# MA 24: Spindynamics / Switching II

Time: Thursday 10:15–12:45 Location: H23

MA 24.1 Thu 10:15 H23

**Non-ballistic precessional magnetic random access memories.** — •F. Porrati and M. Huth — Physikalisches Institut, J. W. Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

We present a novel magnetic random access memory (MRAM) architecture, the non-ballistic precessional MRAM, and a related bit addressing scheme based on the sequential application of two unipolar magnetic field pulses. We perform micromagnetic simulations to study the magnetization trajectories and the stability of the states obtained after switching of the magnetization direction. Despite the presence of damped oscillations the final states are stable for field pulses of subnanosecond duration.

MA 24.2 Thu 10:30 H23

**Magnetization dynamics of $Cr0_2$(100) thin films** — •Georg Müller[1], Jakob Walowski[1], Marija Djordevic[1], Guo-Xing Miao[2], Arunava Gupta[2], and Markus Münzenberg[1] — [1]IV. Phys. Institut, Georg-August-Universität, Göttingen, Germany — [2]MINT, University of Alabama, Tuscaloosa, AL, USA.

Because of its outstanding half metallic electronic properties, the ferromagnet $Cr0_2$ (100) is an interesting candidate for future spintronic devices. In this study the magnetization dynamics of $Cr0_2$ (100) films are examined by all-optical pump probe technique where precessional motion is induced by an anisotropy field pulse. The sample exhibits a strong magneto-crystalline in-plane anisotropy, which results in a peculiar dependence of the precessional frequency on the applied external field with respect to the anisotropy field. This behaviour can be understood by studying the energy landscape of the sample. Also the precessional damping shows a strong dependence on the applied external field in hard-axis direction. This gives rise to the question of which nature the damping mechanism in this sample is.

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MA 24.3 Thu 10:45 H23

**Ultrafast magnetization dynamics probed by anisotropic magnetoresistance** — •Santiago Serrano-Guisan[1], Hans-Werner Schumacher[1], Karsten Rott[2], and Günter Reiss[2] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116, Braunschweig, Germany — [2]University of Bielefeld, Department of Physics, Universitätsstr. 25, D-33615 Bielefeld, Germany

We study ultrafast magnetization dynamics and relaxation of a single ferromagnetic layer by time resolved measurements of the anisotropic magnetoresistance (AMR). The samples consist of a 5 nm Ta seed layer, 5 nm permalloy (Fe19Ni81) and a 3 nm Al cap layer. The films are microstructured into disks of 4-6 micrometer diameter and are contacted by coplanar wave guides for ultra fast AMR detection. The samples show an AMR ratio around 0.25% and the typical cos2 angular dependence. Ultrafast magnetic excitation field pulses (rise time ~ 75ps, fall time ~ 670ps and duration at half maximum ~ 230ps) are applied using a pulse line on chip. Additionally, in plane static magnetic fields are applied using external coils. The temporal variation of the AMR upon pulse excitation clearly reveals the damped precession of the magnetization of the permalloy disk. From comparison to macro spin simulations we derive a Gilbert damping parameter of 0.008 for the permalloy. This technique can be used to access the dynamics of a wide variety of microstructured magnetic thin film devices showing AMR.

MA 24.4 Thu 11:00 H23

**Ultrafast dynamics of the magnetic phase transition on FeRh** — •Ilie Radu[1,2], Alexander Weber[1], Paul Ramm[1], Christian Stamm[2], Torsten Kachel[2], Niko Pontius[2], Jan Thiele[3], Hermann Dürr[2], and Christian Back[1] — [1]Institut für Experimentelle Physik, Universität Regensburg, Germany — [2]BESSY GmbH, Berlin, Germany — [3]Hitachi Global Storage Technologies, San Jose, U.S.A.

The laser-induced dynamics of the antiferromagnetic (AFM) to ferromagnetic (FM) phase transition of the FeRh alloy is studied by two complementary experimental techniques: the time-resolved magneto-optical Kerr effect (MOKE) and the time-resolved X-ray circular magnetic dichroism (XMCD). The transient MOKE data reveal an ultrafast onset of the FM ordering within 500 fs after femtosecond laser excitation. This result points to an electronically-driven AFM-FM transition since the lattice heating and the resulting lattice expansion evolve on a longer time scale. From the time-resolved XMCD spectra we obtain a similar dynamics for the Fe and Rh magnetic moments with a rise-time of 100 ps, which seems to contradict the dynamic MOKE data. The possible origin of this discrepancy will be discussed in terms of excitation and detection mechanisms in MOKE and XMCD. Due to the large magnetic moment of FeRh established in the FM state, one can use the ultrafast phase transition to trigger a coherent magnetization precession of a thin ferromagnetic film in contact with FeRh. Here, we present first pump-probe MOKE measurements of such a double layer system of CoPd/FeRh, that show two oscillatory components at 60 GHz and 80 GHz.

MA 24.5 Thu 11:15 H23

**Critical damping of precessional magnetization dynamics in microscopic spin valve elements** — •Hans-Joachim Elmers[1], Frederik Wegelin[1], Dimitri Valdaitsev[1], Alexander Krasyuk[1], Sergei Nepijko[1], Gerd Schönhense[1], Ingo Krug[2], and Claus M. Schneider[2] — [1]Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz, Germany — [2]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

We have studied ultrafast magnetization processes in micropatterned spin valve structures using time-resolved x-ray photoemission electron microscopy combined with x-ray magnetic circular dichroism (XMCD-PEEM). Exciting the magnetodynamics with ultrafast field pulses of 250 ps width, we find the dynamic response of the free layer to strongly depend on the amplitude and repetition rate (0.5 - 1 GHz) of the exciting field pulses. This response can be only roughly described by a single spin model using an unexpectedly high damping constant of $\alpha = 0.025$, which is 2-3 times higher than reported for single ferromagnetic layers and results in a critical damping of the magnetization oscillations. A pulse repetition rate of 1 GHz leads to an oscillatory response thus limiting the available bandwidth of the sensor. Time resolved microscopy reveals that the magnetodynamics does not follow a phase coherent precessional motion. The observed deviations from the single spin model are attributed to the excitation of additional short wavelength standing spin wave modes.

MA 24.6 Thu 11:30 H23

**Dynamic Quasi-Particle Behaviour of Geometrically Confined Domain Walls** — •Daniel Bedau, Mathias Kläui, and Ulrich Rüdiger — Universität Konstanz, 78467 Konstanz

Magnetic domain walls in laterally confined elements feel the potential landscape generated by notches. Depending on its type the domain wall is either symmetrically pinned inside of the notch (transverse wall) or pinned adjacent to the notch (vortex wall)[1]. This pinning allows to reliably switch magnetic domain walls between different positions, because of the long range of the attractive potential which locks the domain walls to the notch positions. The width of the potential, the depth, corresponding to the pinning strength, and the angular dependence of the pinning potential have been published [2,3,4]. Because of their small lateral extensions domain walls can act like quasi particles oscillating in a potential well, which allows us to study the potential by measuring the oscillation frequency of the domain wall. We have chosen to study magnetic rings, because the ring structure allows precise control of the domain wall spin structure via the lateral dimensions and the thickness of the film. To measure the structure of the potential, a new setup has been built to determine the influence of microwave excitations on the electrical properties of domain walls in the range from 10 MHz up to 20 GHz at low temperatures. [1] M. Kläui et al., Phys. Rev. B **68**, 134426 (2003), Physica B **343**, 343 (2004) [2] M. Kläui et al., Phys. Rev. Lett. **90**, 97202 (2003) [3] M. Kläui et al., Appl. Phys. Lett. **87**, 102509 (2005) [4] D. Bedau et al., J. Appl. Phys., (in press 2007)

MA 24.7 Thu 11:45 H23

**Breathing Fermi surface model for noncollinear magnetization: A generalization of the Gilbert equation** — •Daniel Steiauf and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart

Within the breathing Fermi surface model the damping of the magnetization dynamics is related to the change of the Fermi surface with changing magnetic configuration, given by the orientations of the atomic magnetic moments: This change requires a scattering of the electrons among the single-electron states in reciprocal space, and this in turn requires time. For a uniform cooperative rotation of all magnetic moments the change of the Fermi surface results from spin-orbit coupling. In this case the theory yields a Gilbert-type equation of motion for the magnetization with the damping scalar of the original Gilbert equation replaced by a damping matrix which depends on the momentary orientation of the magnetization. The change of a non-collinear magnetization configuration leads to an even stronger change of the Fermi surface resulting from the interatomic exchange interactions. The damping then is described by a damping matrix which is different for different sites and which depends on the momentary magnetization configuration of the whole system, i.e., the equation of motion is nonlocal.

MA 24.8 Thu 12:00 H23

**Temperature dependent magnetization switching** — •Alexander Sukhov and Jamal Berakdar — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle/Saale, Germany

Recenlty, it has been shown [1] that the switching behaviour of magnetic nanoparticles can be well controlled by means of time-dependent magnetic fields. Motivated by these findings, we study in this theoretical work the spin-dynamics and the switching properties of a magnetic nanoparticles (Stoner-particles) using the Landau-Lifshitz-Gilbert equation extended for the case of finite temperatures, a task which has not been tacked by previous studies [2]. In particular, we are interested in the minimal amplitudes of the switching fields and the corresponding reversal times of the magnetic moment of the nanoparticle both for static and time-dependent external fields depending on the damping. Optimal parameters for the magnetization reversal and their temperature dependence are worked out.

References:
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[2] Z. Z. Sun and X. R. Wang, Phys. Rev. Lett. **97**, 077205 (2006).

MA 24.9 Thu 12:15 H23

**Spin transfer induced magnetization dynamics using the Ag/Fe(100) interface** — •Ronald Lehndorff, Daniel E. Bürgler, and Claus M. Schneider — Institut für Festkörperforschung and cni - Center of Nanoelectronic Systems for Information Technology, Forschungszentrum Jülich GmbH, D-52425 Jülich

Spin-polarized currents in magnetic nanostructures induce magnetization dynamics, which differ strongly from magnetic field induced dynamics [1, 2]. The Ag/Fe(100) interface has been predicted to have a strong spin dependence of the interface resistance and should therefore be a good spin polarizer [3] and give strong spin transfer effects. We study spin transfer induced magnetization dynamics in single-crystalline, layered systems grown by molecular beam epitaxy. The layer sequence is 2 nm Fe/ 6 nm Ag/ 20 nm Fe. The topmost layer is structured by e-beam lithography and ion beam etching into a circle of 65 to 85 nm in diameter. To characterize the structures we measure the current-perpendicular-plane giant magnetoresistance. Current induced switching and current driven high-frequency excitations of the free layer are recorded under different angles of the magnetic field with respect to the crystal axes of the Fe(100) layers.

[1] J.C. Slonczewski, J. Magn. Magn. Mater. **159**, L1 (1996)
[2] L. Berger, Phys. Rev. B **54**, 9353 (1996)
[3] D. Stiles, A. Zangwill, Phys. Rev. B **66**, 014407 (2002)

MA 24.10 Thu 12:30 H23

**Ferromagnetic resonance study of the interlayer exchange coupled NiFe/Ru/NiFe films** — •Mohamed Belmeguenai, Tobias Martin, Georg Woltersdorf, and Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

Ferromagnetic bilayers exchange coupled through a non-magnetic metallic layer are used in magnetic recording devices. Their dynamics at 1 to 10 GHz which present a fundamental limit to increasing data rates have been studied in this work. We used conventional ferromagnetic resonance (FMR) and vector network analyzer FMR to study the different excited dynamic modes in exchange coupled Si/Ta/NiFe(30 nm)/Ru(dRu)/NiFe(30 nm)/Ta films with variable Ru thicknesses dRu. The interlayer exchange coupling (IEC) constants are determined by VSM and MOKE. The dynamic measurements show the existence of an optic and an acoustic precession mode. Their resonance frequencies and therefore the IEC are found to oscillate as a function of dRu with a period of 8.5 Å. The frequency oscillations of the optic mode are coupling-dependent while those of the acoustic mode are indirectly related to coupling via the canting angle of the layer magnetizations. The FMR measurements carried out at 22 and 35 GHz revealed clearly different behaviors of the FMR linewidths as a function of dRu for the optic and acoustic modes and we observed perpendicular standing spin-waves. The FMR linewidth of the different excited modes increases with the microwave frequencies and typical damping constants of 0.0073 have been measured.