MA 45: Magnetic Relaxation and Gilbert Damping

Time: Thursday 9:30–11:00 Location: POT/0351

MA 45.1 Thu 9:30 POT/0351

Nonlinear magnon-magnon coupling in a ferrimagetic YIG sphere at cryogenic temperatures — •Johannes Weber[1,2], Richard Schlitz[3], Sebastian T. B. Goennenwein[3], Matthias Althammer[1,2], and Hans Huebl[1,2,4] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]TUM School of Natural Sciences, Technische Universität München, Garching, Germany — [3]Department of Physics, University of Konstanz, Konstanz, Germany — [4]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany

Yttrium ion garnet (YIG) is known for its low magnetic damping properties, which are optimized in single crystalline YIG spheres, making it a potent candidate for nonlinear magnonics. The magnetic spectrum shows numerous so called Walker modes. Here, we present two-tone pump and probe microwave spectroscopy measurements of the magnetization dynamics of a 250 μm YIG sphere. The data shows signatures of three-magnon scattering, when the drive exceeds the first order Suhl instability threshold. We quantitatively analyze the underlying non-linearity for different Walker modes. These experiments enable a pathway for probing quantum signatures in magnetic systems.

MA 45.2 Thu 9:45 POT/0351

Evidence of relativistic field-derivative torque in nonlinear THz response of magnetization dynamics — •Arpita Dutta[1], Pratyay Mukherjee[6], Swosti P. Sarangi[1], Somasree Bhattacharjee[6], Christian Tzschaschel[2,3], Debankit Priyadarshi[3], Kouki Mikuni[4], Takuya Satoh[4,5], and Ritwik Mondal[6] — [1]NISER Bhubaneswar, HBNI, Jatni, India — [2]Max-Born Institute, Berlin, Germany — [3]ETH Zurich, Switzerland — [4]Institute of Science Tokyo, Japan — [5]Quantum Research Center for Chirality, Okazaki, Japan — [6]IIT (ISM) Dhanbad, India

The selective addressing of spins by THz electromagnetic fields via Zeeman torque is one of the most successful means of controlling magnetic excitations. Here, we show that the conventional Zeeman torque on the spin is not sufficient, rather an additional relativistic field derivative torque is essential to realize the observed magnetization dynamics. We accomplish this by exploring the ultrafast nonlinear magnetization dynamics of a ferrimagnetic garnet when excited by two co-propagating THz pulses. Having identified the Kaplan-Kittel mode at 0.48 THz, resulting from the exchange interaction, we drive this to a nonlinear regime. We find that the observed nonlinear trace of the magnetic response cannot be mapped to the magnetization precession induced by the Zeeman torque, while the Zeeman torque supplemented by an additional FDT follows the experimental evidences.

MA 45.3 Thu 10:00 POT/0351

Quantum Landau-Lifshitz-Gilbert equation — •Yuefei Liu — Nordita, Stockholm University and KTH Royal Institute of Technology, SE-10691 Stockholm, Sweden — Center for Quantum Spintronics, Department of Physics, NTNU, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

The classical Landau-Lifshitz-Gilbert (LLG) equations describe magnetization dynamics. Extending them to quantum systems is difficult, but we introduce an effective equation that is considered as a quantum analog of LLG equation [PRL 133, 266704 (2024)]. It reproduces classical features for ferromagnetically coupled spin-1/2 dimers, yet deviates strongly in antiferromagnetic and entangled cases, suggesting a new paradigm beyond Lindblad-type master equations.

MA 45.4 Thu 10:15 POT/0351

Temperature dependence of volume and interface contributions to the magnetic damping of Permalloy thin films — Verena Ney[1], Kilian Lenz[2], Fabian Ganss[2], René Hübner[2], Jürgen Lindner[2], and •Andreas Ney[1] — [1]Johannes Kepler Universität, Linz, Österreich — [2]Helmholtz-Zentrum Dresden-Rossendorf, Deutschland

The magnetic damping of $Ni_{80}Fe_{20}$ (Permalloy, Py) thin films has been reported to be lowest when sandwiched in Al cap and spacer layers [1]. Here we study the Gilbert damping parameter α as a function of Py layer thickness via temperature- and frequency-dependent ferromagnetic resonance (FMR) experiments. The full FMR dataset allows to separate the Gilbert-like contributions to the FMR linewidth from non-Gilbert-like ones like two magnon scattering processes. In addition, the Py thickness series allows to deconvolute α into its respective bulk and interfacial contributions and their respective temperature dependencies. While the bulk contribution monotonously decreases with temperature from 0.0061(1) down to 0.0054(1), the interfacial contribution shows a subsequent increase at low temperature. The remaining bulk contribution, which is only of resistivity-like character, can be considered to reflect the intrinsic magnetic damping properties of Py thin films, while the interface contribution contains both resistivity- and conductivity-like contributions [2].

[1] V. Ney et al. Phys. Rev. Materials **8**, 124410 (2024)
[2] V. Ney et al. Phys. Rev. Materials (submitted, 2025)

MA 45.5 Thu 10:30 POT/0351

Thickness-dependent modulation of magnetization dynamics in ultralow-damping Co_2MnSi Heusler alloys measured by ultrafast TR-MOKE — •Levi Geier[1], Anulekha De[1], Anna Maria Friedel[1,2], Philipp Pirro[1], Martin Aeschlimann[1], and Georg von Freymann[1,3] — [1]RPTU University Kaiserslautern-Landau — [2]Institut Jean Lamour, UMR CNRS 7198, Université de Lorraine, 54000 Nancy, France — [3]Fraunhofer Institute for Industrial Mathematics ITWM, Kaiserslautern

We measure the laser-induced ultrafast demagnetization and subsequent damped precession of the magnetization dynamics in Co_2MnSi Heusler alloys of varying thicknesses (4 nm - 18 nm). The study is performed by a time-resolved magneto-optical Kerr effect (TR-MOKE) setup based on an all-optical pump-probe approach. An ultralow effective damping down to an effective Gilbert damping constant $\alpha = 0.004$ is measured for the 18-nm-thick sample, which increases with decreasing applied magnetic field and increasing pump fluence. We attribute this trend to the generation of incoherent magnons in addition to the coherent magnons after excitation by the laser pulse. Moreover, we observe a strong dependence of the effective damping parameter on the film thickness. The effective damping decreases significantly with increasing film thickness, presumably due to two-magnon scattering. Interestingly the quenching of the magnetization during the demagnetization does not change significantly with pump fluence.

MA 45.6 Thu 10:45 POT/0351

Systematic Theory of Real-Time Atomistic Spin Dynamics — •Sarah Damerow and Michael Potthoff — I. Institute of Theoretical Physics, University of Hamburg

We present a systematic response-theoretical approach for deriving indirect interactions and novel couplings in the effective dynamics of classical spins coupled to generic lattice-fermion models. Via a systematic twofold expansion of the exact time evolution operator, namely in the coupling strength and in the retardation time, one identifies a rich variety of spin-, orbital-, and site-dependent contributions to the equations of motion. These include the familiar Ruderman–Kittel–Kasuya–Yosida and the Dzyaloshinskii–Moriya interactions. Additional anisotropic terms, different types of Gilbert damping and of geometrical spin torques, as well as various spin-inertia terms emerge. While the order of expansion suggests the order of magnitude of the effects, symmetry analysis allows for their classification. The practical feasibility of the approach is demonstrated with numerical results obtained for a Chern insulator.