MA 12: Magnetization Dynamics and Damping

Time: Tuesday 9:30–11:30 Location: H19

MA 12.1 Tue 9:30 H19

Oscillatory dynamics of strongly coupled magnetic domain walls in three-dimensional chiral nanostructures — •Pamela Morales Fernández[1,2], I. Konstantinos Douveas[3], S. Ruiz Gómez[4], E. Zhakina[1], L. Turnbull[1], M. König[1], A. Hierro Rodríguez[5], N. Leo[6], S. Finizio[7], S. Wintz[8], C. Abert[3], D. Suess[3], A. Fernández Pacheco[2], and C. Donnelly[1,9] — [1]MPI CPFS, Germany — [2]TU Viena, Austria — [3]University of Vienna, Austria — [4]ALBA Synchrotron, Spain — [5]Universidad de Oviedo, Spain — [6]Loughborough University, UK — [7]PSI, Switzerland — [8]BESSY II, Germany — [9]Hiroshima University, Japan.

The expansion of nanomagnetism into three dimensions opens opportunities for new topological textures, curvilinear effects, and exotic magnetization dynamics. Here, we investigate the magnetization dynamics in 3D double-helix nanostructures, which host strongly coupled domain wall pairs formed through the interplay of shape anisotropy, chirality, and inter-helix magnetostatic interactions. Using direct 3D nanofabrication techniques, cobalt nano double helices are grown on top of microwave antennas and exposed to GHz magnetic fields. Time-resolved scanning transmission X-ray microscopy reveals enhanced dynamics in the area of the coupled domain walls within the helical conduits. Observed dynamics depend on the geometrical parameters of the system and excitation frequency, matching with micromagnetic simulations that reveal additional higher-frequency modes beyond the reach of the experimental technique. This work provides insights into the physics of 3D nanomagnetism, advancing control for future technologies.

MA 12.2 Tue 9:45 H19

Anisotropic energy dissipation in model Kagome systems — Rajgowrav Cheenikundil[1], Zhiwei Lu[2], Ivan Miranda[3], Manuel Pereiro[4], and •Danny Thonig[1,4] — [1]Örebro University, Sweden — [2]KTH Royal Institute of Technology, Sweden — [3]Linnaeus University, Sweden — [4]University Uppsala, Sweden

Recent efforts have been directed towards understanding spin-orbit mediated phenomena such as the spin Hall effect [1], and energy dissipation phenomena [2], which are enhanced by non-collinear magnetism. Notably, the latter results in anisotropies in energy dissipation that have not been methodically investigated.

We employ the Kubo-Bastin formalism [3] of linear perturbation theory to calculate the non-local Gilbert damping tensor in a model Kagome system with Rashba spin-orbit coupling. This approach is implemented in the Cahmd code [4]. We vary the magnetic state according to different chiralities and phase differences.

Remarkably, the Bastin formalism connects the occurrence of anisotropic damping to a Fermi-sea contribution and, consequently, to spin-spin Berry curvature. Our systematic study examines the dependency of isotropic and anisotropic effective damping, as well as the full non-local damping, on electron lifetimes, Rashba parameters, and other factors. The results of this study pave the way for controlled dissipation in innovative spintronics applications.

[1] Scientific Reports 6, 28076 (2016); [2] Phys. Rev. Lett. 113, 266603 (2014); [3] Phys. Rev. B 102, 085113 (2020); [4] available at https://cahmd.gitlab.io/cahmdweb/

MA 12.3 Tue 10:00 H19

propelling ferrimagnetic domain walls by dynamical frustration — •reza doostani — university of cologne, cologne, germany

In this work, we realize the concept of active matter in a solid state system. By sending a ferrimagnet out of equilibrium by an oscillating magnetic field, we activate rotational goldstone mode where spins start to rotate clockwise or anti-clockwise depending on the ferromagnetic component. We see that in this setup, a domain wall moves actively to the left or right due to dynamical frustration. We further discuss the dynamics of these domain walls and the relation between domain wall motion and the external field amplitude, as well as their interaction and consequence of these on the whole system. Furthermore, we continue to study the effect of defects on the movement of domain walls.

MA 12.4 Tue 10:15 H19

Tunable magnetic easy axis orientation with ion irradiation — •Gabriel Gray[1], Kilian Lenz[1], Alexandra Lindner[1], Jürgen Lindner[1], Jürgen Fassbender[1], Fabian Ganss[1], Rodolfo Gallardo[2], and Pedro Landeros[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Material Research, Dresden, Germany — [2]Universidad Técnica Federico Santa María, Department of Physics, Valparaíso, Chile

Our research focuses on the ion-irradiation-induced changes in magneto-crystalline anisotropy and exchange coupling in epitaxially grown Fe thin films in the (110) orientation under ultra-high vacuum conditions on GaAs (110) single crystals. A Cr capping layer was deposited to prevent oxidation. The samples were irradiated with Cr ions at varying kinetic energies and fluences. Subsequent magnetic characterizations were performed using Ferromagnetic Resonance and Vibrating Sample Magnetometry techniques, while structural characterizations where perform using X-ray Diffractometry and Transmission Electron Microscopy.

Our results reveal a clear correlation between ion fluence and modifications in uniaxial magneto-crystalline anisotropy, while cubic anisotropy and the effective magnetization remain largely unaffected. Notably, the observed changes are sufficient to induce a reorientation of the easy axis of magnetization in the system.

MA 12.5 Tue 10:30 H19

Evidence of relativistic field-derivative torque in nonlinear THz response of magnetization dynamics — •Arpita Dutta[1], Christian Tzschaschel[2,3], Debankit Priyadarshi[3], Kouki Mikuni[4], Takuya Satoh[4,5], Ritwik Mondal[6], and Shovon Pal[1] — [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 terahertz (THz) electromagnetic fields via Zeeman torque is, by far, 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 (FDT) 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 between the rare-earth and transition metal sublattices, we drive this mode 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.

[1] A. Dutta, *et al.*, Phys. Rev. Materials **8**, 114404 (2024).
[2] A. Dutta, *et al.*, arXiv:2408.05510 (2024).

MA 12.6 Tue 10:45 H19

Ferromagnetic resonance linewidth as a probe for investigating magnon-phonon interaction — •Gauravkumar Patel[1], Rodolfo Gallardo[2], Ruslan Salikhov[1], Sven Stienen[1], Kilian Lenz[1], Olav Hellwig[1,3], and Jürgen Lindner[1] — [1]Helmholtz-Zentrum Dresden–Rossendorf, Dresden, Germany — [2]Universidad Técnica Federico Santa María, Valpariso, Chille — [3]Chemnitz University of Technology, 09107 Chemnitz

The Ferromagnetic resonance (FMR) linewidth measurements provide information about dynamic energy losses present in magnetic materials. For materials with high magnetoelastic coupling strength, like Co, the uniform precession can excite the elastic vibrations in the underlying lattice. Using the FMR linewidth as a probe, we investigate this magnon-phonon interaction in Co thin films on Pt seed layers. This interaction results in a non-monotonic behavior of the linewidth as a function of frequency, showing multiple peaks at specific frequencies, in contrast to the typical Gilbert-like linear dependence. The magnon-phonon coupling is more pronounced in Co thin films with higher perpendicular anisotropy. Variation of the Co or Pt layer thickness shifts the linewidth peak position, indicating control over the frequency of the generated phonon.

MA 12.7 Tue 11:00 H19

Landau-Lifshitz damping from Lindbladian dissipation in

quantum magnets — •Götz Uhrig — TU Dortmund University

As of now, the phenomenological classical Landau-Lifshitz (LL) damping of magnetic order is not linked to the established quantum theory of dissipation based on the Lindbladian master equation. This is an unsatisfactory conceptual caveat for the booming research on magnetic dynamics. Here, it is shown that LL dynamics can be systematically derived from Lindbladian dynamics using a local mean-field theory. Thereby, the successful LL approach is set on a firm quantum basis in the regime where the Lindblad approach is applicable. Furthermore, we extend the LL dynamics in a systematically controlled way to include not only changes of the orientation of the magnetization $\vec{m}$, but also of its length $|\vec{m}|$. The key aspect is that the Lindbladian relaxation must be adapted to the Hamiltonian $H(t)$ at each instant of time in time-dependent non-equilibrium systems. It is conjectured that this idea holds true well beyond the damping of magnetic dynamics given the appropriate hierarchy of time scales.

MA 12.8 Tue 11:15 H19

Dynamics of electronic phase separation at the laser-induced insulator/metal transition in LPCMO — •Maximilian Staabs, Tim Titze, Karen Stroh, Stefan Mathias, Vasily Moshnyaga, and Daniel Steil — I. Physikalisches Institut, Universität Göttingen, Göttingen, Deutschland

The closely related colossal magnetoresistive manganites LCMO and LPCMO exhibit surprising differences in their transient reflectivity dynamics after nanosecond pulsed laser excitation close to their metal-to-insulator transition (MIT). Transient resistance measurements reveal that both systems show transient metallization effects upon laser excitation in the vicinity of the static MIT. These are, however, weak and on the timescale of the laser pulse for LCMO, but much stronger and long-lived for LPCMO. We attribute the differences between these compounds to the presence of mesoscopic electronic phase separation in LPCMO in the MIT region, stabilized by Jahn-Teller polarons [1]. Laser excitation leads to the annihilation of Jahn-Teller distortions [2,3], thus enabling charge transfer between the formerly separated electronic phases. This process is observed as a collapse of the global electrical resistivity on the nanosecond timescale, whereas the recovery of the insulating phase separated state takes nearly 20 nanoseconds [4].

[1] V. Moshnyaga *et al.*, Phys. Rev. B **89**, 024420 (2014)
[2] M. Fiebig *et al.*, Appl. Phys. B **71**, 211 (2000)
[3] H. Matsuzaki *et al.*, Phys. Rev. B **79**, 235131 (2009)
[4] T. Titze *et al.*, Phys. Rev. Research **6**, 043168 (2024)