MA 19: Spin-Dynamics/Switching I

Time: Wednesday 15:15–19:00 Location: H23

MA 19.1 Wed 15:15 H23

Observation of partial decoherence of quantized spin waves in nanoscaled magnetic ring structures — •Helmut Schultheiss[1], Patrizio Candeloro[1], Sebastian Schäfer[1], Hans Nembach[2], Britta Leven[1], Andrei Slavin[3], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, Germany — [2]NIST, Boulder, Colorado, USA — [3]Oakland University, Rochester, Michigan, USA

Nanoscale magnetic ring structures have recently attracted large attention due to their richness in magnetization structures. Not many investigations have been devoted to the spin waves in such elements and a full picture of the spin dynamics has not been emerged so far. Here we report on micro-focus Brillouin light scattering spectroscopy studies of the quantization mechanisms and in particular of the coherence of spin waves in 15 nm thick NiFe rings with varying diameters (from 1 to 3 μm). The magnetic excitations for both the vortex and the onion state were investigated. For the onion state several interesting effects were identified. First, in the pole regions spin wave wells are created due to the inhomogeneous internal field. Second, in the regions in between, modes with constant frequencies are observed only for the smallest structures, which are quantized in radial and azimuthal directions due to spatial coherence and confinement in the ring structure. For larger rings a continuous frequency variation with position is observed and is well reproduced by spin-wave calculations and micromagnetic simulations. This work is supported by the DPG within the SPP1133 and the Japanese government within the NEDO project 2004IT093.

MA 19.2 Wed 15:30 H23

Spin waves in semi-circular $Ni_{81}Fe_{19}$ ring segments in the presence of domain walls — •Britta Leven, Christian Sandweg, Helmut Schultheiss, Sebastian Hermsdörfer, and Burkard Hillebrands — FB Physik and Forschungsschwerpunkt MINAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We present a study of spin wave properties in semi-circular $Ni_{81}Fe_{19}$ ring segments in the presence of domain walls. The spin wave spectra are detected with a lateral resolution of 300 nm employing micro-focus Brillouin light scattering spectroscopy. The elements are prepared using a combination of electron beam lithography and molecular beam epitaxy. The ring segments have a radius of 10 μm, a width of 500 nm and a thickness of 10 nm. In order to localize a domain wall a 200 nm wide protrusion has been added at the pole region of the ring structure, which acts as nucleation site if an external magnetic field is applied in radial direction. It is thus possible to study spin wave spectra in the element either in the presence or in the absence of a domain wall by applying an external magnetic field in radial or tangential direction, respectively. In the absence of a domain wall we observe typical spin wave quantization effects due to the confinement of the ring segment in radial direction. In contrast, in the presence of a domain wall the quantized wave profile is distorted in the vicinity of the domain wall due to the variation of the internal magnetic field. Technical support of P.A. Beck, of the Nano+Bio Center, TU Kaiserslautern and financial support by the DFG within the SPP1133 and the NEDO project No 2004IT093 funded by the Japanese government is acknowledged.

MA 19.3 Wed 15:45 H23

Detecting Vortex Chirality by Ferromagnetic Eigenmodes in Mesoscopic Rings — •Fabian Giesen[1,2,3], Jan Podbielski[1], Bernhard Botters[1,4], and Dirk Grundler[1,4] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg — [2]Department of Physics, University of Alberta, Edmonton, Alberta, T6G 2J7 Canada — [3]Max-Born-Institut für ür Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2 A , 12489 Berlin — [4]Lehrstuhl für Experimentalphysik E10, TU München, James-Franck-Straße 1, 85747 Garching

Using broadband ferromagnetic resonance and specially engineered asymmetries in permalloy rings we are able to detect the statistics of chirality of the vortex state in an array of rings. We make use of localized modes in the rings which serve as a probe for the local magnetization direction. We find that the asymmetry suppresses the usual domain wall propagation reversal process, which in the case of concentric rings, leads to a distribution of vortex chirality directions. Instead the reversal takes place through a buckling of the magnetization in the wide ring arm. This arm always switches first and leads to a control of the vortex chirality with a fidelity of better than 97%. The chirality $\xi = \pm 1$ can be selected by the inital external field direction.

The research was funded by BMBF Spintronic 12N8283, iCore and CIAR.

MA 19.4 Wed 16:00 H23

Eigenmode-Localization Transition in Mesoscopic Ferromagnetic Rings — •Fabian Giesen[1,2,3], Jan Podbielski[1], and Dirk Grundler[4] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg — [2]Department of Physics, University of Alberta, Edmonton, Alberta, T6G 2J7 Canada — [3]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2 A , 12489 Berlin — [4]Lehrstuhl für Experimentalphysik E10, TU München, James-Franck-Straße 1, 85747 Garching

We have investigated the dynamic eigenmode spectrum of ferromagnetic micron-sized rings in the quasi-saturated (‘onion’) state. Inductive broadband detection of spin dynamcis (vector network analyzer ferromagnetic resonance) was used to detect the spin dynamics spectrum. The ring width was varied systematically and the spectra revealed a gradual localization of eigenmodes in the regions where the internal field is at maximum and at minimum. Using micromagnetic simulations and a semi-analytical WKB approach the increasing internal field inhomogeneity can be shown to be the reason for the mode localization process. The research was funded by BMBF Spintronic 12N8283, iCore and CIAR.

MA 19.5 Wed 16:15 H23

Direct observation of the out-of-plane vortex core magnetization — K.W. Chou[1], A. Puzic[1], •H. Stoll[1], D. Dolgos[1], M. Curcic[1], B. Van Waeyenberge[2], A. Vansteenkiste[2], T. Tyliszczak[3], G. Woltersdorf[4], C.H. Back[4], and G. Schütz[1] — [1]MPI für Metallforschung, Stuttgart — [2]Dep. of Subatomic and Radiation Physics, Ghent University — [3]Advanced Light Source, Berkeley, CA — [4]Inst. für Exp. und Angew. Physik, Univ. Regensburg

The vortex core, which plays a key role in magnetic vortex dynamics, was investigated by time-resolved scanning transmission X-ray microscopy. Reversal of the vortex core by excitation with short bursts of an in-plane alternating field was discovered recently [1]. This allows dynamic switching of the vortex core polarization with a one-period magnetic field burst as low as 1.5 mT, in contrast to (static) out-of-plane fields of half a Tesla needed so far. Micromagnetic simulations enabled us to explain this novel switching scheme by creation of a vortex-antivortex pair with opposite polarization in respect to the original vortex and annihilation of the antivortex with the original vortex. At the end a vortex with opposite polarization remains [1]. By improving our experiments we now are able to directly observe the reversal of the out-of-plane magnetization of the vortex core rather than monitoring a change in the sense of gyration. In addition, a strong distortion was observed in the spin distribution of the moving vortex core with an asymmetry in the motion for a core pointing up and down respectively.

[1] B. Van Waeyenberge, A. Puzic, H. Stoll, K. W. Chou et al., Nature 444, 461 (2006)

MA 19.6 Wed 16:30 H23

Picosecond spin dynamics of Gd(0001) studied by linear dichroism of 4f shell. A time-resolved experiment combined laser and synchrotron radiation — •Helena Prima Garcia[1], Alexev Melnikov[2], Martin Lisowski[2], Roland Schmidt[1], Uwe Bovensiepen[2], and Martin Weinelt[1,2] — [1]Max-Born-Institute, Berlin, Germany. — [2]Freie Universität , Berlin, Germany

We have studied ultrafast magnetization dynamics in Gd(0001) films alignment by time-resolved X-ray photoemission spectroscopy. Absorption of a 50 fs laser-pump-pulse at 800 nm leads to optical excitation of the Gd valence electrons. We probe the relaxation dynamics by linear dichroism in photoemission from the Gd 4f electrons using a 60 eV, 50 ps probe-pulse at the synchrotron user facility BESSY, Germany. Linear dichroism in photoemission is proportional to the magnetic moment of the $4f^7$ electrons. The breakdown of the magnetic ordering upon fs laser excitation has been reported based on magneto-optical studies to occur within 100 fs. The recovery of the equilibrium magnetization is driven by cooling of the lattice and spin-lattice interaction. It proceeds on a 100 ps time scale [2]. Here we show the breakdown of the magnetic moment after laser excitation within the probe pulse duration and the subsequent recovery to the equilibrium value. As linear dichroism is a measure of the alignment of the Gd 4f moments, its breakdown is a further proof of laser-induced desmagnetization.

[1] Oleg Krupin, Phd thesis, Fachbereich Physik Freie Universität Berlin, Germany.

[2] A. Vaterlaus, et.al. Phys. Rev. Lett. 67, (1991) 3314.

MA 19.7 Wed 16:45 H23

Current-Induced Excitations in Single Ferromagnetic Layer Nanopillars — •Malte Scherff, Anne Parge, Tore Niermann, Michael Seibt, and Markus Münzenberg — IV. Phys. Inst., Universität Göttingen

So far the focus of angular momentum transfer studies has usually been put on ferromagnet/ normal magnet/ ferromagnet trilayer junctions. Our work also includes transport experiments in junctions with only a single ferromagnetic layer.

All experiments have been performed on nanopillars with a diameter of ˜80 nm,which are fabricated in a simplified one step process: Holes are created into a thin PMMA film by e-beam lithography and filled with different metal layers by evaporation. The remaining PMMA serves as an insulating template between the Au bottom- and the Cu top-contact.

To improve the preparation parameters, structural analysis has been done by simple cross sectional views as well as accurate TEM measurements of lamella-samples prepared by focused ion beam.

The transport properties were obtained in a four point measurement configuration, where the differential resistance dV/dI was measured by a lock-in technique in an external magnetic field. For sufficiently large DC current densities anomaly changes of resistance were observed in trilayers (up to 3%) and single layers (up to 1.5%). They are related to dynamic excitations and static changes in magnetic configuration, respectively.

This work was supported by DFG, SPP 1133.

MA 19.8 Wed 17:00 H23

Spin transfer torque studies using focused-ion-beam assisted nanostencil mask fabrication — •Nicolas Müsgens[1], Mohamed Tarik[1], Coen Smits[1], Georg Richter[1], Bernd Beschoten[1], Gernot Güntherodt[1], Alexander Schwedt[2], and Joachim Mayer[2] — [1]II. Physikalisches Institut, RWTH Aachen, 52056 Aachen, and Virtual Institute of Spinelectronics (VISel), Jülich/Aachen — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen, 52065 Aachen

The transfer of a spin torque of a spin-polarized current onto a macroscopic magnetization has been investigated in confined magnetic nanostructures. Focused-ion-beam (FIB) is used to fabricate nanostencil masks with lateral device dimensions below 100 nm. Afterwards the nanopillar stack (Co/Cu/Co) is deposited in theses templates. The current-induced switching is demonstated with a giant magneto-resistance effect up to 1.6 % at room temperature.

The systematic current-induced behavior of the junctions has been investigated by studying differential resistance versus bias-current characteristics at various external magnetic fields. In addition to a hysteretic switching behavior and the appearance of resistance peaks at high magnetic fields and current densities of j $\sim 10^8 \frac{A}{cm^2}$, we found pronounced dips, which shift to lower currents with increasing external magnetic fields.

Work supported by DFG through SPP 1133

MA 19.9 Wed 17:15 H23

Magnetic damping in all-optical pump-probe experiments — •J. Walowski[1], G. Müller[1], M. Djordjevic Kaufmann[1], M. Münzenberg[1], and M. Kläui[2] — [1]IV. Phys. Inst., Universität Göttingen, Germany — [2]Fachbereich Physik, Universität Konstanz, Germany

Magnetization dynamics of ferromagnetic films (FM) was studied with the help of an amplified 80 fs Ti:Sapphire laser system. The sample located in an external magnetic field H_{ext} is demagnetized by an intensive pump laser pulse ($> 40\ \frac{\mathrm{mJ}}{\mathrm{cm}^2}$). The magnetization relaxation is traced with a probe beam up to 1 ns after excitation.

The magnetic damping constant is investigated in the case of emission of spin currents on FM/NM interfaces (non-local damping) and spin scattering on nonmagnetic (NM) dopants.

For the non-local damping wedge shaped samples with Ni and Py are investigated for various spin sinks (Cu, Pd, Dy). It is found that the damping increases up to three times at thicknesses < 10 nm of the FM layer.

In the case of spin scattering permalloy samples alloyed with low concentration of Dy and Pd were studied. The results show that the damping parameter depends on the alloy material and its percentage.

The nature of the different dissipation processes is further investigated.

Research is supported by DFG SPP 1133.

MA 19.10 Wed 17:30 H23

Slow recovery of magnetic anisotropy following ultrafast optical excitation of a spin-reorientation transition — •Thomas Eimüller[1], Andreas Scholl[2], Edward Amaladass[3], Bernd Ludescher[3], Gisela Schütz[3], Michael Binder[4], and Christian Back[4] — [1]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy — [2]Advanced Light Source, LBNL, Berkeley, CA, USA — [3]Max-Planck-Institute for Metals Research, Stuttgart — [4]University of Regensburg, Experimental and Applied Physics

Multilayered Fe/Gd systems, showing a spin reorientation transition (SRT) from in-plane to out-of-plane magnetization with rising temperature, have been studied by x-ray photoemission electron microscopy (X-PEEM). We found a continuous, i.e., second order transition between in-plane and out-of-plane domains, with a coexistence of both types in a temperature interval of about 25 K. The dynamics of this SRT has been investigated in an optical pump - x-ray-probe experiment. A short laser pulse raises the temperature of the sample by about 25 K. By scanning the delay time between 0 and 8 ns the dynamic response of the Fe and Gd magnetic moments has been recorded with X-PEEM, resulting in a temporal resolution below 100 ps and a spatial resolution below 100 nm. We found large time dependent XMCD effects generated by a damped spin precession, superposed to a slow relaxation (> 8 ns) of the easy axis back into the sample plane. This relaxation is way longer than the measured and simulated heat diffusion time and may shade new light into the transport of torque form the spin into the lattice system.

MA 19.11 Wed 17:45 H23

Brillouin light scattering observations of a magnetodielectric wave in thin ferrite films — •Timo Neumann[1], Natalia Sergeeva[1,2], Thomas Schneider[1], Alexander Serga[1], and Burkard Hillebrands[1] — [1]TU Kaiserslautern, Kaiserslautern, Germany — [2]Elektrotechnical University, St. Petersburg, Russia

We report on optical observations of a thermally excited mode detected above the region of existence of dipolar dominated spin waves in thin, in-plane magnetized YIG-films. The possibility to amplify this mode by means of longitudinal parametrical pumping is demonstrated.

In experiments with 7 μm thick YIG-films in a tangentially applied, static magnetic bias field, a thermally excited mode was observed for field strength H_0 varying from below 100 Oe to 4300 Oe using the Brillouin light scattering spectroscopy technique. A linear dependence of the mode frequency ω, which lies above the frequency of Damon-Eshbach modes, on the external magnetic field was found.

Effective parametric amplification was realized in the case when the pumping frequency ω_P equalled approximately twice the frequency ω of the mode. In contrast, no significant amplification of the signal was noted for other ratios $2 > \omega_P/\omega > 0,7$ considered. In particular, direct perpendicular force excitation with $\omega_P = \omega$, as can be easily achieved for magnetic modes, did not take place.

We associate the observed thermal mode to a magnetodielectric wave localized in the sample.

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MA 19.12 Wed 18:00 H23

X-ray imaging of current driven stochastic domain-wall motion — •Guido Meier[1], Markus Bolte[1], René Eiselt[1], Ulrich Merkt[1], Benjamin Krüger[2], Daniela Pfannkuche[2], Dong-Hyun Kim[3], and Peter Fischer[4] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstr. 11, 20355 Hamburg — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [3]Department of Physics and Institute for Basic Science Research, Chungbuk National University, Cheongju 361-763, South Korea — [4]Center for X-Ray Optics, LBNL, Berkeley, CA 94720, USA

Magnetic transmission x-ray microscopy is used to directly visualize the influence of a spin-polarized current on domain walls in curved permalloy wires. Pulses of nanosecond duration and high current density up to $1.0 \times 10^{12} A/m^2$ are used to move and to deform the domain wall. The current pulse drives the wall either undisturbed, i.e., as a composite particle through the wire or causes structural changes of the magnetization. Repetitive pulse measurements reveal the stochastic nature of current induced domain-wall motion. From the experiments we estimate the ratio $\xi/\alpha = 0.96 \pm 0.02$ between the degree of nonadiabaticity ξ and the Gilbert damping parameter α. This indicates the importance of the nonadiabatic contribution to current driven domain-wall motion. Supported by the DFG via SFB 668 and GK 1286 as well as by the U.S. DOE Contract No. DE-AC02-05-CH11231.

MA 19.13 Wed 18:15 H23

Magnetization dynamics of a single cross-tie wall — •Karsten Kuepper[1], Daniel Markó[1], Matthias Buess[2], Jörg Raabe[2], Christoph Quitmann[2], and Jürgen Fassbender[1] — [1]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, Bautzner Landstr. 128, D-01328 Dresden — [2]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, - PSI, Switzerland

We report the imaging of the magnetic excitation spectrum of a single cross-tie wall by means of x-ray magnetic circular dichroism - photoemission electron microscopy (XMCD-PEEM). The permalloy rectangle was excited by a short magnetic in plane pulse with a maximum field value of about 20 Oe. The high temporal and lateral resolution allows a detailed quantitative analysis of the magnetodynamic excitations. We find new eigenmodes in the frequency domain which are characteristic for the vortex-antivortex interaction in a single cross-tie wall. We discuss our experiment along micromagnetic simulations.

MA 19.14 Wed 18:30 H23

Effect of parametric pumping on phase profiles of dipolar spin waves in YIG film — •Natalia Sergeeva[1,2], Timo Neumann[1], Thomas Schneider[1], Alexander Serga[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik, TU Kaiserslautern, Kaiserslautern, Germany — [2]St. Petersburg Electrotechnical University, St. Petersburg, Russia

The phase profile of a spin wave (SW) packet propagating through the area of parametric pumping in a longitudinally magnetized yttrium-iron-garnet (YIG) film waveguide was studied. The magnetic media was influenced by spatially localized microwave parallel pumping of double frequency. The phase profile of the SW packet was measured by means of phase-sensitive time- and space-resolved Brillouin light scattering spectroscopy as well as by conventional microwave technique. The influence of pumping power, pumping duration and moment of application of pumping on the phase profiles was investigated. It was observed that a nonlinear phase accumulation process significantly distorts the initially flat phase profile of the SW packet. The mentioned effect is caused by the magnetic barrier formed by exchange dominated magnons, which were parametrically excited from the thermal level in the pumping area.

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MA 19.15 Wed 18:45 H23

Time-, Spin- and Energyresolved photoemission microscopy of 3d transition metals — •Bernd Heitkamp, H. A. Dürr, and W. Eberhardt — Albert-Einstein-Strasse 15, 12489 Berlin

Understanding ultrafast de- and remagnetization processes are of considerable interest, since it allows to shorten the read/write-cycles in magnetism based memories.

Our approach is to combine the nm-spatial resolution of a photoelectron emission microscopy (PEEM) with a fs time-resolution using the pump-probe technique. Magnetic sensitivity is obtained by detecting the spin of the emitted photoelectrons.

Experiments on Nickel and Cobalt show a demagnetization below one picosecond. Electron- and Spindynamics strongly depend on the dielectric response of the nanostructures.