MA 23: Non-ultrafast magnetization dynamics

Time: Wednesday 9:30–12:30 Location: H 0112

MA 23.1 Wed 9:30 H 0112

Quantitative comparison of different methods for the Gilbert damping in clean ferromagnets. — •Jens Renè Suckert, Filipe Souza Mendes Guimarães, Jonathan Chico, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The Gilbert damping constant describes relaxation in magnetic systems. Efforts to describe the damping from first principles have been made for almost 50 years [1]. A multitude of approaches to calculate the damping have been proposed since then [1,2,3]. Still, a disparity between theoretical and experimental descriptions at low temperatures [3] and between different theoretical approaches persists. In particular, the behaviour of clean ferromagnets at low temperatures is still debated [4]. In this work, we present calculations of the damping constant for clean Fe, Ni and Co bulk systems using a unified framework based on a multi-orbital tight-binding model to investigate the different approaches and resolve the disparity at low temperatures. This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-consolidator grant 681405 – DYNASORE).
[1] V. Kamberský, Czech J. Phys. 26, 1366 (1976).
[2] A. Brataas, et *al.*, Phys. Rev. Lett. 101, 037207 (2008).
[3] S. Mankovsky et *al.*, Phys. Rev. B 87, 014430 (2013).
[4] D.M. Edwards, J. Phys.: Condens. Matter 28, 086004 (2016).

MA 23.2 Wed 9:45 H 0112

Local spin-wave dispersion and damping in thin yttrium iron garnet films — •Rouven Dreyer[1], Niklas Liebing[1], Eric R. J. Edwards[1,2], and Georg Woltersdorf[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle (Saale), Germany — [2]National Institute of Standards and Technology Boulder, CO, U.S.A.

By time-resolved magneto-optic imaging we investigate the spin-wave dispersion and spin-wave damping in yttrium iron garnet thin film samples with a thickness of 200 nm. Using the inhomogeneous magnetic field generated by a coplanar waveguide spin waves are excited at a fixed frequency while the wavelength is tuned by the external magnetic field. By imaging the excited spin waves with a scanning time-resolved MOKE setup and mapping their dispersion we identify a method to determine the damping of the homogeneous mode locally. Furthermore we find that in the vicinity of avoided crossings in the spin-wave dispersion the group velocity of excited spin waves is close to zero. Here we are able to extract the Gilbert damping parameter for localized spin waves. The obtained values are in good agreement with the results for the uniform mode. In comparison to inductive FMR measurements we find narrower linewidths for the uniform mode due to the local character of our measurements.

MA 23.3 Wed 10:00 H 0112

Analysis of magnetoelastic coupling in Co-Pt multilayer systems — •Norbert Weinkauf[1], Peter Gaal[1], Raanan Tobey[2], Chia-Lin Chang[2], and Hans Peter Oepen[1] — [1]Institute of Nanostructure and Solid State Physics, University of Hamburg, Germany — [2]Faculty of Science and Engineering, University of Groningen, the Netherlands

We have measured optically excited magnetization precession on thin, in-plane Co-Pt multilayer systems on glass substrate. Using a three-temperature model the fast energy transfer from the electron and spin system to the lattice few picoseconds after optical excitation is explained. The initial lattice temperature after excitation is significantly lower than the Curie temperature of Cobalt. Hence we assume that demagnetization and the subsequent precession is instantly driven by shear strain and not heat. In addition we derive a quantitative model by the analytical solution of the Landau-Lifshitz equation.

Furthermore we use transient grating excitation on the same cobalt multilayers. The time-resolved measurement of Faraday rotation and of the diffraction from the transient grating yields information about the magnetoelastic coupling. Two distinct resonances were detected, one assigned to a surface acoustic wave, one to surface skimming longitudinal wave. These can be calculated by a parametric oscillator model and the Landau-Lifshitz equation.

In addition, similar measurements were performed for Co-Pt multilayer systems on 500nm SiNi-membranes. We observe distinct differences in the acoustic mode spectrum compared to bulk substrates.

MA 23.4 Wed 10:15 H 0112

Fabrication and Characterization of individual sub-100 nm YIG Structures using Brillouin Light Scattering Microscopy — •Björn Heinz[1], Thomas Brächer[1], Michael Schneider[1], Philipp Pirro[1], Bert Lägel[1], Carsten Dubs[2], Oleksii Surzhenko[2], and Andrii V. Chumak[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]INNOVENT e.V., Technologieentwicklung Jena, 07745 Jena, Germany

Yttrium-iron-garnet (YIG) is a unique material with outstanding magnetic properties such as the lowest known spin-wave damping. It is therefore well suited for the investigation of fundamental spin-wave dynamics and a promising candidate for the application in magnonic circuits and logic devices. In this work, we study the impact of micro- and nanostructuring by means of electron beam lithography and successive ion milling on individual spin-wave waveguides. These structures are fabricated from a 41 nm thin film grown by liquid phase epitaxy (LPE). Their width varies from a few microns down to the sub-100 nm regime. By exciting the magnetization dynamics with a microwave field and performing time resolved Brillouin light scattering (BLS) microscopy measurements we investigate the influence of the structuring process on the magnon lifetime. Additionally the spin-wave mode spectra are extracted by means of thermal BLS measurements. This research has been supported by ERC Starting Grant 678309 MagnonCircuits and DFG Grant DU 1427/2-1.

MA 23.5 Wed 10:30 H 0112

Ferromagnetic resonance in superconductor/ferromagnet bilayers — •David Sanchez-Manzano[1], Myoung-Woo Yoo[2], Hiroshi Naganuma[2,3], Pierre Mergny[2], Abdelmadjid Anane[2], Jacobo Santamaria[1], and Javier E. Villegas[2] — [1]GFMC , Dpto F. Materiales, University Complutense of Madrid (Spain) — [2]CNRS -Thales, Unité Mixte de Physique, Palaiseau (France) — [3]Department of Applied Physics, Tokyo University of Science, 1-3, Kagurazaka, Shinjuku-ku, Tokyo (Japan)

We study the superconductor/ferromagnet proximity effect via ferromagnetic resonance (FMR) [1] in S/F bilayers that combine the high-temperature superconductor YBa2Cu3O7 with different ferromagnets, either Permalloy (NiFe) or the half-metallic La0.7Sr0.3MnO3. We compare the results of this bilayers to reference ferromagnetic single layers to observe how the presence of the superconductor layer affects the FMR signal. The FMR linewidth is studied as a function of temperature (10K-293K) and frequency (up to 20 G Hz) to obtain the damping constant (α) above and below the superconducting critical temperature. The results will be discussed in the frame of the spin-pumping theory considering the superconductor a spin sink where part of the FMR generated angular momentum relaxes in the superconductor through spin-pumping. [2].

[1] Bells, C., Aarts, J. et al. Phys. Rev. Lett. 100 047002 (2008) [2] Yokoyama, T. & Tserkovnyak, Y. Phys. Rev. B 80, 104416 (2009)

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MA 23.6 Wed 10:45 H 0112

Influence of substrate doping on Spin Pumping — •Babli Bhagat, Tanja Strusch, Michael Farle, and Florian M Römer — Faculty of Physics and Center for Nanointegration (CENIDE), University of Duisburg-Essen, Lotharstr. 1, 47057, Duisburg, Germany

Spin Pumping into semiconductor has a technical as well as fundamental relevance for spintronic devices. The magnetic damping of a Ferromagnet/Semiconductor heterostructure should be influenced by the conductivity and other properties of the semiconductor.

We have studied magnetic damping in Pt/Ag/Fe/GaAs(110) epitaxial heterostructures with different doping of GaAs (undoped, n-doped, and p-doped) by Ferromagnetic Resonance measurements (FMR). Samples were prepared using electron beam evaporation at $< 8*10^{-8}$ Pa at the rate of $\sim$1Å/minute. Low Energy Electron Diffraction (LEED) was done before and after depositing epitaxial Fe film on

GaAs. Ex situ FMR from 1-40GHz was performed in three different crystallographic directions namely easy <100>, hard <111> and intermediate <110> in plane direction of the film. Also angle dependent FMR at ~13GHz were performed. The Gilbert-Damping parameter α and anisotropic constants were calculated by fitting frequency dependent and angle dependent lineshape respectively. We observed different damping behaviour at different directions of the film. With respect to undoped sample there is ~15% increase in α in hard <111> direction in p-doped sample while ~12% increase in <110> direction. In easy direction there is instead ~28% decrease of damping parameter with undoped sample in p-doped GaAs.

MA 23.7 Wed 11:00 H 0112

Simulation of hot-electron spin currents in magnetic multilayers — Dennis M. Nenno[1,2], Marius Weber Weber[1], Rolf Binder[2], and •Hans Christian Schneider[1] — [1]University of Kaiserslautern, Kaiserslautern, Germany — [2]University of Arizona, Tucson, USA

“Hot electron” spin-currents in magnetic heterostructures, which result from excitation by ultrafast optical pulses, have been described by different non-diffusive electron-transport calculations [1,2]. We present a computational approach to hot-electron transport in magnetic multilayers based on the particle-in-cell method for the Boltzmann transport equation. This approach allows one to simulate the electronic dynamics in the whole slab, including transmission coefficients and ab-initio material data. From the calculations, we extract typical transport coefficients and clarify the contribution of secondary carrier generation in the transition from ballistic to diffusive transport behavior.

We combine our transport model with a calculation of the emitted fields to determine the radiation spectrum from spintronic Terahertz emitters [3], and analyze both single emitters and arrays.

[1] M. Battiato et al., Phys. Rev. B 86, 024404 (2012).
[2] D. M. Nenno et al., Phys. Rev. B 94, 115102 (2016).
[3] T. Seifert et al., Nature Photonics 10, 483 (2016).

15 minutes break

MA 23.8 Wed 11:30 H 0112

Dynamic nuclear polarization with single shallow NV center in diamond — •Farida Shagieva, Andrej Denisenko, Philipp Neumann, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart, Stuttgart, Germany

Nuclear magnetic resonance (NMR) is one of the most powerful techniques used in physics and life sciences. The latest developments in this area are directed to make high-resolution NMR systems that are smaller, cheaper, more robust and portable than the existing ones. Recently, the shallow nitrogen-vacancy centres in diamond started to be used for nanoscale NMR imaging and spectroscopy of nuclear species under ambient conditions [1]. These multifunctional quantum sensors provide the noninvasive methods to get the chemical composition [2] of the molecules and to study the system dynamics within the nanoscopic volume above the diamond surface. Despite a remarkable progress in this area, potential applications are often limited by low sensitivity. Hyperpolarisation techniques have the potential to overcome this limitation and revolutionise the use of compact NMR. Several techniques to realise the (DNP) dynamic nuclear polarization using NV centres have been demonstrated for internal diamond spins [3-4]. The goal of this study is to perform a hyperpolarization of external for diamond solid spins and demonstrate an improvement of the NMR signal.

[1] T. Staudacher et al., Science 339, 561 (2013).
[2] N. Aslam et al., Science 357, 67 (2017).
[3] P. London et al., PRL 111, 067601 (2013).
[4] F. Poggiali et al., Phys. Rev. B 95, 195308 (2017).

MA 23.9 Wed 11:45 H 0112

Time-resolved magneto-optical investigation of Surface Acoustic Wave sensors (SAW) — •Cai Müller, Anne Kittmann, Phillip Durdaut, Benjamin Spetzler, Sebastian Zabel, Rasmus B. Holländer, Michael Höft, Franz Faupel, Eckhard Quandt, and Jeffrey McCord — Institute for Materials Science, Kiel University, Kiel, Germany

Surface acoustic waves (SAW) delay lines and resonators can be tuned via magnetostrictive layers and application of an external magnetic field by magnon-phonon interactions [1]. This mechanism enables magnetic field sensing. Knowledge of the local magnetization structure during the SAW excitation helps to understand the exact magnetic origin of the SAW-modulation. Here investigations of the magneto-dynamic response of a thin FeCoSiB film on a quartz substrate by time-resolved magneto-optical wide-field imaging are presented. The method enables direct measurements of the wave velocity. The data suggests a strong magnetization response of domain walls to the local effective field generated by the SAW.

[1] Smole, P. et al., IEEE International Frequency Control Symposium and PDA Exhibition Jointly with the 17th European Frequency and Time Forum, 2003, p. 903-906 (2003)

MA 23.10 Wed 12:00 H 0112

Coupling between vortices and antivortices in a cross-tie wall studied by time-resolved SEMPA — •Fabian Kloodt-Twesten, Susanne Kuhrau, Philipp Staeck, Hans Peter Oepen, and Robert Frömter — Center for Hybrid Nanostructures, Universität Hamburg, Germany

In the framework of the Thiele equation magnetic vortices and antivortices can be treated as quasiparticles. Confining a single (anti-)vortex in a magnetic microstructure causes linear restoring forces, which results in an oscillator equation describing the field-driven motion of individual solitons. Using TR-SEMPA [1] we investigate the coupling of magnetic vortices and antivortices in a cross-tie wall in rectangular FeCoSiB-structures. While the vortices exhibit a clear oscillation the antivortices show almost no discernible movement. Both types of magnetic solitons are mutually coupled via the domain energy (part of the stray-field energy), resulting in a coupled oscillation mode under HF-field excitation. TR-SEMPA results and micromagnetic simulations show an excellent agreement indicating that the boundary condition in the sample together with a strong coupling between both solitons is the driving mechanism of the observed behavior. The motion is composed from the contributions of two terminating vortices and a mutual vortex-antivortex coupling along the confined cross-tie structure.

[1] R. Frömter et al., Appl. Phys. Lett. 108, 142401 (2016).

MA 23.11 Wed 12:15 H 0112

Electric field control of gyration dynamics of magnetic vortices — •Mariia Filianina[1,2], Lorenzo Baldrati[1], Tetsuya Hajiri[3], and Mathias Kläui[1,2] — [1]Mainz University, 55128 Mainz, Germany — [2]Graduate School of Excellence MAINZ, 55128 Mainz, Germany. — [3]Nagoya University, 464-8603 Nagoya, Japan.

Energy-efficient control of magnetism is fundamental for the development of spintronic devices. This is enabled for instance by the electric field control of the magnetization, as can be done in multiferroic materials [1]. Significantly large magneto-elastic effect (ME), i.e. tuning the magnetic anisotropy by strain, can be induced by an electric field in magnetic thin films grown on piezoelectric substrates [2-5]. While the quasi-static behavior of the ME effect has been thoroughly analyzed, there are only a few experimental studies of the effect of ME coupling on the dynamical behavior of the magnetization [4,5].

Here we report on the electric field control of magnetic vortex core gyration dynamics via ME effect in magnetostrictive microstructures fabricated on top of a piezoelectric substrate. Piezoelectric strain modifies the anisotropy and thus the vortex gyration trajectories which we image by means of time-resolved XMCD-PEEM. A comparison with micromagnetic simulations is presented to quantitatively assess the dynamical effect resulting from the ME coupling.

1. N.A. Spaldin and M. Fiebig, Science 309, 391 (2005). 2. J.G. Wan et al., Appl. Phys. Lett. 88, 182502 (2006). 3. S. Finizio et al., Phys. Rev. Appl. 1, 021001 (2014). 4. M. Foerster et al., Nat. Commun. 8, 407 (2017). 5. S. Finizio et al., Phys. Rev. B 96, 054438 (2017).