MA 31: Focus Session: Magnetic Damping Phenomena in Thin Films and Nanostructures (jointly with DS)

Organizers: J. Lindner (HZDR), H. Ebert (TU München)

New emerging technologies for enhanced magnetic information storage require an improved understanding and control of the mechanisms that influence the magnetization reversal and stability on the nanoscale. The key property in this context is magnetic relaxation as it governs all processes that invoke the dynamic behavior of the magnetization. In this session we aim to discuss recent progress in understanding intrinsic Gilbert damping as well as extrinsic relaxation channels which are relevant for the timescales of femto- to nanoseconds. Besides experimental approaches in time and frequency domain, state-of-the art theoretical descriptions on an ab-initio basis as well as model calculations are reviewed.

Time: Wednesday 15:00–17:30 Location: H10

Topical Talk MA 31.1 Wed 15:00 H10

An overview of magnetic damping in ferromagnets — •Robert McMichael — National Institute of Standards and Technology, Center for Nanoscale Science and Technology, Gaithersburg MD USA

Many of the applications for magnetic nanotechnology depend on the ability to write and read information quickly by switching and measuring the magnetization in magnetic nanostructures, and the magnetic damping plays an important role in the dynamics. The desired amount of damping depends on the application. For example, in some cases, strong damping enables fast switching, while in other cases strong damping prevents switching. In this talk, I will give a brief introduction to the phenomenology of damping, or relaxation, of magnetization in ferromagnets, which is often nicely described by a viscous drag or Gilbert damping. I aim to supplement this phenomenological picture by reviewing the current understanding of damping mechanisms in ferromagnetic metals. The primary mechanism involves transferring energy to electronic states near the Fermi surface. Additionally, in nanostructures, the dynamic effects of damping can be modified by spin polarized currents either that are injected from external sources or that are generated spontaneously by the magnetization precession. I will conclude by focusing on problems of interpreting damping measurements in materials with defects, and on the opportunities for intrinsic damping measurements in nanostructures.

Topical Talk MA 31.2 Wed 15:30 H10

Magnetic Damping on Femtosecond Time Scales — •Markus Münzenberg — Georg-August University, I. Phys. Institute, Göttingen, Germany

Achieving high speed magnetization dynamics in magnetic materials is at the heart of the engineering of spin-based electronic devices. Microscopic processes in a magnetic materials involve electrons, their spins, and their interactions with phonons. Materials with low damping constants can be realized by controlling the spin-flip channels at the Fermi level. Metallic Heusler compounds show a Gilbert damping of 0.002-0.006, however, the theoretically predicted values are $10^{-5} - 10^{-4}$.

The experiments we report in this talk demonstrate a successful control of spin polarization and spin dynamics on ultrafast time scales in magnetic materials through their electronic structure. For achieving a systematic variation in their electronic structure as a control, we have made a selection of so-called half-metals, in the family of the Heusler compounds and pseudogap materials that are close relatives, but their electronic structure is robust against structural disorder. Interestingly, similar values of spin polarization are seen in the pseudogap materials as well, making them another promising class of high-spin-polarization materials.

[1] A. Mann, J. Walowski, M. Münzenberg, S. Maat, M. J. Carey, J. R. Childress, C. Mewes, D. Ebke, V. Drewello, G. Reiss, A. Thomas, Phys. Rev. X 2, 041008 (2012).

Topical Talk MA 31.3 Wed 16:00 H10

Two-Magnon Excitations: From Periodical Perturbations to Magnonic Crystals — •Kilian Lenz — Magnetism Division, Institute for Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01324 Dresden

Two-magnon scattering is a well-known effect e.g. in ferromagnetic resonance experiments leading to a linewidth broadening. Available theory so far was based on random defects acting as a dipolar scattering potential. Recently it was shown by Landeros and Mills [1] that this theory can be extended to handle two-magnon scattering in *periodically* perturbed films, which can be easily created by lithographical patterning. These perturbed films are the intermediate step towards full magnonic crystals. The extended model allows for analytically calculating the response function of 1D and 2D periodically perturbed ferromagnetic films in almost perfect agreement to FMR experiments as I will show. A striking feature e.g. is the mode splitting due to the two-magnon scattering which opens magnonic band gaps. This splitting can be tailored by the geometric and magnetic sample parameters.

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[1] P. Landeros and D. L. Mills, Phys. Rev. B 85, 054424 (2012).

Topical Talk MA 31.4 Wed 16:30 H10

Gilbert damping parameter from first-principles — •Diemo Ködderitzsch[1], Sergiy Mankovsky[1], Hubert Ebert[1], and Georg Woltersdorf[2] — [1]Universität München, Dept. Chemie, Butenandtstraße 5-13, D-81377 München, Germany — [2]Universität Regensburg, Fak. f. Physik, Universitätsstraße 31, 93040 Regensburg, Germany

Conventionally, magnetisation dynamics is discussed on the basis of the Landau-Lifshitz-Gilbert equation containing a damping term for the magnetisation. So far in first-principles calculations, the scattering processes responsible for the transfer of energy associated with the magnetisation to the lattice (due to spin-orbit coupling) are usually represented by an adjustable relaxation time parameter. Recent approaches tackled this problem by introducing a scheme employing scattering theory. [1,2] We here present a general approach to calculate the damping parameter from first-principles based on the linear response Kubo formalism, as implemented within the fully relativistic Korringa-Kohn-Rostoker band structure method. This approach allows, in particular, to account for scattering processes due to chemical disorder or thermal lattice vibrations. Results for 3*d* transition-metals and their alloys, and impurity systems, compared to experiment demonstrate the viability of the approach. [3,4]

[1] Brataas *et al.*, PRL **101**, 037207 (2008) [2] Starikov *et al.*, PRL **105**, 236601 (2010) [3] Ebert, Mankowsky, Ködderitzsch and Kelly, PRL **107**, 066603 (2011) [4] Mankowsky, Ködderitzsch, Woltersdorf and Ebert, submitted to PRB (2012)

Topical Talk MA 31.5 Wed 17:00 H10

Spin dynamics and relaxation in ferrimagnets — Frank Schlickeiser, Sönke Wienholdt, Denise Hinzke, and •Ulrich Nowak — Universität Konstanz, 78457 Konstanz, Germany

Recent experiments on all-optical switching in GdFeCo [1] have focused much attention on the spin dynamics of ferrimagnets. The understanding of relaxation mechanisms is here even more complicated than in a ferromagnet due to the fact that the two sublattices of the ferrimagnet can exchange energy and angular momentum without dissipation, keeping the total energy and angular momentum constant.

We discuss the theory of the dynamics of ferrimagnets on different length scales, ranging from microscopic spin models to mesoscopic descriptions with a two-sublattice Landau-Lifshitz-Bloch equation. Our results for the temperature dependence of the frequencies and effective damping parameters of the normal modes represent a generalization and improvement of formetwo-sublatticer approximated solutions [2]. Furthermore, we discuss the role of angular momentum conservation and dissipation for the recently discovered transient ferromagnetic-like state [3] and for the pure thermal switching of ferrimagnets [4].

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FEMTOSPIN) and from the CAP at the University of Konstanz.

[1] K. Vahaplar *et al.*, Phys. Rev. Lett. **103**, 117201 (2009).
[2] F. Schlickeiser *et al.*, Phys. Rev. B, in press.
[3] I. Radu *et al.*, Nature **472**, 205 (2011).
[4] T. A. Ostler *et al.*, Nat. Commun. **3**, 666 (2012).