MA 8: INNOMAG e.V. Prizes 2024 (Diplom-/Master and Ph.D. Thesis)

Die Arbeitsgemeinschaft Magnetismus der DPG hat einen Dissertationspreis und einen Diplom-/Masterpreis ausgeschrieben, welche auf der Tagung der DPG 2024 in Berlin vergeben werden. Ziel der Preise ist die Anerkennung herausragender Forschung im Rahmen einer Diplom-/Masterarbeit beziehungsweise einer Promotion und deren exzellente Vermittlung in Wort und Schrift. Im Rahmen dieser Sitzung tragen die besten der für ihre an der Hochschule eines Mitgliedslands der European Physical Society durchgeführten Diplom-/Masterarbeit beziehungsweise Dissertation Nominierten vor. Im direkten Anschluss entscheidet das Preiskomitee über den Gewinner bzw. die Gewinnerin des INNOMAG e.V. Diplom/Master-Preises und des Dissertationspreises 2024. Talks will be given in English!

Time: Monday 15:00–18:25 Location: H 1058

MA 8.1 Mon 15:00 H 1058

Breakdown of Chiral Edge Modes in Topological Magnon Insulators — •Jonas Habel — Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — Munich Center for Quantum Science and Technology (MC-QST), Schellingstr. 4, 80799 München, Germany

Topological magnon insulators (TMI) are ordered magnets supporting chiral edge magnon excitations. These edge states are envisioned to serve as topologically protected information channels in low-loss magnonic devices. The standard description of TMI is based on linear spin-wave theory (LSWT), which approximates magnons as free noninteracting particles. However, magnon excitations of TMI are genuinely interacting even at zero temperature, calling into question descriptions based on LSWT alone. Here we perform a detailed nonlinear spin-wave analysis to investigate the stability of chiral edge magnons. For the first time, we provide direct theoretical evidence that the chiral edge states in topological magnon insulators decay. Our results highlight a challenge for the realization of novel spintronic devices based on topologically protected edge transport.

MA 8.2 Mon 15:20 H 1058

Dynamics of magnon gases in microscopic temperature landscapes — •Franziska Kühn[1], Matthias R. Schweizer[1], Georg von Freymann[1,2], Alexander A. Serga[1], and Burkard Hillebrands[1] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Fraunhofer Institute for Industrial Mathematics ITWM, Fraunhofer Platz 1, 67663 Kaiserslautern, Germany

This work is focused on the behavior of a thermally generated magnon gas in artificial magnetization landscapes on the micrometer scale. A unique setup was created by combining microfocused Brillouin light scattering spectroscopy with a heating laser, which imprints two-dimensional temperature landscapes onto the yttrium-iron garnet film sample by phase-based wavefront modulation. The temperature change, regulated by the power of the optical intensity patterns, influences the saturation magnetization and shifts the magnon dispersion relation. It was demonstrated with both measurements and simulations, that in addition to the magnetization variations, it is necessary to consider the connected variations of the demagnetization field. The local temperature-dependent demagnetization field influences the dispersion relation in the opposite direction and affects different magnon modes diversely, leading to strong frequency shifts. This effect creates a powerful tool for the manipulation of magnon Bose-Einstein condensates as well as for the directional control of magnon supercurrents. Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)-TRR 173/2-268565370 Spin+X (Project B04)

MA 8.3 Mon 15:40 H 1058

Optimized hyperthermia approach using Fe3O4/SiO2/Ni multishell nanoellipsoids — •Inci Nur Sahin[1], Marina Spasova[1], Michael Farle[1], Veronica Salgueirino[2], and Ecem Tiryaki[2] — [1]University Duisburg-Essen, Duisburg, Germany — [2]University of Vigo, Vigo, Spain

The use of approximately 20nm magnetite nanoparticles (NPs) for inductive heating has proven effective in cancer treatment, inducing necrotic cell death at temperatures above 43°C. Operating in the superparamagnetic state, these NPs don't exhibit remanent magnetization and stray fields, averting agglomeration and potential blood vessel clogging. Since foreign bodies below 50nm are deposited in the kidneys instead of in the tumour, larger diameters are desirable. However, magnetite particles that exceed the 20nm limit enter the ferromagnetic state with a noticeable demagnetizing field. This inevitably leads to the formation of clusters and poses a risk to the blood vessels. For this reason, magnetite/silica/nickel multi-shell ellipsoids were produced with the aim of compensating the stray fields of ferromagnetic NP. This is to be achieved by extinguishing the stray field of the core and the outer shells. Through a wet chemical process, 545nm long and 165nm wide Fe3O4/SiO2 NPs with a 10% standard deviation were prepared and coated with a 50nm thick nickel shell. Comparing the Nickel-sheathed and non-Nickel-sheathed NPs, it was found that the Nickel-sheathed NPs indeed exhibited a reduced remanence, provided three times the heating power 180 W/g during induction heating, and provided seven times the temperature increase ΔT= 20°C.

15 min. break

MA 8.4 Mon 16:15 H 1058

Spintronic terahertz emission: insights and applications — •Oliver Gueckstock — Freie Universität Berlin

To extend current charge-based electronics by new features and functionalities, the electron spin, as a new degree of freedom, is likely to play a major role in future information technology. Devices using spintronics need to be competitive with other information carriers and, therefore, it is required to push the bandwidth of the elementary spintronic operations to the terahertz (THz) frequency range. To study ultrafast spin transport in prototypical magnetic-non-magnetic (F|N) bilayers, we excite them with femtosecond laser pulses. Following absorption of the pulse, a spin current in F is launched and converted into a transverse charge current in N and/or F, giving rise to the emission of a THz electromagnetic pulse. Using this approach, along with an analysis based on symmetry arguments and modeling, this thesis answers the following central open questions: Is ultrafast spin transport mediated by magnons as universal as indicated by previous modelling? What impact does the frequently neglected F/N interface between F and N have on the ultrafast spin-to-charge current conversion? How can we exploit spintronic features for new functionalities of spintronic THz emitters, which are also potentially interesting for space applications? By studying spin current dynamics on their natural timescale, one may find new interesting effects or push existing concepts to THz frequencies, which might advance future spintronic applications to work at higher clock rates.

MA 8.5 Mon 16:40 H 1058

Spin waves in curved magnetic shells — •Lukas Körber — HZDR, Dresden, Germany — TU Dresden, Germany

Exploring 3D systems has attracted several research fields, including the study of ferromagnets and superconductors. Given the underlying order parameter and interactions, twisting and bending flat into curved shells leads to emerging effects when the bending radius approaches the system's internal length scales. Curvature-induced anisotropies and magnetochiral interactions have been widely studied in ferromagnetic systems, uncovering the stabilization of solitons, pinning of domain walls, or suppression of the Walker breakdown.

The impact of curvature and geometry on low-energy magnetization dynamics (the propagation of spin waves) manifests in several aspects. For example, curvature can modify dynamic magnetic charges. As a result, magneto-chiral symmetry breaking of magnetostatic origin can lead to asymmetric spin-wave dispersion, nonreciprocal spatial mode profiles and strongly modify nonlinear magnetization dynamics. Moreover, a nontrivial topology of three-dimensional magnetic specimens can induce a Berry phase of spin waves or impose selection rules on the dynamics of magnetic textures. Furthermore, achiral symmetry breaking, induced, e.g., by lowering rotational symmetries, can lead to symmetry-governed doublet splitting. Here, we explore several of the aforementioned geometrical effects on magnetization dynamics and present the development of noval numerical techniques to study spin waves in curved magnetic shells efficiently.

MA 8.6 Mon 17:05 H 1058

Antiferromagnetic Insulatronics: Control and Manipulation of Magnetic Domains — •Hendrik Meer — Institute of Physics, Johannes Gutenberg-University Mainz

The control of the spin structure is key for the development of future antiferromagnetic spintronic devices. Here, we explore how the antiferromagnetic domains of insulating NiO and CoO thin films can be manipulated. We use synchrotron and lab-based imaging to investigate three key tools to control the antiferromagnetic order: First, we apply electric currents through an adjacent heavy metal layer and study different device geometries to determine the underlying switching mechanism [1]. Second, we investigate the effect of the patterning shape on the antiferromagnetic ground state [2]. Third, we explore a non-contact writing scheme of the antiferromagnetic ordering via irradiation with laser pulses [3]. By revealing several writing mechanisms for the antiferromagnetic order, we expand the toolbox of antiferromagnetic insulatronics [4].

[1] H. Meer et al., Nano Lett. 21, 114 (2021).
[2] H. Meer et al., Phys. Rev. B 106, 094430 (2022).
[3] H. Meer et al., Adv. Funct. Mater. 2213536 (2023).
[4] H. Meer et al., Appl. Phys. Lett. 122, 080502 (2023).

MA 8.7 Mon 17:30 H 1058

Exploring ultrafast dynamics of electrons in heavy-fermion materials by THz time-domain spectroscopy — •Chia-Jung Yang and Manfred Fiebig — Department of Materials, ETH Zurich, Switzerland

The development of novel states of matter is a significant aspect of modern physics, with quantum phase transitions (QPT) playing a crucial role. These transitions are dominated by quantum fluctuations of magnetic and electronic degrees, giving rise to new behavior emerging near the quantum-critical point. Heavy-fermion materials, which exhibit strong coupling between magnetic and electronic properties, serve as an ideal platform for exploring these phenomena. This work utilizes terahertz time-domain spectroscopy (THz-TDS) to investigate the ultrafast electronic dynamics across QPTs in such materials. THz-TDS, effective in probing low-energy excitations, illuminates the dynamics of quasiparticles and provides direct access to information that was otherwise not accessible before [1]. In prototypical heavy-fermion materials, we have thus discovered novel types of quantum-matter dynamics. Specifically, in $YbRh_2Si_2$, we observed the first example of critical slowing down in a fermionic system close to a QPT [2]. In $CeCu_{6-x}Au_x$, we distinguished two different correlated contributions to the optical conductivity [3] and identified lattice coherence in the form of heavy-fermion formation from optical coherence in the form of superradiance.

[1] Nat. Rev. Mater **8**, 518 (2023). [2] Nat. Phys. **19**, 1605 (2023). [3] Phys. Rev. Research **2**, 033296 (2020)

30 min. discussion break and bestowal of INNOMAG e.V. Diplom-/Master Prize and Ph.D. Thesis Prize