. Rev. Lett. **114**, 247206 (2015).
[3] F. Garcia-Sanchez *et al.*, Phys. Rev. B **89**, 224408 (2014).

15 min. break

Invited Talk MA 45.3 Wed 17:00 HSZ 04

Snell's Law for Spin Waves — •Johannes Stigloher[1], Martin Decker[1], Helmut Koerner[1], Kenji Tanabe[2], Takahiro Moriyama[3], Takuya Taniguchi[3], Hiroshi Hata[3], Marco Madami[4], Gianluca Gubbiotti[4], Kensuke Kobayashi[5], Teruo Ono[3], and Christian Back[1] — [1]University Regensburg , Regensburg, Germany — [2]Nagoya University, Nagoya, Japan — [3]Kyoto University, Uji, Japan — [4]Universita di Perugia, Perugia, Italy — [5]Osaka University, Osaka, Japan

Snell's law is well known in optics and describes refraction of light at the transition between two media with different dispersion relations. In our experiments, we model this transition by a thickness step in a ferromagnetic material. Spin waves are excited in a Permalloy film of 60 nm thickness and propagate into a film of 30 nm thickness. Since these two regions have different dispersion relations [1-3] we are able to observe Snell's law for spin waves by measuring the refraction for a variety of samples with varying incident angles [3]. Snell's law for spin waves deviates from Snell's law in optics, since the spin wave dispersion relation is anisotropic, i.e. it depends strongly on the angle of propagation direction with respect to the external field [4].

[1] K. Tanabe et al., Appl. Phys. Exp. 7, 053001 (2014). [2] J.N. Toedt et al., Phys Rev B 93, 184416 (2016). [3] J. Stigloher et al., Phys. Rev Lett., 117,037204 (2016). [3] B.A. Kalinikos and A.N. Slavin, J. Phys. D: Solid State Physics 19, 7013 (1986).

MA 45.4 Wed 17:30 HSZ 04

Magnon-skyrmion scattering in chiral magnets — •Markus Garst — Institut für Theoretische Physik, Technische Universität Dresden, Zellescher Weg 17, 01062 Dresden, Germany

Chiral magnets support topological skyrmion textures due to the Dzyaloshinskii-Moriya spin-orbit interaction. We discuss the interaction between such a magnetic skyrmion and its small-amplitude fluctuations, i.e., the magnons in a two-dimensional chiral magnet. The magnon spectrum includes few magnon-skyrmion bound states, in particular, a breathing mode and a quadrupolar mode, which will give rise to subgap magnetic and electric resonances. Due to the skyrmion topology, the magnons scatter from an emergent flux density that leads to skew and rainbow scattering, characterized by an asymmetric and oscillating differential cross section. As a consequence of the skew scattering, a finite density of skyrmions will generate a topological magnon Hall effect. Using the conservation law for the energy-momentum tensor, we demonstrate that the magnons also transfer momentum to the skyrmion. As a consequence, a magnon current leads to magnon pressure reflected in a momentum-transfer force in the Thiele equation of motion for the skyrmion. This force is reactive and governed by the transport scattering cross sections of the skyrmion; it causes not only a finite skyrmion velocity but also a large skyrmion Hall effect.

[1] C. Schütte and M. Garst, Phys. Rev. B 90, 094423 (2014)
[2] S. Schroeter and M. Garst, Low. Temp. Phys. 41, 817 (2015)

MA 45.5 Wed 17:45 HSZ 04

Frequency-division multiplexing in magnonic networks by spin-wave caustics — •Frank Heussner, Alexander A. Serga, Burkard Hillebrands, and Philipp Pirro — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany

Frequency-division multiplexing is the basis for parallel data processing in a single device and for efficient information transport through logic circuits. In such networks, signals at different frequencies are used to simultaneously transfer information through the same conduits in different frequency channels.

In this work, we present an approach for the realization of frequency-division multiplexing in magnonic networks, where spin waves (SW) are used to transport information and to perform logic operations by exploiting, e.g., interference effects. In particular, we utilize non-diffractive spin-wave beams in in-plane magnetized 2D magnetic media, so called SW caustics, which originate from the anisotropic SW dispersion. By using micromagnetic simulations, we demonstrate how the frequency dependency of the propagation direction of SW caustics can be used to split SW signals of different frequencies into different SW waveguides. Finally, we present the design of a passive device at the micrometer scale which performs frequency-division multiplexing in a magnonic network.

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