MA 16: INNOMAG e. V. Dissertation Prize

The Working Group Magnetism (Arbeitsgemeinschaft Magnetismus der DPG) awards a dissertation prize whose aim is to recognise outstanding research done within the framework of a doctorate and communication of this research in an excellent way, both verbally and in writing. The prize is kindly supported by INNOMAG e.V. In this finalists session, pre-selected nominees will present and defend their dissertation. Afterwards, the prize committee decides on the winner of the INNOMAG e.V. Dissertation Prize 2020 and the award of 1000 EURO.

Time: Monday 15:00–16:40 Location: POT 6

MA 16.1 Mon 15:00 POT 6

Spintronics with Terahertz Radiation: Probing and driving spins at highest frequencies — •Tom S. Seifert[1,2] and Tobias Kampfrath[2] — [1]ETH Zurich — [2]Free University Berlin

Spin-orbit interaction (SOI) will be of central importance for future spin-based electronics (spintronics) as it permits charge-to-spin conversion [1]. It is highly interesting to study spin dynamics at terahertz (THz) frequencies because spintronic devices should eventually operate at THz rates. In our experiments, we employ femtosecond optical and THz pulses to trigger ultrafast spin and charge dynamics in magnetic thin-film stacks with a strong SOI. We study THz emission from multilayers of magnetic and nonmagnetic materials [2,3]. By varying the magnet from conducting to insulating and from ferro- to antiferromagnetic, we aim at identifying different mechanisms generating ultrafast spin currents, including super-diffusive spin transport [4] and magnon-mediated transfer of spin angular momentum [5,6]. Finally, we drive spins at highest speeds by switching an antiferromagnetic CuMnAs memory element employing strong THz pulses [7]. These results were obtained in close collaborations with the research groups of J. Barker, C. Ciccarelli, T. Jungwirth, M. Kläui, Y. Mokrousov, M. Münzenberg, P.M. Oppeneer and D. Turchinovich. [1] A. Hoffmann et al., Phys. Rev. Appl. 4 (2015). [2] T. Kampfrath et al., Nat. Nanotech. 8 (2013). [3] T. Seifert et al., Nat. Phot. 10 (2016). [4] M. Battiato et al., PRL 105 (2010). [5] Kurebayashi et al., Nat. Mat. 10 (2011). [6] T. Seifert et al., Nat. Commun. 9 (2018). [7] K. Olejnik et al., Science Adv. 4 (2018).

MA 16.2 Mon 15:25 POT 6

Linear and nonlinear spin waves in nanoscale magnonic structures for data processing — •Qi Wang — Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern, Germany

Spin waves, and their quanta magnons, attract attention as novel data carriers instead of electrons in future low-energy data processing units due to their short wavelength, low losses, and abundant nonlinear phenomena. Although separated spin-wave logic gates have already been demonstrated, the smallest sizes of these elements are in the ranges of a few micrometers and are not competitive with the current state-of-the-art CMOS technology. Moreover, the realization of an integrated magnonic circuit is still an unresolved challenge.

The objective of this talk is to present a nanoscale magnon directional coupler as a universal data processing unit for performing different logic operations and suitable for the integration into a magnonic circuit. First, the spin-wave characteristics in the nanoscale waveguides were studied theoretically and experimentally. This knowledge, as well as the numerical studies of the directional coupler, allowed for its realization at the nanoscale and the characterization using Brillouin Light Scattering spectroscopy. The nonlinear functionality of the coupler required for selective spin-wave guiding, depending on its amplitude, was demonstrated. Finally, the first integrated magnonic circuit consisting of two couplers and performing half-adder functionality was studied numerically. These studies were supported by ERC StG MagnonCircuits.

MA 16.3 Mon 15:50 POT 6

Highly efficient domain wall motion in ferrimagnetic bi-layer systems at the angular momentum compensation temperature — •Robin Bläsing and Stuart S. P. Parkin — Max Planck Institute of Microstructure Physics

Highly efficient current-induced motion of chiral domain walls was recently demonstrated in synthetic antiferromagnetic (SAF) structures due to an exchange coupling torque (ECT). The ECT derives from the antiferromagnetic exchange coupling through a ruthenium spacer layer between the two perpendicularly magnetized layers that comprise the SAF. In my dissertation I report that the same ECT mechanism applies to ferrimagnetic bi-layers formed from adjacent Co and Gd layers. In particular, I show that the ECT is maximized at the temperature T_{A} where the Co and Gd angular momenta balance each other, rather than at their magnetization compensation temperature T_{M}. Since the device temperature is significantly increased by the current pulses, taking into account Joule heating is of major importance when determining T_{A}. The velocity of the domain walls driven by electrical current is highly sensitive to longitudinal magnetic fields but I show that this is not the case near T_{A}. My studies provide new insight into the ECT mechanism for ferrimagnetic systems. Additionally, the minimum threshold current density to move domain walls is significantly decreased in Co/Gd bi-layers compared to SAF structures. The high efficiency resulting from the ECT and low threshold current density makes my study important for advanced domain wall-based spintronic devices.

MA 16.4 Mon 16:15 POT 6

Spin-orbit driven transport: Edelstein effect in Rashba systems and topological materials — •Annika Johansson — Institute of Physics, Martin Luther University Halle-Wittenberg, Halle, Germany

A charge current driven through a system with broken inversion symmetry can generate a spatially homogeneous spin polarization. This phenomenon is known as Edelstein effect [1,2]. Using semiclassical Boltzmann transport theory, I investigate the Edelstein effect in two- and three-dimensional Rashba systems and topological materials. Whereas the current-induced spin density in conventional isotropic Rashba systems is in-plane and perpendicular to the charge current, I show that the direction as well as the magnitude of the induced spin density can be strongly modified in systems with reduced symmetry, which provides new opportunities to control and manipulate the electrically induced magnetization [3].

Further, I predict a highly efficient Edelstein effect in three-dimensional Weyl semimetals, mainly originating from their topological surface states due to their favorable Fermi surface geometry, their strong spin polarization and the enhanced momentum relaxation time [4]. In comparison to Rashba systems, the Edelstein effect in Weyl semimetals is enhanced by at least one order of magnitude.

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[2] V. Edelstein, Solid State Commun. 73, 233 (1990).
[3] A. Johansson et al., Phys. Rev. B 93, 195440 (2016).
[4] A. Johansson et al., Phys. Rev. B 97, 085417 (2018).