# MA 31: Magnetization Dynamics III

Time: Wednesday 11:00–12:45 Location: HSZ 403

MA 31.1 Wed 11:00 HSZ 403

**Atomistic Simulations of the Dynamaics of Antiferromagnets and Ferrimagnets** — •Sönke Wienholdt[1], Frank Schlickeiser[1], Oksana Chubykalo-Fesenko[2], and Ulrich Nowak[1] — [1]Universität Konstanz, Germany — [2]Instituto de Ciencia de Materiales de Madrid, Spain

So far, ultrafast all-optical magnetization switching has been demonstrated experimentally only in ferrimagnetic materials like GdFeCo[1]. A reason for this restriction seems to be the antiferromagnetic coupling of the two sub-lattices in these materials, which may lead to completely different dynamics as compared to a ferromagnet, combined with a strong, ultrashort magnetic field pulse induced by the inverse Faraday effect [2]. Also the heating by the laser pulse is assumed to play a crucial role in this process and it was speculated that the special properties of the ferrimagnet close to the compensation point could be relevant [3].

To understand the dynamics in these materials, we perform atomistic simulations of antiferromagnets as well as ferrimagnets, driven either by extern magnetic field pulses or variation of the spin temperature. We calculate the effective frequencies and damping parameters, compare them with experimental findings[4] and analytical results and investigate possible switching mechanisms as well as their typical timescales. [1] C.D. Stanciu et al., Phys. Rev. Lett., 99 (047601), 2007 [2] A.V. Kimel et al., Nature Physics, 5 (727 - 731), 2009 [3] K. Vahaplar et al., Phys. Rev. Lett. 103 (117201), 2009 [4] C.D. Stanciu et al., Phys. Rev. B, 73 (220402), 2006

MA 31.2 Wed 11:15 HSZ 403

**Time-resolved magnetization dynamics of tetragonally distorted antidot lattices** — •Benjamin Lenk, Fabian Garbs, and Markus Münzenberg — I. Physikalisches Institut, Universität Göttingen

Femtosecond laser pulses can be used to optically excite (pump) and subsequently measure (probe) magnetization dynamics on timescales as long as nanoseconds. Two-dimensional arrays of antidots in a ferromagnetic film provide a periodic "potential" to the excited spin waves and induce drastic changes in the magnetization dynamics.

Magnonic modes with Bloch-like character can be observed as well as non-dispersive localized modes situated at the edges of the individual antidots. The understanding of these rivaling effects is only possible via the locally varying internal magnetic field. In the presented work a tetragonal distortion of the initially square lattice is used to address this issue. In combination with the applied external field the resulting asymmetry leads to differently large overlaps of the regions of strong field inhomogeneity.

We focus on the influence of the in-plane angle between external field and distorted antidot lattice. In particular, by applying the field along the long or short axis the overlap of regions of inhomogenious internal magnetic field can be varied. Thus, a tuning of the degree of localization is possible.

MA 31.3 Wed 11:30 HSZ 403

**Nonlinear magnon scattering in nano-sized Permalloy elements** — •Henning Ulrichs[1], Vladislav E. Demidov[1], Sergej O. Demokritov[1], and Sergei Urazhdin[2] — [1]Institut für angewandte Physik, Universität Münster, Correnstraße 2-4, 48149 Münster, Germany — [2]Department of Physics, West Virginia University, Morgantown, WV 26506, USA

In this talk we will report about nonlinear magnetization dynamics in sub-micron-sized elliptical Permalloy dots. The dynamics was excited using intense microwave pulses and studied by means of micro-focus Brillouin light scattering spectroscopy. In the linear regime, one predominantly observes excitation of the fundamental eigenmode of the dot, which resembles the FMR mode in such a confined geometry. At higher pulse powers a secondary, low-frequency mode is excited in addition to the fundamental mode. This process nucleates at the center of the dot, where the amplitude of the fundamental mode shows a maximum. Our explanation assumes a scattering of magnons of the fundamental mode into the lowest frequency state. This process is reminiscent of the initial phase in the formation of magnon Bose-Einstein condensate observed in low-loss garnet films.

MA 31.4 Wed 11:45 HSZ 403

**Angular momentum conservation in ultrafast spin manipulation processes on magnetic nanoclusters** — •Georg Lefkidis and Wolfgang Hübner — Kaiserslautern University of Technology and Research Center OPTIMAS, Germany

Ultrafast optical $\Lambda$ processes have been shown to lead to coherent spin manipulation on magnetic nanostructures with a few magnetic centers [1-3]. Thus multicenter magnetic clusters allow exploiting spin dynamics for full-fledged logic functionalization [2]. To explain the angular momentum conservation during the spin-flip processes we propagate in time the intragap levels of a NiO cluster under the influence of a linearly polarized laser pulse [3]. Subsequently we calculate the induced time-dependent electric polarization in the material and Fourier-transform into the frequency regime while convoluting with a time-weighting function. This way we calculate the frequency- and time-dependent Stokes vector. Using quantum optics analysis we show how the coherently induced material polarization leads to angular-momentum exchange between the light and the irradiated NiO surface. We also predict a dynamic Kerr-effect, which provides a signature for monitoring spin-dynamics, by simply measuring the transient rotation and ellipticity of the reflected pump beam [1].

[1] G. Lefkidis, G. P. Zhang, and W. Hübner, Phys. Rev. Lett. **103**, 217401 (2009).
[2] W. Hübner, S. Kersten and G. Lefkidis, Phys. Rev. B **79**, 184431 (2009).
[3] G. Lefkidis and W. Hübner, Phys. Rev. B **76**, 014418 (2007).

MA 31.5 Wed 12:00 HSZ 403

**Evolution from superparamagnetism to ferromagnetism in nanostructures studied by first-principles magnetization dynamics** — •Danny Böttcher[1,2], Arthur Ernst[1], and Jürgen Henk[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

With respect to the ongoing miniaturization of spintronic devices, the magnetic stability of nanostructures becomes increasingly important. These systems have, thus, to be described theoretically on the atomic length-scale and on the femtosecond time-scale.

We report on an investigation of atomistic magnetization dynamics by means of the stochastic Landau-Lifshitz-Gilbert equation. The exchange and anisotropy parameters of the spin Hamiltonian are computed from first principles. For the paradigmatic Co nanoislands on Cu(111), we focus on the evolution from superparamagnetic (noncollinear) states to a ferromagnetic (collinear) state in dependence on temperature, island size, and external magnetic field. It turns out that corners and edges of the triangular islands act as nucleation centers of magnetic nanodomains.

MA 31.6 Wed 12:15 HSZ 403

**Lateral spin-valve devices operated by spin pumping** — •Nils Kuhlmann, Andreas Vogel, Toru Matsuyama, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

In the last years, all-metal lateral spin-valve devices have been studied intensively since they provide fundamental understanding of spintronics [1], as well as new concepts for logic devices [2]. Recently, high frequency properties of nanostructures became of great interest because of potential technological applications. The aim of our work is to build an all-metal lateral spin-valve device, where the injected spin current arises from a ferromagnet driven at ferromagnetic resonance (FMR) with an rf-field, pumping spins into the adjacent normal metal [3]. The detection of a spin current created by spin pumping with a spin-valve structure in non-local geometry provides the possibility to quantify the pumping efficiency but has not yet been accomplished. We present the basic concept of a FMR pumped spin-valve device, and show first results. The cone angle of the magnetization precession of a single electrode driven in FMR was determined via the anisotropic magnetoresistance (AMR) to be up to 14°, which is to the best of our knowledge the highest value reportet in the literature so far. Also, the dependence of the interaction between the electrodes on the distance between them was investigated and optimized.

[1] A. Vogel et al., APL 94, 122510 (2009); [2] T. Kimura et al., APL 97, 182501 (2010); [3] M. V. Costache et al., PRL 97, 216603 (2006)

MA 31.7 Wed 12:30 HSZ 403

**Nonlinear hybridization of the fundamental eigenmodes of microscopic ferromagnetic ellipses** — •Matthias Buchmeier[1], Vladislav E. Demidov[1], Karsten Rott[2], Patryk Krzysteczko[2], Jana Münchenberger[2], Günter Reiss[2], and Sergej O. Demokritov[1] — [1]Institute for Applied Physics, University of Münster, Germany — [2]Department of Physics, Bielefeld University, Germany

We present an experimental study of nonlinear eigenmodes of microscopic Permalloy elliptical elements using micro-focus Brillouin light scattering spectroscopy, a technique providing sub-micrometer spatial resolution. We find that two fundamental eigenmodes of such ferromagnetic elements, the edge and the center mode, show an essentially different nonlinear behavior [1]. With increasing amplitude, the frequency of the edge mode exhibits a continuous positive nonlinear shift. On the other hand the frequency of the center mode stays unchanged until it is approached by the edge mode. Subsequently the modes hybridize which influences both the frequencies and the spatial distributions of the dynamic magnetization. As a consequence of this nonlinear hybridization the distributions lose the shape well known for the linear regime and take a hybrid form. Our findings contribute to the deep understanding of the essentially nonlinear large-amplitude magnetization dynamics in microscopic magnetic-film structures, which is of special importance for the understanding of spin-transfer-torque and microwave-assisted magnetization-switching phenomena.

[1] V. E. Demidov et al., *Phys. Rev. Lett.* **104**, 217203 (2010).