MA 49: Magnetization Dynamics III of 3

Time: Friday 9:30–12:00 Location: H22

MA 49.1 Fri 9:30 H22

Driving magnetization dynamics via mid-infrared phonon excitation — •Sebastian Mährlein[1], Ilie Radu[2], Michael Gensch[3], Alexey Kimel[4], Alexandra Kalashnikova[5], Roman Pisarev[5], Martin Wolf[1], and Tobias Kampfrath[1] — [1]Fritz Haber Institute of the Max Planck Society, 14195 Berlin, Germany — [2]Helmholtz-Zentrum Berlin BESSY II, 12489 Berlin, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [4]Radboud University Nijmegen, Nijmegen 6525AJ, The Netherlands — [5]A.F. Ioffe Physical Technical Institute, St. Petersburg 194021, Russia

The fundamental interactions between electrons, spins and the lattice of a solid have always been subject of large scientific interest. Here, we investigate the coupling between phonons and the ordered spin system of ferrimagnetic oxides on ultrashort time scales, an elusive and actively debated issue of modern ultrafast magnetism.

For this purpose, we use intense electromagnetic pulses at terahertz (THz) frequencies, from both table-top and accelerator-based sources, to resonantly excite a specific phonon mode. The impact of this vibrational excitation on the spin system is monitored by detecting the transient Faraday rotation of a subsequently arriving optical probe pulse. As such, we obtain access to the magnetization dynamics with a time resolution of down to 10fs. These mode-selective pumping experiments show a response of the spin system on a timescale of few picoseconds and thus indicate an (ultra)fast spin-lattice interaction. The possible underlying coupling mechanisms will be discussed.

MA 49.2 Fri 9:45 H22

The ultrafast demagnetization-time and -rate of Ni after laser pulse irradiation within the Elliott-Yafet theory — •Christian Illg, Michael Haag, and Manfred Fähnle — Max-Planck-Institut für Intelligente Systeme, Heisenbergstr. 3, 70569 Stuttgart, Germany

It is well known that a thin Ni film demagnetizes within about 100 fs after irradiation with a strong fs laser pulse [1]. Several mechanisms have been proposed which try to explain this effect but until now the underlying mechanism is still unclear [2].

We use the Elliott-Yafet theory which has the electron-phonon scattering as underlying mechanism and which we have extended to ferromagnets [3]. We calculate the demagnetization-time and -rate in Ni by using the ab-initio spin-density-functional theory (realistic electronic states) and an ab-initio force-constant model [4] (realistic phonon states). Finally, we compare the results with experimental data for low laser fluences.

Furthermore, the total angular momentum conservation during the demagnetization process is discussed thoroughly.

[1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996)
[2] M. Fähnle, C. Illg, J. Phys.: Condens. Matter 23, 493201 (2011)
[3] D. Steiauf, C. Illg, M. Fähnle, J. Magn. Magn. Mater. 322, L5 (2010)
[4] C. Illg, B. Meyer, M. Fähnle, Phys. Rev. B 86, 174309 (2012)

MA 49.3 Fri 10:00 H22

Left-right symmetry breaking of spin wave propagation in magnetic tubes — •Attila Kákay[1], Ming Yan[2], and Riccardo Hertel[3] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Deutschland — [2]Shanghai University, Shanghai, China — [3]IPCMS, CNRS UMR 7504, Strasbourg, France

A recent micromagnetic study [1] predicted chiral symmetry breaking of domain wall (DW) dynamics in magnetic nanotubes. This striking behavior arises from the curvature of the magnetic surface. In this investigation based on our micromagnetic finite-element code TetraMag [2], we show that the curvature of the tube surface does not only affect the DW motion, but has also a significant effect on the spin wave propagation. We observe a left-right symmetry break in the propagation of Damon-Eshbach type spin waves. The waves are excited by applying locally a monochromatic high-frequency magnetic field. We find that in tubular geometries with purely azimuthal magnetization, spin waves with the same frequency, surprisingly, display different wavelengths when propagating to the left or to the right. Therefore, the magnon dispersion relation of magnetic tubes does not only depend on the wave number, but also on its sign. Our systematic micromagnetic analysis shows that this effect is scale-invariant and that it originates from the magnetostatic interaction. We conclude that this is a general property of ferromagnetic curved surfaces and tubes.

[1] M. Yan, C. Andreas, A. Kákay, F. Garcia-Sanchez and R. Hertel, *Appl. Phys. Lett.* **100** 252401 (2012) [2] A. Kákay, E. Westphal and R. Hertel, *IEEE Trans. Magn.* **46** 2303 (2010)

MA 49.4 Fri 10:15 H22

Elastically driven ferromagnetic resonance in nickel thin films — •Matthias Pernpeintner[1], M. Weiler[1], L. Dreher[2], H. Huebl[1], R. Gross[1], M. S. Brandt[2], and S. T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany

Recently, it has been shown that elastic strain induced by coherent phonons in a ferromagnet can be used to resonantly excite magnetization precession via magnetoelastic coupling [1,2]. In our experiments, we study hybrid structures consisting of a bulk $LiNbO_3$ crystal covered by a thin nickel film. A surface acoustic wave (SAW) propagating on the $LiNbO_3$ surface induces coherent phonons in the Ni film. The resulting magnetization dynamics are studied as a function of orientation and strength of an externally applied, static magnetic field. We present an analytical model as well as numerical calculations which quantitatively reproduce our experimental results. Furthermore, we analyse the effects of the SAW type on the magnetization dynamics. We also present recent experimental data obtained from a $LiTaO_3$/Ni hybrid structure, which supports both Rayleigh and shear-horizontal waves. Our results open the path for radio-frequency magnon-phonon coupling experiments, e.g., acoustic spin pumping. Financial support from the DFG via SPP 1538 SpinCAT and the Excellence Cluster Nanosystems Initiative Munich (NIM) is gratefully acknowledged.

[1] M. Weiler *et al.*, Phys. Rev. Lett. **106**, 117601 (2011)
[2] L. Dreher *et al.*, Phys. Rev. B **86**, 134415 (2012)

MA 49.5 Fri 10:30 H22

Configurational dependence of the magnetization dynamics in spin valve systems — •Ruslan Salikhov[1], Radu Abrudan[1], Frank Brüssing[1], Florin Radu[2], Ilgiz Garifullin[3], Kurt Westerholt[1], and Hartmut Zabel[1] — [1]Ruhr-Universität Bochum, Germany — [2]Helmholtz Zentrum Berlin für Materialien und Energien, Berlin, Germany — [3]Zavoisky Physical-Technical Institute of Russian Academy of Sciences, Kazan, Russia

Using time-resolved x-ray resonant magnetic scattering (tr-XRMS), which was implemented using the ALICE chamber at BESSY II of the Helmholtz Zentrum Berlin [1], we report on the precessional dynamics of spin valve systems with parallel (P) and antiparallel (AP) orientation of magnetizations. We observe in Co/Cu/Py spin valve systems an increase of the magnetic damping parameter in Py with changing magnetization direction of Py and Co layers from P to AP orientation [2]. We attribute this finding to the configurational dependence of the spin pumping effect [3]. Furthermore we studied the temperature dependence and possible other causes for the configurational dependence of the damping parameter, such as domain wall induced coupling or magnetic dipole coupling [4]. The main focus is on Co/Cu/Py trilayers and on Co2MnGe/V/Py trilayers with spin valve properties.

[1] St. Buschhorn et al., J. Synchr. Rad. 18, 212 (2011). [2] R. Salikhov et al., Appl. Phys. Lett. 99, 092509 (2011). [3] J.-V. Kim, C. Chappert, JMMM 286, 56 (2005). [4] R. Salikhov et al., Phys. Rev. B 86, 144422 (2012).

MA 49.6 Fri 10:45 H22

A new resonance in vortex core switching based on an interaction between gyromode and spin-waves — •Markus Sproll[1], Hans Bauer[2], Matthias Kammerer[1], Matthias Noske[1], Georg Dieterle[1], Ajay Gangwar[2], Markus Weigand[1], Hermann Stoll[1], Georg Woltersdorf[2], Christian Back[2], and Gisela Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart, Germany — [2]Department for Experimental Physics, University of Regensburg, Germany

The discovery of low-field vortex core (VC) switching using the sub-GHz vortex gyromode [1] as well as the much faster VC reversal by excitation of magnetostatic azimuthal spin waves in the multi-GHz range [2] mark milestones in the chapter of non-linear magnetic VC dynamics and finally lead to switching times within less than 100 ps. Here we report on surprising and unexpected new effects which have been observed by experiments at the MAXYMUS x-ray microscope at BESSY II, when the linear (sub-GHz) gyromode and circular (multi-GHz) spin waves are excited simultaneously. (i) A lowering of up to one order of magnitude of the spin wave mediated VC switching threshold is found with increasing gyromode excitation, explained by an interference of the spin waves with the excited gyromode rotation and (ii) a new additional resonance at 2.5 GHz appears which is explained by frequency doubling leading to a generation of the 'regular' 5 GHz (n=1, m=-1) spin wave mode - but only, if the sub-GHz gyromode is excited simultaneously. [1] Van Waeyenberge et al., Nature 444, 461 (2006); [2] Kammerer et al., Nature Communications 2, 279 (2011)

MA 49.7 Fri 11:00 H22

Spin wave mediated sub-100 ps vortex core reversal — •M. Noske[1], M. Weigand[1], M. Kammerer[1], M. Sproll[1], G. Dieterle[1], A. Gangwar[3], B. Van Waeyenberge[2], H. Stoll[1], G. Woltersdorf[3], C. Back[3], and G. Schütz[1] — [1]MPI for Intelligent Systems, Stuttgart — [2]Department of Solid State Science, Ghent University, Belgium — [3]Department of Physics, Regensburg University

Low field magnetic vortex core (VC) reversal by exciting the sub-GHz vortex gyromode [1] has triggered intensive studies of VC dynamics, also due to its potential for spintronics applications. Recently we could speed up VC switching significantly by exciting magnetostatic azimuthal spin wave modes with rotating multi-GHz ac magnetic field bursts [2,3]. In this contribution we demonstrate VC switching times below 100 ps and unidirectional VC reversal in sub-micron Permalloy discs by excitation with two orthogonal unipolar magnetic field pulses of 50 ps. The magnetization dynamics during VC reversal were imaged by time-resolved scanning transmission X-ray microscopy at the MAXYMUS endstation at BESSY II with time and spatial resolution of 45 ps and 25 nm. Phase diagrams for VC reversal were obtained by varying lengths, amplitudes and the sense of rotation of the pulse sequence revealing a small parameter range for selective VC reversal. All our results are in good agreement with micromagnetic simulations.

[1] B. Van Waeyenberge et al., Nature 444, 461-464 (2006).
[2] M. Kammerer et al., Nature Communications 2, 279 (2011).
[3] M. Kammerer et al., PRB 86, 134426 (2012).

MA 49.8 Fri 11:15 H22

Spin waves in a microstructured metallic magnonic crystal with periodic variation of the saturation magnetization — •Björn Obry[1], Thomas Brächer[1,2], Philipp Pirro[1], Andrii V. Chumak[1], Florin Ciubotaru[1], Alexander A. Serga[1], Julia Osten[3], Jürgen Fassbender[3], and Burkard Hillebrands[1] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, 67663 Kaiserslautern, Germany — [3]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany, and TU Dresden, 01062 Dresden, Germany

We study spin waves in a microstructured magnonic crystal consisting of a $Ni_{81}Fe_{19}$ (Permalloy) waveguide with a periodic variation of the saturation magnetization M_S. By localized ion implantation of the waveguide a modification of the saturation magnetization to $M_S/M_S^0 = 0.93$ has been obtained. Brillouin light scattering microscopy measurements of the spin-wave propagation spectrum yield two pronounced band gaps, where spin-wave propagation is prohibited. Two cases of the spin-wave excitation inside and outside the magnonic crystal region are presented. Due to the narrow band gaps achieved by the absence of topographical structuring and due to the existence of nonlinear multi-magnon interactions this magnonic crystal allows for a deeper insight into the general wave dynamics in metamaterials.

MA 49.9 Fri 11:30 H22

Nonreciprocal spin waves excitation in perpendicular magnetized Permalloy microstructures — •Florin Ciubotaru, Alexander Serga, Andrii Chumak, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Spin waves in micro- and nanosized magnetic structures have attracted growing attention due to the prospective applications in magnon spintronic devices. For example, the use of phase and amplitude of spin waves as an information carrier in magnetic logic circuits is extensively studied. The control of spin-wave excitation and the manipulation of their propagation characteristics is of crucial importance for the development of such devices. Here we report on micromagnetic simulations [1] of the spin-wave emission from a nanosized antenna in perpendicular magnetized Permalloy microstructures. We show that depending on the film thickness the same antenna exhibit either a symmetric or an asymmetric spin-wave radiation. In addition, the character of the spin-wave emission can be controlled by the excitation frequency at a fixed bias magnetic field. Support from DFG (grant SE-1771/1-2) is gratefully acknowledged. [1] OOMMF open code, M. J. Donahue, and D. G. Porter, Report NISTIR 6376, NIST, Gaithersburg, MD (1999).

MA 49.10 Fri 11:45 H22

Effects of the lattice discreteness on the Damon-Eshbach mode — •Julian Hüser, Thomas Kendziorczyk, and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Spin wave dispersion relations in ferromagnetic thin films are often calculated within a continuum model based on the Landau-Lifshitz equation thereby neglecting the underlying lattice structure in real materials. In this talk we present and analyze some differences between the magnetostatic modes obtained in a lattice model and the well known results of Damon and Eshbach. For this purpose we calculate the spin wave dispersion with a discrete model consisting of classical spins which are stacked on a cubic lattice and interact only via dipolar forces. The discrete model yields new qualitative features in comparison with the results of Damon and Eshbach. We observe several surface modes and the degeneracy of the spin waves which propagate perpendicularly to the applied magnetic field is lifted. These modes form a quasi-continuous volume band in which hybridizations between the modes take place.