MA 43: Magnetization / Demagnetization Dynamics III

Time: Thursday 9:30–12:00 Location: EB 301

MA 43.1 Thu 9:30 EB 301

Control of the effective damping in Heusler/Pt microstructures via the spin-transfer torque effect — •Thomas Meyer[1], Thomas Brächer[1], Philipp Pirro[1], Tobias Fischer[1], Alexander Serga[1], Hiroshi Naganuma[2], Koki Mukaiyama[2], Mikihiko Oogane[2], Yasuo Ando[2], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Applied Physics, Graduate School of Engineering, Tohoku University, Sendai 980-8579, Japan

We present the control of the effective spin-wave damping by the spin-transfer torque exerted by a pure spin current injected into Heusler compound microstructures. In this work, the pure spin current is generated by a DC current in a Pt layer adjacent to the magnetic layer via the spin-Hall effect. Especially, the used cobalt-based Heusler compound $Co_2Mn_{0.6}Fe_{0.4}Si$ used in this work already provides a comparably low Gilbert damping. Thus, this class of materials is very promising for the usage in any devices based on spin waves as only very low currents for the control of the effective damping are needed. The obtained results show a strong influence of an applied DC current on the spin-wave properties. Investigations using only thermally excited spin waves exhibit a strongly increased spin-wave intensity due to a decreased effective damping. The measurements show the feasibility of using the spin-transfer torque effect to control the effective spin-wave damping in waveguides which is very promising for future applications using propagating spin waves to transfer information.

MA 43.2 Thu 9:45 EB 301

Full electric detection of a Bose-Einstein condensate via the spin-pumping effect — •Dmytro A. Bozhko[1,2], Akihiro Kirihara[3], Andrii V. Chumak[1], Gennadii A. Melkov[4], Yaroslav Tserkovnyak[5], Burkard Hillebrands[1], and Alexander A. Serga[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Germany — [3]Smart Energy Research Laboratories, NEC Corporation, Japan — [4]Faculty of Radiophysics, Taras Shevchenko National University of Kyiv, Ukraine — [5]Department of Physics and Astronomy, University of California, USA

It is well known, that magnons excited in an insulating magnetic medium can transfer their angular momenta to free electrons in an adjacent non-magnetic metal layer, and thus generate a spin current via the spin-pumping effect. Due to the inverse spin Hall effect (ISHE) this current is transformed into a charge current and is measured as an electric voltage. It is commonly believed that the magnitude of the ISHE voltage increases with the total number of magnons in a spin-wave system as well as with the energy of these magnons. However, the electric signal, which corresponds to the formation of a magnon Bose-Einstein condensate (BEC) by a freely evolving magnon gas after the termination of an external pumping, breaks with this rule: The transition of the thermalized gaseous magnons to the lowest energy states leads to a pronounced upward jump of the voltage magnitude. This unusual behaviour can be understood as a result of a rectification of a coherent microwave current induced by the coherence of the BEC.

MA 43.3 Thu 10:00 EB 301

Spin-transfer Torque Magnetisation Switching in Multilayered System from Atomistic Spin Dynamics — •Fan Pan[1], Anders Bergman[2], and Lars Bergqvist[1] — [1]Department of Material and Nano Physics, School of ICT, KTH Royal Institute of Technology, Electrum 229, 164 40, Kista, Sweden — [2]Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20, Uppsala, Sweden

The magnetization dynamics of a synthetic layered magnetic materials, prototype for a magnetic random access memory device, has been investigated through first-principles and atomistic spin dynamics simulations (ASD). It is found that the magnetization dynamics driven by the spin-transfer torque (STT) is of nonlinear character and the roles of adiabatic and non-adiabatic STT are still not clear. Therefore, our study aims to gather a deeper understanding of these intrinsic properties. We have compared two different system geometries, both with an applied current flowing perpendicular to the plane of the layers. If no restriction is imposed to the magnetisation of the both outer layers, a steady-state processing motion is found. A more complicated switching behaviour is found if the magnetization of one layer is fixed and the other is free to rotate. In the latter case, the critical current density of the magnetization reversal is described both analytically and numerically. In addition, the optimal conditions of STT induced switching are suggested. Finally, we have performed calculations of experimental available systems using material parameters from electronic structure calculations based on density functional theory.

MA 43.4 Thu 10:15 EB 301

Phonon-affected Gilbert damping tensor within the breathing Fermi-surface model — •Danny Thonig[1], Nicki F. Hinsche[2], Jürgen Henk[2], and Olle Eriksson[1] — [1]Department of Material Theory, Uppsala University, Sweden — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Concerning magnetic switching, an essential property of magnetic devices is the relaxation rate which depends strongly on the damping α in the magnetization dynamics. This angular-momentum dissipation was predicted to be dominated by the coupling between the magnon and the phonon reservoir [1]. Especially in the high-temperature regime, discrepancies between theory and experiment call for deeper understanding of the phonon-mediated damping, for example by means of a model.

We apply the breathing Fermi-surface model [2] in the framework of a Green-function tight-binding approach [3] and transition matrix theory. For bulk Stoner magnets, the spatial disorder (phonons) is considered either as gaussian-distributed around the equilibrium positions or as a self-energy. We compare these two approaches with each other, with other *ab initio* methods as well as with experiment.

[1] H. Ebert, S. Mankovsky, D. Ködderitzsch, and P. J. Kelly., Phys. Rev. Lett, **107** (2011) 066603

[2] V. Kamberský, Cz. Journal of Physics B, **34** (1984) 1111

[3] D. A. Papaconstantopoulos and M. J. Mehl, J. Phys.: Condens. Matter, **15** (2003) R413-R440

MA 43.5 Thu 10:30 EB 301

Optically Induced Ferromagnetic Resonance in Magnetic Iron Garnets — •Manuel Jäckl[1], Ilya A. Akimov[1], Vladimir I. Belotelov[2,3,4], Anatoly K. Zvezdin[3,4], and Manfred Bayer[1] — [1]Experimentelle Physik 2, TU Dortmund, D-44221 Dortmund, Germany — [2]Lomonosov Moscow State University, 119991 Moscow, Russia — [3]Russian Quantum Center, Novaya St. 100, Skolkovo, Moscow Region, 143025, Russia — [4]Prokhorov General Physics Institute, Russian Academy of Sciences, 119991 Moscow, Russia

We use the inverse Faraday effect in order to influence the magnetization of a ferromagnetic bismuth iron garnet (BIG) film by means of circularly polarized femtosecond laser pulses. Optical excitation modifies the magnetization and triggers its precession around the equilibrium position with a lifetime of several nanoseconds and a frequency of 2 – 7 GHz in transverse magnetic fields of 70 – 250 mT, respectively. The phase of the precession changes by 180 degrees when the helicity of the exciting laser pulses is switched from σ^+ to σ^-. Optically induced ferromagnetic resonance is achieved using a sequence of optical pulses with low pulse energy of 50 pJ and high repetition rate of $F_{\mathrm{Rep}} = 1$ GHz which is larger than the decay rate of the oscillation. We observe an amplification of the laser induced Faraday rotation signal by 60 % when the precession frequency corresponds to the resonance condition ($F = nF_{\mathrm{Rep}}$, n is integer).

15 min. break

MA 43.6 Thu 11:00 EB 301

Gilbert damping from nonperturbative partial summation — •David Vincent Altwein, Elena Y. Vedmedenko, and Roland Wiesendanger — University of Hamburg, Hamburg, Germany

We devise an exact way to recover the concept of Rayleigh-dissipation from the framework of quantum field theory (QFT) which is illustrated for magnetization dynamics. Initially, an effective hamiltonian for a subsystem is obtained by employing the inequivalent sets of canonical operators, generated by the system-bath-interactions, causing vacuum polarization which gives rise to a geometric expansion in a complexe quantity. The latter's imaginary part is intimately connected to the irreducible polarization and self-energy operators of the problem and appears as a damping parameter which contains nonperturbative information. Remarkably, we obtain the Landau-Lifshitz-Gilbert-Equation with its correct scaling of the gyromagnetic ratio γ, stemming directly from the renormalization of charge e and mass m of the problem whilst lowest order perturbation theory in the interaction strength was used to derive the Landau-Lifshitz-Equation microscopically. Conceptually, our approach shares certain similarities with the known truncation schemes, employed in the QFT framework for dissipation and it uses a smaller set of assumptions than many popular system-bath-approaches in the literature.

MA 43.7 Thu 11:15 EB 301

Spin precession mapping at ferromagnetic resonance via nuclear resonant — •Lars Bocklage[1,2], Christian Swoboda[3], Kai Schlage[1], Hans-Christian Wille[1], Liudmila Dzemiantsova[1,2], Guido Meier[4,2,3], and Ralf Röhlsberger[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — [3]Institut für Angewandte Physik, Universität Hamburg, Germany — [4]Max-Planck-Institut für Struktur und Dynamik der Materie, Hamburg, Germany

We employed nuclear resonant scattering (NRS) to study spin dynamics at ferromagnetic resonance. NRS measures the temporal decay of nuclear transitions of Mössbauer isotopes, the 14.4 keV transition of iron-57 in our case. The inherent sensitivity to dynamical effects, its isotope sensitivity, and its combinability with diffraction techniques makes NRS a perfect candidate to investigate magnetization dynamics on nanometer length scales. We present NRS results measured on a ferromagnetic film excited at its ferromagnetic resonance in the GHz-regime. At ferromagnetic resonance the NRS time spectra of the nuclear decay are altered. The reduction of the effective hyperfinefield due to the spin precession is identified as source for the changes in the time spectra. We are able to determine the precession trajectory of the magnetic moments from the measured time spectra. The method provides a new way to study magnetization dynamics with high precision.

MA 43.8 Thu 11:30 EB 301

Gilbert-like damping mediated by time retardation in atomistic magnetization dynamics — •Danny Thonig[1], Jürgen Henk[2], and Olle Eriksson[1] — [1]Department of Material Theory, Uppsala University, Sweden — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

The switching dynamics of atomic magnetic moments is determined by the loss of angular momentum. This damping in the equation of motion correlates a magnetic moment at a time t to its very recent value at a time $t - \delta t$. However, physical events are time retarded; that is, magnetic moments are linked to their state at any $t' < t$. This raises two questions: 1. How does time retardation affect the evolution of magnetic moments? 2. Could time retardation motivate a damping mechanism proportional to the Gilbert damping?

We consider the time-retarded form of the atomistic Landau-Lifshitz-Gilbert equation that accounts for momentum length conservation. More precisely, various retardation functions are applied to the equation of motion without Gilbert damping. We consider a macrospin model as well as realistic materials, like Fe bulk.

From an analytical model as well as from numerical simulations we establish a damping mechanism proportional to the Gilbert damping. On top of this, we also find higher-order effects, like nutation. Our model and results suggest that the origin of damping and inertia in magnetic systems could be due to time retardation.

MA 43.9 Thu 11:45 EB 301

Microscopic theory of Gilbert damping in metallic ferromagnets — •Antonio Costa and Roberto Muniz — Universidade Federal Fluminense, Niteroi, RJ, Brazil

We present a microscopic theory for magnetization relaxation in metallic ferromagnets of nanoscopic dimensions that is based on the dynamic response function in the presence of spin-orbit coupling. Our approach allows the calculation of the Gilbert damping parameter even in perfectly crystalline systems, where other approaches fail. We demonstrate that the relaxation properties are not completely determined by the transverse susceptibility alone, and that the damping rate has a non-negligible frequency dependency in experimentally relevant situations.