MA 48: Magnetization / Demagnetization Dynamics IV

Time: Thursday 15:00–17:15 Location: EB 301

MA 48.1 Thu 15:00 EB 301

Magnetic reversal and magnetization dynamics in artificial ferromagnetic quasicrystals — •Vinayak Bhat[1,2], Barry Farmer[2], Lance DeLong[2], Joseph Sklenar[3], John Ketterson[3], and Justin Woods[2] — [1]Technical University of Munich, Munich, Germany — [2]University of Kentucky, Lexington, USA — [3]Northwestern University, Evanston, USA

Studies on ferromagnetic (FM) antidot arrays, i.e. arrays of non-magnetic regions in an otherwise continuous FM thin film, so far have been restricted to periodic lattices [1]. We have fabricated artificial FM quasicrystals (AFQs) in the form of connected networks of nanostructured Permalloy segments on five-fold rotationally symmetric (but aperiodic) Penrose P2 tilings (P2Ts) [2]. Low-field DC magnetization curves M(H,T) indicate abrupt transitions between ordered magnetization textures, and novel "asymmetric" ferromagnetic resonance modes are found to exist on only one side of the field origin accompanying "knee" anomalies in M(H,T). We argue that AFQs behave also as novel artificial spin ice systems that exhibit non-stochastic switching, pinned Dirac monopoles, and Dirac strings due to their aperiodicity and inequivalent pattern vertices.

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[1] S. Neusser et al., Adv. Mater. 21, 2927 (2009). [2] V. S. Bhat et al., Phys. Rev. Lett. 111, 077201 (2013).

MA 48.2 Thu 15:15 EB 301

Fokker-Planck approach to the theory of magnon-driven spin Seebeck effect — •Levan Chotorlishvili and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Heinrich-Damerow-Str. 4, 06120 Halle, Germany

Considering the spin Seebeck effect we calculate the mean value of the total spin current flowing through a normal-metal/ferromagnet interface. The spin current emitted from the ferromagnet to the normal metal is evaluated in the framework of the Fokker-Planck approach for the stochastic Landau-Lifshitz-Gilbert equation. We show that the total spin current depends not only on the temperature difference between the electron and the magnon baths, but also on the external magnetic field and the magnetic anisotropy. In addition, the spin current is shown to saturate with an increasing magnon temperature, and the saturation temperature increases with increasing the magnetic field and/or the magnetic anisotropy. Based on the solution of the stochastic Landau-Lifshitz-Gilbert equation which is discretized for a ferromagnetic chain subject to a uniform temperature gradient, we performed a detailed numerical study of the spin dynamics with a focusing particularly on finite-size effects. Our particular aim was to study the spin Seebeck effect beyond the linear response regime. We find that within our model the microscopic mechanism of the spin Seebeck current is the magnon accumulation effect quantified in terms of the exchange spin torque. // Ref: S. R. Etesami et al Phys. Rev. B 90, 014410 (2014); L. Chotorlishvili et al Phys. Rev. B 88, 144429 (2013).

MA 48.3 Thu 15:30 EB 301

Hybridisation of azimuthal spin waves with higher order gyromodes in magnetic vortex structures — •M. Noske[1], G. Dieterle[1], M. Weigand[1], J. Förster[1], M. Fähnle[1], H. Stoll[1], A. Gangwar[1,2], G. Woltersdorf[3], A. Slavin[4], C.H. Back[2], and G. Schütz[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart — [2]Department of Physics, University of Regensburg — [3]Department of Physics, Martin Luther University Halle — [4]Department of Physics, Oakland University, Rochester, MI, USA

Hybridization with the fundamental gyromode (G0) in magnetic vortex structures results in the well known frequency splitting of CW and CCW rotating azimuthal spin waves. Here we focus on the higher order gyromodes G1 and G2, characterized by a strong z dependence of their magnetization with one or two nodes in z direction. We demonstrate that hybridizations exist, not only between the fundamental gyromode G0 and azimuthal spin waves, but also between these spin waves and higher order gyromodes. Three-dimensional micromagnetic simulations have been performed in Permalloy discs, diameter 500 nm, with thicknesses varying from 5 nm to 100 nm. At small sample thicknesses, hybridisation with higher order gyromodes does not play a role. With increasing sample thicknesses the z dependence of the magnetization of azimuthal spin waves is significantly altered by a hybridisation with the G1 gyromode (in a medium thickness range) and the G2 mode (at larger sample thicknesses). However, hybridisation with these higher gyromode is only observed at those spin waves where their senses of rotation correspond with that of the gyromodes.

MA 48.4 Thu 15:45 EB 301

Electrical determination of vortex state in sub-micron magnetic elements — •Ajay Gangwar[1,2], Hans G. Bauer[1], Jean-Yves Chauleau[1], Matthias Noske[2], Markus Weigand[2], Hermann Stoll[2], Gisela Schütz[2], and Christian H. Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg, Germany — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany

Magnetic vortices, characterized by two boolean topological quantities: chirality (c) and polarity (p), are currently under close scrutiny [1]. We have studied vortex dynamics excited by spin transfer torque and found that the vortex states can be detected electrically by analyzing homodyne voltage signals generated by the anisotropic magneto-resistance (AMR) effect [2]. An in-plane external dc magnetic field is required to rectify the homodyne signal which can be measured with a nanovoltmeter. The sign of this DC voltage changes with the handedness (+cp or -cp) of the vortex state which makes the AMR effect a promising technique to investigate vortex states electrically. In addition, the vortex dynamics was also observed by direct imaging in a Scanning Transmission X-ray Microscope in order to verify the measured AMR signal, in particular its correct range of power and frequency. Our experimental results have found to be consistent with micromagnetic simulations which gives us a better understanding of the experimental outcome and proofs the validity of the AMR technique. [1] M. Kammerer et al., Nature Commun. 2, 279 (2011). [2] M. Goto et al., PRB 84, 064406 (2011).

MA 48.5 Thu 16:00 EB 301

Parametric amplification of spin waves in a microstructured magnonic waveguide — •Thomas Brächer, Frank Heussner, Philipp Pirro, Tobias Fischer, Alexander A. Serga, and Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Parallel parametric amplification has proven to be a useful means of spin-wave excitation and amplification in microstructured magnonic waveguides. Therefore, it is a very versatile tool for the field of magnonics, where the limited lifetime of magnons still constitutes a major limitation for, e.g., the construction of microstructured magnonic circuits.

Here, we report on some of the perspectives and limitations of the this technique. In particular, we focus on the velocity and the range of spin waves which are amplified throughout their propagation along a magnonic waveguide. We show that, for the use of a single amplification pulse, one has to find a trade-off between a fast signal propagation and a large range of the amplified spin waves. Here, the latter is limited by the amplification of the thermal noise.

MA 48.6 Thu 16:15 EB 301

Spin-wave propagation within domain-walls — •Kai Wagner, Thomas Sebastian, Attila Kákay, and Helmut Schultheiss — Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Research efforts to deploy spin waves as information carriers in micro- and nano-structured ferromagnetic materials have increased tremendously over the recent years. However, tailoring guided spin-wave propagation in two dimensions still remains a delicate challenge. Here we demonstrate spin-wave transport inside a domain-wall. For this, we perform micromagnetic simulations for thin film elements in a Landau state. To excite spin-wave resonances inside the domain-wall we apply pulsed as well as cw-excitation in a constricted area at the domain-wall-edge. We find several spin-wave modes of different energies with well distinguished wave vectors. They exhibit a positive dispersion and propagate along the domain-wall towards the vortex core. Domain-walls, thus, open the perspective for reprogrammable and yet non-volatile spin-wave waveguides of nanometer width. Financial support

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MA 48.7 Thu 16:30 EB 301

Design of a fully functional spin-wave majority gate — •Stefan Klingler, Philipp Pirro, Thomas Brächer, Britta Leven, Burkard Hillebrands, and Andrii V. Chumak — Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Magnon-Spintronics aims to replace the electron charge as information carrier by the transport of spin via the fundamental excitations of the magnetization - spin waves and their quanta the magnons - in order to utilize novel methods and effects in the solid state for future information technology. Information can then be stored in the spin-waves' phase, and thus the data processing occures by the interference of different spin waves.

One important step towards the application of spin-wave devices is the realization of a majority gate, due to its configurability and functionality. It allows to evaluate the majority of an odd number of input signals, and can be used to rebuild multiple logic operations with a single gate like AND-, OR-, NAND- and NOR-operations.

Here, we present the microstructure design and numerical simulations of a fully functional three-input spin-wave majority gate, as well as a spin-wave mode section process, which allows for a single-mode operation therein. For this, we use the material parameters of YIG and spatial dimensions which ensure an easy fabrication. By superimposing the different input waves in the gates, the resulting interference patterns in the output signal will have the same phase, as the majority of the incoming spin waves. With this, the full majority operation is processed and the truth table of the function is reproduced.

MA 48.8 Thu 16:45 EB 301

Evolution of Spin Wave Modes in Periodically Perturbed Thin Films — •Manuel Langer[1,2], Rodolfo A. Gallardo[3], Anja Banholzer[1], Tobias Schneider[1,2], Kai Wagner[1], Pedro Landeros[3], Kilian Lenz[1], Jürgen Lindner[1], and Jürgen Fassbender[1,2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden — [2]Technical University Dresden, 01069 Dresden — [3]Technical University Valparaíso, Valparaíso, Chile

The transition from a continuous thin film to a magnonic crystal is studied by ferromagnetic resonance (FMR).
Ion irradiation as well as reactive ion beam etching were used to realize a periodic modulation of the sample surface after patterning by electron beam lithography.
Mode-splitting in the FMR spectra has been investigated dependent on the size of the perturbations and compared to available analytical perturbation theory. Numerical simulations have been carried out to identify the spin waves corresponding to the mode spectra as well as to understand deviations between measurement and analytical theory for large perturbations.
This work is supported by DFG grant LE2443/5-1.

MA 48.9 Thu 17:00 EB 301

A scenario for dynamic magnonic spin-wave traps — Frederik Busse[1], •Maria Mansurova[1], Benjamin Lenk[1], Marvin von der Ehe[2], and Markus Münzenberg[2] — [1]I. Physikalisches Institut, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institut für Physik, Greifswald University, Felix-Hausdorff-Straße 6, 17489 Greifswald, Germany

This work contributes to the understanding of spin waves behavior in periodically structured magnetic materials [1,2] subject to a heat gradient. We use an all-optical approach to both excite and detect spin waves using short (femtosecond) pulses. The femosecond laser pulse is used twofold: It allows generating spin-waves locally, and as we demonstrate in this work, the same pulse can be used to create defined thermal gradient in a periodic array of antidots. The saturation magnetization varies as a function of temperature due to the spatial thermal profile induced by the femtosecond pump pulse that persists for up to one nanosecond. We consistently observe a shift of 0.5 GHz of the excited spin waves towards higher frequencies as we perform spatially-resolved measurements. Moreover, no spin waves are detected outside the excitation spot. This is explained by considering that a temperature gradient imposes additional scattering as spin waves are continuously reflected when entering a colder region with higher saturation magnetization and can be used as a dynamic trap for the femtosecond laser driven spin-wave excitations.

[1] H. Ulrichs, et al. Applied Physics Letters 97, 092506 (2010)
[2] B. Lenk, et al. Physics Reports 507, 107 (2011)