# MA 8 Spindynamik I

Zeit: Freitag 15:15–18:30 Raum: TU H1028

MA 8.1 Fr 15:15 TU H1028

**High wave vector spin waves in ultrathin hcp Co-films on W(110)** — •M. Etzkorn[1], P. S. Anil Kumar[1], W. Tang[1], R. Vollmer[1], Y. Zhang[1], H. Ibach[2], and J. Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — [2]Institut für Schichten und Grenzflächen ISG3, Forschungszentrum Jülich, 52415 Jülich

We present spin-polarized electron energy loss spectroscopy (SPEELS) measurements of high wave vector spin waves in ultrathin hcp Co-films on W(110) and compare the results to results obtained on fcc Co on Cu(001) [1]. In general, in both systems the spin-wave excitations show similar behaviour. A surprisingly good agreement was found between the measured dispersion of hcp and fcc Co and the dispersion of a surface spin wave in a nearest neighbor Heisenberg model. For both systems the product of the exchange coupling constant and the magnetic moment is JS = 15 meV within the experimental error. The spin-wave dispersion measured on thin, hcp Co-films by SPEELS is also compared to results of inelastic neutron scattering experiments performed on bulk hcp Co [2]. A moderate reduction of JS was found for the thin films.

The intensity of the spin-wave loss feature in the SPEEL- spectra strongly depends on the kinetic energy of the scattering electrons. High spin-wave intensities are only observed for incoming electron energies below about 10 eV.

[1] R. Vollmer, M. Etzkorn, P. S. Anil Kumar, H. Ibach and J. Kirschner, Phys. Rev. Lett. 91 (2004) 147201. [2] T. G. Perring, A. D. Taylor and G. L. Squires, Physica B 213&214 (1995) 348.

MA 8.2 Fr 15:30 TU H1028

**Phase-sensitive Ultrafast Spin Dynamics in Antiferromagnetic $Cr_2O_3$** — •T. Satoh[1,2], B.B. van Aken[1], N.P. Duong[1], Th. Lottermoser[1], and M. Fiebig[1] — [1]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin — [2]RCAST, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo

With the discovery of magnetization processes on the (sub-) ps time scale the coupling processes between spins, electrons and lattice that allow such rapid manipulation of the magnetic order parameter became a central topic. Here we discuss the temporal evolution of spin and charge lattices in antiferromagnetic $Cr_2O_3$ upon excitation with an intense 100 fs laser pulse. Optical second harmonic generation (SHG) is used as probe for the magnetic and crystallographic sublattices, since linear magnetooptical techniques fail because of the absence of a macroscopic magnetization. By coherent interference of the magnetic and crystallographic contributions to SHG the temporal evolution of both amplitudes and phases of the magnetically induced signal can be observed. The dynamical response of $Cr_2O_3$ occurs on three different time scales ($\sim$ 1 ps, $\sim$ 10 ps, $\sim$ 1 ns). The result indicate weak spin-lattice coupling in the absence of the pump light field and a different temporal evolution of the amplitude and the phase of the magnetic signal. Possible relations to the magnetoelectric behavior of $Cr_2O_3$ are discussed.

MA 8.3 Fr 15:45 TU H1028

**Magnetization dynamics in all optical pump probe experiments** — •Marija Djordjevic, Mario Lüttich, Peter Moschkau, and Markus Münzenberg — IV. Physikalisches Institut, Universität Göttingen

Developing spintronics demands new insight in magnetization dynamics in the sub ns regime. Short pulses of Ti: Sapphire laser (50fs) are used in time resolved magneto optical Kerr effect experiments to follow electron and spin dynamics of ferromagnetic and not-magnetic thin films (Fe, Ni, Co, Al, Cu) upon laser heating. Different timescales are observed: ultrafast demagnetization in the first ps after the absorption of the laser pulse and precession of the magnetization in the GHz regime. The mechanisms involved in ultrafast demagnetization can be described within the three temperature model, which relates temperatures of electrons, lattice and spins. From this model electron-phonon and spin-phonon coupling constants can be determined. Standing spin waves are observed for longer time scales, >100ps. The precessive dynamics is in good agreement with dynamic LLG calculations, therefore the intrinsic and non-local Gilbert damping parameter can be determined, as well as the Eigen frequency of magnetic precessional modes.

MA 8.4 Fr 16:00 TU H1028

**Spin-Wave Eigenmodes of Permalloy Squares with Closure Domain Structure** — •Korbinian Perzlmaier[1], Matthias Buess[1], Christian H. Back[1], Vladislav E. Demidov[2], Burkard Hillebrands[2], and Sergej O. Demokritov[3] — [1]Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, D-93040 Regensburg, Germany — [2]Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany — [3]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany

We investigate the magnetization dynamics of 16nm thick and 4 $\mu$m wide permalloy squares in a closure domain state using two complementary experimental techniques: Time Resolved Scanning Kerr Micoroscopy (TRSKEM) and Micro Focus Brillouin Light Scattering ($\mu$BLS). In the $\mu$BLS case, the spin wave spectrum is imaged for a sample excited perpendicularly at different frequencies, while in the TRSKEM case the response of the out-of plane component of the sample's magnetization upon a fast rise time perpendicular field pulse excitation is recorded in the time domain. In the latter case, the mode structure is then extracted using Fourier Transformation. In addition to a low-frequency mode localized in the domain walls, additional modes in the domains with a main quantization perpendicular to the static magnetization were detected. While TRSKEM is better suited for the observation of low frequency modes, BLS yields better results for modes at higher frequencies. In the overlap of these two frequency spaces, good agreement can be found.

MA 8.5 Fr 16:15 TU H1028

**Ferromagnetic resonance in magnetic microstructures studied using phase resolved Kerr microscopy** — •Ingo Neudecker, Rainer Höllinger, Dieter Weiss, and Christian H. Back — Institut fuer Experimentelle und Angewandte Physik, Universitaet Regensburg, Universitaetsstrasse 31, 93040 Regensburg

We present a technique to investigate the eigenmode spectrum with a spatial resolution of about 300 nm using phase resolved magneto optic Kerr effect.

Instead of exciting the magnetic elements by a short magnetic field pulse containing a broad frequency spectrum we use a sinusoidal magnetic field to excite only a single mode of the system. The sinusoidal excitation is phase locked to the repetition rate of 80 MHz of our Ti:Sapphire laser system. Due to the bandwidth of the signal generator we are able to investigate the eigenmode spectrum from 80 MHz up to 20 GHz in 80 MHz intervals, limited in principle only by the spatial resolution of the Kerr setup.

The magnetic system investigated are 4 micron diameter permalloy disks with 20 nm thickness defined by electron beam lithography on top of a lithographically fabricated microwave guide.

The in plane high frequency field excites symmetry breaking azimuthal eigenmodes, which we were able to resolve up to the third order. Additionally we identified the spatially resolved evolution of the main mode as a function of a static external bias field. A comparison of the results to Network Analyzer - ferromagnetic resonance measurements and micromagnetic simulations show excellent agreement.

MA 8.6 Fr 16:30 TU H1028

**Stopping of spin wave pulses using a non-stationary bias magnetic field** — •Alexander A. Serga[1], Alexander André[1], Burkard Hillebrands[1], Thomas Schneider[1], Sergey O. Demokritov[2], and Andrey N. Slavin[3] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — [3]Department of Physics, Oakland University, Rochester, Michigan 48309, USA

The new phenomenon of phase-coherent recovery of a spin wave packet stopped and stored in standing spin waves was observed. The process is realized by means of a local alteration of the applied magnetic field. The field change shifts temporarily the dispersion curve in frequency and converts the modes comprising the spin wave packet from magnetostatic surface wave modes into exchange standing spin waves and vice versa. The converted standing spin waves were conserved for a storage time much larger than the spin wave relaxation time using parallel parametric pumping applied to the magnetic medium. The restored propagating spin wave packet preserves its phase coherency with the initial input packet irrespective of the initial phase of the parametrical pumping and the conservation time.

MA 8.7 Fr 16:45 TU H1028

**Parametric Generation of Forward and Phase-Conjugated Spin-Wave Bullets in Magnetic Films** — •Alexander A. Serga[1], Burkard Hillebrands[1], Sergey O. Demokritov[2], Andrey N. Slavin[3], P. Wierzbicki[3], Vitaliy Vasyuchka[4], Oleksandr Dzyapko[4], and Andriy Chumak[4] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — [3]Department of Physics, Oakland University, Rochester, Michigan 48309, USA — [4]Department of Radiophysics, Taras Shevchenko National University of Kiev, Kiev, Ukraine

The new physical effect of parametrically stimulated generation of two-dimensional nonlinear objects, so-called spin-wave bullets, has been observed in a magnetic film. It has been shown experimentally and by numerical simulation that interaction of a linear two-dimensional spin wave packet with the microwave magnetic field in a pulsed parametric pumping process leads to the formation of strongly self-focused spin wave bullets propagating both in forward and reversed directions. The focusing of the reversed (phase-conjugated) bullet is strongly pronounced due to the combined effects of the nonlinear four-wave self-focusing and linear focusing caused by the two-dimensional wave front reversal process.

MA 8.8 Fr 17:00 TU H1028

**Quasi-2D nonlinear spin wave waveforms in in-plane confined ferromagnetic films** — •Alexander A. Serga[1], Mikhail Kostylev[1], Burkard Hillebrands[1], Sergey O. Demokritov[2], and Andrey N. Slavin[3] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Kaiserslautern, Germany — [2]Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, Münster, Germany — [3]Department of Physics, Oakland University, Rochester, Michigan 48309, USA

The formation of quasi-2D spin-wave waveforms in longitudinally magnetized stripes of ferrimagnetic film was observed by using time- and space-resolved Brillouin light scattering technique. In the linear regime it was found that the confinement decreases the amplitude of dynamic magnetization near the lateral stripe edges. Thus, the so-called effective dipolar pinning of dynamic magnetization takes place at the edges. In the nonlinear regime a pronounced formation of focus and a collapse of the waveform were observed. The experiments and a numerical simulation of the pulse evolution show that the shape of the formed waveforms and their behavior are strongly influenced by the confinement.

MA 8.9 Fr 17:15 TU H1028

**Excitations with negative dispersion in a spin vortex** — •Matthias Buess[1,2], Tuomas P. J. Knowles[2], Rainer Höllinger[1], Thomas Haug[1], Uwe Krey[1], Dieter Weiss[1], Danilo Pescia[2], Michael R. Scheinfein[3], and Christian H. Back[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg, Germany — [2]Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule Zürich, CH-8093 Zürich, Switzerland — [3]Simon Fraser University, 8888 University Drive, Burnaby BC U5A 156, Canada

Thin-circular lithographically defined magnetic elements with a spin vortex configuration are excited with a short perpendicular magnetic field pulse. The excited modes are imaged using time resolved magneto-optic Kerr microscopy and Fourier transformation. We extract the excitation spectrum from platelets ranging from 1 to 6 micron diameter and 15 nm thickness. Two types of modes are observed: radially symmetric modes with circular nodes and symmetry breaking modes with diametric nodes. The frequency of the modes with circular nodes increases with the number of nodes. In contrast, the frequency of the modes with diametric nodes decreases with the number of nodes. This behaviour is explained accurately by an analytical model. The model reproduces this phenomenon by considering the magnet-ostatic energy associated with the excited modes as suggested by Fletcher and Kittel more than 40 years ago ( P. C. Fletscher and C. Kittel, Phys. Rev. **120**, 2004 (1960) ).

MA 8.10 Fr 17:30 TU H1028

**Thickness dependent magnetization dynamics of Permalloy elements observed by time-resolved wide-field Kerr microscopy** — •Andreas Neudert, Jeffrey McCord, Rudolf Schäfer, and Ludwig Schultz — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

We investigated the magnetization dynamics of 10 to 160 nm thin Permalloy elements using time-resolved wide-field Kerr microscopy (lateral resolution 0.3 $\mu$m, temporal resolution 20 ps). The ferromagnetic structures with lateral sizes of some ten micrometers are deposited onto a coplanar waveguide to excite them with in-plane pulsed magnetic fields produced by a standard voltage pulse generator. Due to the varying film thickness the internal domain wall structure changes (Neel, crosstie, Bloch wall) and the influence onto the magnetization dynamics will be discussed.

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MA 8.11 Fr 17:45 TU H1028

**Time resolved magnetization dynamics of ultrathin Fe(001) films: Spin-pumping and two-magnon scattering** — •Georg Woltersdorf[1,2], Matthias Buess[1], Christian Back[1], and Bret Heinrich[2] — [1]Universität Regensburg, Universitätsstraße 31, 93040 Regensburg Germany — [2]Simon Fraser University 8888 University Drive V5A 1S6 Burnaby BC Canada

The time resolved magnetic response of ultrathin epitaxial Fe(001) grown on GaAs(001) and covered by Au, Pd, and Cr capping layers was investigated by time and spatially resolved Kerr effect measurements. The multilayer structures were prepared by Molecular Beam Epitaxy on GaAs(001) substrates. The magnetization was excited by an in-plane magnetic field pulse while the wavelength of the excitation (resonant mode) was roughly 2 $\mu$m. Each of the three capping layer represents a unique case of spin dynamics. Au cap layers resulted in the Fe bulk Gilbert damping. Pd cap layers caused an additional Gilbert damping due to spin-pump/spin-sink effects. Cr cap layers lead to a strong extrinsic damping which can be described by two-magnon scattering. The strength of the extrinsic damping can be controlled by shifting the spin manifold with respect to the excited k-vector using an external bias field.

MA 8.12 Fr 18:00 TU H1028

**Field-pulse induced generation of spin waves at domain boundaries in permalloy microstructures observed by XMCD-PEEM** — •A. Krasyuk[1], S.A. Nepijko[1], A. Oelsner[1], H.J. Elmers[1], C.M. Schneider[2], and G. Schönhense[1] — [1]Institut für Physik, Johannes Gutenberg - Universität, 55099 Mainz — [2]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich

Stroboscopic XMCD-PEEM imaging gives direct access to fast remagnetization processes. At gradients in the region of 1mT/500 ps we have observed the fast formation of blocking domains (incoherent magnetization rotation [1]) and a rapid coherent rotation of the domain magnetization [2] resulting in a field-induced magnetic flux traversing the microstructure. Here we report on measurements with a high time resolution in the 10 ps-range employing the low-$\alpha$ multibunch operational mode of BESSY II providing photon pulses of < 2ps width. Domain images with time increments of down to 10 ps revealed a rapid oscillation of the visible position of the domain boundaries. A micromagnetic simulation using the NIST code (OOMMF) gives evidence of the excitation of spin waves at the domain boundaries as a consequence of the fast displacement of the domain wall during the field pulse. The plane-wave like spin wave travels perpendicular to the wall thus giving rise to an apparent oscillation of the wall position with a frequency in the 10 GHz range. Financial support by BMBF (grants 05KS1UM1/5 and 05KS1BDA/9) and DFG (Schwerpunktprogramm SPP 1133) is gratefully acknowledged.

[1] C.M. Schneider et al., Appl. Phys. Lett. 85 (2004) 2562
[2] D. Neeb et al., J. Phys.: Condens. Matter (2004) in print

MA 8.13 Fr 18:15 TU H1028

**Time-resolved photoelectron emission microscopy of magnetic nanostructures** — •B. Heitkamp, L. Heyne, H.A. Durr, and W. Eberhardt — BESSY GmbH, Albert-Einstein-Strasse 15, 12489 Berlin

In view of the ever-growing field of magnetoelectronics it is of major importance to understand the fundamental physical phenomena. Our approach is to combine nm spatial resolution of a photoemission microscope (PEEM) and fsec-laser technique. By analyzing the spin-polarization of the emitted photoelectrons magnetic sensitivity can be obtained. The magnetic nanostructures under investigation show a strong dependence of the emission characteristics on light polarization and wavelength. This can be explained by plasmon-excitation and other coherence effects. Pump-probe experiments can be used to study the electron and spin-dynamics on a fsec-time scale.