MA 16: Magnetization and Demagnetization Dynamics I

Time: Tuesday 9:30–12:30 Location: H34

MA 16.1 Tue 9:30 H34

Three-dimensional Character of the Magnetization Dynamics in Magnetic Vortex Structures — •Matthias Noske[1], Hermann Stoll[1], Manfred Fähnle[1], Georg Dieterle[1], Johannes Förster[1], Markus Weigand[1], Ajay Gangwar[2], Georg Woltersdorf[3], Andrei Slavin[4], Christian H. Back[2], and Gisela Schütz[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]Department of Physics, University of Regensburg, Germany — [3]Department of Physics, Martin Luther University, Halle, Germany — [4]Department of Physics, Oakland University, Rochester, MI, United States

Three-dimensional linear spin-wave eigenmodes of a Permalloy disk having finite thickness are studied by micromagnetic simulations based on the Landau-Lifshitz-Gilbert equation. The eigenmodes found in these simulations are interpreted as linear superpositions (hybridizations) of 'approximate' three-dimensional eigenmodes, which are the fundamental gyromode G_0, the spin-wave modes and the higher-order gyromodes G_N (flexure modes), the thickness dependence of which is represented by perpendicular standing spin waves. This hybridization leads to new and surprising dependencies of the mode frequencies on the disk thickness. The three-dimensional character of the eigenmodes is essential to explain the recent experimental results on vortex-core reversal observed in relatively thick Permalloy disks.

MA 16.2 Tue 9:45 H34

Optically induced magnetization dynamics probed by Lorentz microscopy — •Marcel Möller[1], Tim Eggebrecht[2], Nara Rubiano da Silva[1], Jan Gregor Gatzmann[1], Theo Diekmann[1], Armin Feist[1], Ulrike Martens[3], Henning Ulrichs[2], Vladyslav Zbarsky[2], Markus Münzenberg[3], Claus Ropers[1], and Sascha Schäfer[1] — [1]4th Physical Institute, University of Göttingen, Germany — [2]1st Physical Institute, University of Göttingen, Germany — [3]Interface and Surface Physics, University of Greifswald, Germany

Combining Lorentz microscopy with in-situ optical excitation promises fascinating new insights into magnetization dynamics. Following two different approaches, first we present the generation of a dense vortex-antivortex network by a single intense femtosecond laser pulse in a thin continuous Fe/SN bilayer. The spatial distribution of the vortex-antivortex network exhibits glasslike properties, with well-defined short-range correlations. The formation of the defect network is explained with a Kibble-Zurek-type mechanism involving a rapid temperature quench from the paramagnetic to the ferromagnetic phase.

Secondly, we will report on the ultrafast Lorentz imaging of nanostructured magnetic thin films. Applying a electron-pump/laser-probe scheme using an ultrafast transmission electron microscope (UTEM) will yield access to temporally and spatially resolved magnetization dynamics.

MA 16.3 Tue 10:00 H34

Topological Spin Textures as Emitters for Multidimensional Spin Wave Modes — Volker Sluka[1], Markus Weigand[2], Attila Kakay[1], Katrin Schultheiss[1], Artur Erbe[1], Vasyl Tyberkevych[3], Andrei Slavin[3], Alina Deac[1], Jürgen Lindner[1], Jürgen Fassbender[1], •Jörg Raabe[4], and Sebastian Wintz[4,1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany — [3]Oakland University, Rochester, USA — [4]Paul Scherrer Institut, Villigen, Switzerland

The investigation of propagating spin waves is a key topic of magnetism research [1]. For the excitation of spin waves with short wavelengths, it was typically necessary to either use transducers with sizes on the order of the desired wavelengths (striplines or point-contacts) or to generate those spin waves parametrically by a double-frequency spatially uniform microwave signal [2]. Only recently, a novel mechanism for the local excitation of spin waves has been discovered, which overcomes the wavelength limit given by the minimum patterning size. This method utilizes the translation of natural topological defects, namely the gyration of spin vortex cores [3]. In the present contribution we will show that in a vortex pair system with uniaxial magnetic anisotropy, spin waves of even different symmetries and dimensionalities can be excited. [1] Madami M. et al., Nat. Nanotechnol. 6, 635, (2011). [2] Gurevich A. G. and Melkov G. A., Magnetic Oscillations and Waves, CRC New York, (1996). [3] Wintz S. et al., Joint Intermag/MMM Abstract AC-07, (2013).

MA 16.4 Tue 10:15 H34

Thermally Tunable Coupled Magnetic Vortex Oscillators — •Michael Vogel[1], Johannes Wild[1], Bernhard Zimmermann[1], Michael Müller[1], Claudia K.A. Mewes[2], Tim Mewes[2], Josef Zweck[1], and Christian. H. Back[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, Germany — [2]MINT Center / Depeartment of Physics and Astronomy, University of Alabama, Tuscaloosa, AL, USA

Recently, the magnetization dynamics in neighboring magnetic vortex oscillators coupled via their stray fields came into focus of research [K. Yu. Guslienko, V. Novosad, Y. Otani, H. Shima, and K. Fukamichi, Phys. Rev. B 65, 024414 (2001)]. The system behaves like damped coupled harmonic oscillators. It has been shown that the dynamics of such systems is strongly influenced by the strength of the magnetostatic interaction given by the distance between the elements and the relative configuration of the core polarizations, i.e., the directions of the out-of-plane magnetization components [A. Vogel, A. Drews, T. Kamionka, M. Bolte, and G. Meier, Phys. Rev. Lett. 105, 037201 (2010)]. The control of the coupling in such an array of magnetic discs is essential to implement logic operations. Here we present a novel technique to control the interaction of two or more vortex oscillators by directly influencing their resonance frequencies harnessing their temperature dependency.

MA 16.5 Tue 10:30 H34

Imaging of Higher Order Gyromodes in Vortex Structures — •Johannes Förster[1], Georg Dieterle[1], Matthias Noske[1], Ajay Gangwar[2], Michael Vogel[2], Hermann Stoll[1], Markus Weigand[1], Iuliia Bykowa[1], Michael Bechtel[1], Christian H. Back[2], and Gisela Schütz[1] — [1]MPI für Intelligente Systeme, Stuttgart, Germany — [2]Universität Regensburg, Germany

Magnetic vortex structures appear as ground states of the magnetization in suitable micron-sized ferromagnetic discs. These structures show a broad range of dynamic phenomena. Most basic is the fundamental gyromode where the vortex core gyrates around its equilibrium position with eigenfrequencies of a few hundred MHz. Resonant excitation of this mode causes the vortex core polarity to switch [1].

Besides this fundamental gyromode, higher order gyromodes were predicted in the GHz frequency range by micromagnetic simulations [2,3] and their frequencies were measured by FMR [3]. However, no imaging of such higher order gyromodes have been reported so far.

We will show movies of the first order gyromode in cylindrical Permalloy discs obtained by time-resolved scanning transmission X-ray microscopy. By resonant excitation of this mode switching of the vortex core polarity was observed. In addition, we started imaging the z-dependence of the flexure mode using sensor layers in our samples, by taking advantage of the element specificity of the XMCD effect.

[1] B. Van Waeyenberge, Nature 444, 461 (2006) [2] F. Boust and N. Vukadinovic, PRB 70, 172408 (2004) [3] J. Ding et al., Sci. Rep. 4, 4796 (2014)

15 min. break

MA 16.6 Tue 11:00 H34

Influence of a thermal gradient on parametrically excited magnons in YIG-Pt bilayers — Thomas Langner[1], •Alexander Serga[1], Akihiro Kirihara[2], Burkard Hillebrands[1], and Vitaliy Vasyuchka[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Germany, Kaiserslautern, Germany. — [2]Smart Energy Research Laboratories, NEC corporation, Tsukuba, Japan.

It has been reported that the Spin Seebeck Effect (SSE) might influence the magnetic damping due to a thermal spin transfer torque mechanism. In this work we investigate the influence of the SSE on the parallel parametric generation of magnons. A modification of the damping parameter due to the SSE would lead to a change in the threshold power. We present investigations on an yttrium iron garnet sample covered by a 5 nm thick platinum film clamped between two separately controlled Peltier elements. The threshold power for the generation of parametrically pumped magnons was measured with respect to the applied external magnetic field, first changing the temperature of the sample homogeneously and in a second step with applied temperature gradient perpendicular to the sample plane where a pronounced longitudinal SSE is present. Precise measurements of the threshold power behavior reveal that there is no measurable influence of the spin Seebeck effect on the parametric excitation threshold in a wide range of magnon wavenumbers, whereas a homogeneous temperature change largely influences this threshold power. Financial support by DFG within SPP 1538 "Spin Caloric Transport" is acknowledged.

MA 16.7 Tue 11:15 H34

Study of FM/Pt,Ta bilayers for spin pumping by ferromagnetic resonance spectroscopy — •Andrés Conca, Sascha Keller, Björn Heinz, Laura Mihalceanu, Evangelos Papaioannou, and Burkard Hillebrands — FB Physik und Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

The generation of pure spin currents without accompanying charge currents is of large importance for spintronics and is called to play a critical role in the design of future spintronic devices. The creation and injection of a spin current into a non-magnetic (NM) material from a ferromagnetic (FM) one is commonly referred to as spin pumping. Metallic FM/Pt bilayers show a large increase in magnetic damping due to the presence of spin pumping, and large inverse spin Hall voltages (ISHE) are observed. Valuable information can be gained with FMR techniques without the disturbance of rectification effects present in ISHE measurements. Concretely the parameter $g^{\uparrow\downarrow}$ is accessible.

Here we report on a study of the influence of spin pumping on the FMR properties by using a model epitaxial metallic system of Fe(100)/Pt bilayers and discuss the possible origin of the different observed phenomena. Additional reference samples with no Pt have been also measured to estimate the properties in absence of spin pumping. Additionally, we present also data on CoFeB/Pt and CoFeB/Ta systems to compare the situation with polycrystalline systems.

Support by the Carl Zeiss Stiftung and by M-era.Net is acknowledged.

MA 16.8 Tue 11:30 H34

Control of the effective spin-wave damping in Heusler-Pt waveguides via the spin-transfer torque effect — •Thomas Meyer[1], Thomas Braecher[1,3], Philipp Pirro[1,4], Tobias Fischer[1], Alexander A. Serga[1], Hiroshi Naganuma[2], Koki Mukaiyama[2], Mikihiko Oogane[2], Yasuo Ando[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Sendai 980-8579, Japan — [3]curr. affiliation: Univ. Grenoble Alpes, CNRS, CEA, INAC-SPINTEC, 17 rue des Martyrs, 38054 Grenoble, France — [4]curr. affiliation: Institut Jean Lamour, Université Lorraine, CNRS, 54506 Vandœuvre-lès-Nancy, France

We present the control of the effective spin-wave damping by the spin-transfer torque (STT) exerted by a pure spin current injected into Heusler compound microstructured waveguides. The here used Cobalt-based Heusler compound $Co_2Mn_{0.6}Fe_{0.4}Si$ (CMFS) already provides a comparably low Gilbert damping, thus, this material is very promising for the use in future spintronic devices. In this work, via the STT effect, a pure spin current, generated in a Pt layer via the spin-Hall effect, can exert a torque on the magnetization in the adjacent CMFS layer. The obtained results show a strong influence of an applied DC current on the spin-wave properties. Investigations using only thermally excited spin waves exhibit a strongly increased spin-wave intensity due to a decreased effective damping. This shows the feasibility of using the STT effect in Heusler compound microstructures for future applications.

MA 16.9 Tue 11:45 H34

Magnetization Dynamics in Nanostructured Ni80Fe20 Trilayers — •Tobias Schneider[1,2,3], Kilian Lenz[2], Jürgen Lindner[2], Bernd Scheumann[2], Jürgen Fassbender[2,4], and Ilya N. Krivorotov[1] — [1]Department of Physics and Astronomy, University of California, Irvine, California 92697, USA — [2]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany — [3]Institute for Physics of Solids, Technische Universität Dresden, Zellescher Weg 16, 01069 Dresden, Germany — [4]Institute of Physics, Technische Universität Chemnitz, 09107 Chemnitz, Germany

Spin wave spectra of structured layered systems are interesting for fundamental research since such systems provide great opportunities to investigate spin wave boundary conditions derived for a single nanowire. Therefore precise measurements of the spin wave spectra are necessary. Here, we present electrically detected ferromagnetic resonance measurements of the spin wave spectrum of a Ni80Fe20 trilayer nanowire. The trilayer nanowire with a width of 800 nm was produced by electron beam lithography. The measured spin wave spectra for the easy and hard axis are compared to micromagnetic simulations to understand the magnetization dynamics in detail. The spin wave modes in this system can be divided into acoustic and optical modes known from interlayer exchange coupled films. Funding by the DFG/NSF in the framework of the Materials World Network program is gratefully acknowledged. This work was also supported by the PROMOS program of the TU Dresden.

MA 16.10 Tue 12:00 H34

Standing spin waves excited by spatially non-uniform ultrafast spin transfer torque in Fe/Au/Fe/MgO(001) multilayer — Ilya Razdolski[1], Alexandr Alekhin[1], Nikita Ilin[1], Jan Meyburg[2], Detlef Diesing[2], Vladimir Roddatis[3], Uwe Bovensiepen[4], and •Alexey Melnikov[1] — [1]Fritz-Haber-Institut der MPG, Abt. Phys. Chemie — [2]Universität Duisburg-Essen, Institut für Phys. Chemie — [3]Universität Göttingen, Institut für Materialphysik — [4]Universität Duisburg-Essen, Fakultät für Physik

Ultrafast spin dynamics is the key for development of data storage and spintronics devices. Of particular interest is the generation of ultrashort spin current (SC) pulses and the study of their subsequent spin transfer torque (STT) action on a ferromagnet. We excite non-equilibrium spin-polarized hot carriers (HC) in a top Fe layer of a Fe/Au/Fe/MgO(001) structure by 14 fs-long 800 nm laser pulse. Traversing the Au layer, these HC form SC pulses which are detected by the second harmonic generation: we demonstrate about 300 fs-long SC pulses in Au. When the HC reach the second, 15 nm-thick Fe layer, its magnetization (if it is non-collinear to the HC spin) experiences a torque and starts moving out of the equilibrium. Thus excited picosecond precessional dynamics of the magnetization is monitored by the magneto-optical Kerr effect. We show that owing to a spatially non-uniform STT, on top of the uniform precession, several lowest standing spin wave modes can be excited. Spectral analysis of the excited modes allows for an estimation of the STT depth in Fe to below 2 nm. DFG (ME 3570/1, Sfb 616) and EU 7-th framework program (CRONOS) are acknowledged.

MA 16.11 Tue 12:15 H34

Magnetization dynamics and spin transport in magnetic-tunnel-junctions — •Jakob Walowski[1], Ulrike Martens[1], Christian Denker[1], Robin John[1], Alexander Böhnke[3], Günter Reiss[3], Vladyslav Zbarsky[1,2], and Markus Münzenberg[1] — [1]Institut für Physik, Ernst-Moritz-Arndt Universität, Greifswald, Germany — [2]Fakultät für Physik, Georg-August Universität, Göttingen, Germany — [3]CSMD, Physics Department, Bielefeld University, Germany

We apply ultra short laser pulses to initiate magnetization dynamics and spin-transport in magnetic layers of tunnel-magneto resistance junctions (MTJs) with out-of-plane magnetic anisotropy (PMA). The systems consist of ferromagnetic electodes (FM) separated by an insulator layers FM/MgO/FM. Both processes are induced by the absorption of photons into the electron and spin system.

Probing the dynamics using both components of the time-resolved magneto-optical kerr-effect, the Kerr rotation and Kerr ellipticity, the samples can be probed at different depths[1]. We do the measurements on a wedge sample, where the thickness of the FM electrodes is varied within the range of perpendicular magnetic anisotropy. This enables the insight into the processes in the layers stemming from spin-flip scattering and from spin-polarized transport. Both, spin dynamics and spin transport depend on the properties of the magnetic electrodes and the tunnel barrier.

Financial funding by the DFG SPP 1538 SpinCaT is acknowledged.

[1] *PRB J. Wieczorek et al.*, 92, 174410(2015)