# AGjDPG 6: PhD Student Symposium: Spintronics on the Way to modern Storage Technology I

Time: Thursday 9:50–12:00 Location: BH 243

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**Welcome by the AGjDPG and the organizers**

**Topical Talk** AGjDPG 6.1 Thu 10:00 BH 243

**Magnon Spintronics** — •Burkard Hillebrands, Andrii Chumak, Alexandr Serga, and Benjamin Jungfleisch — Fachbereich Physik and Forschungszentrum OPTIMAS, TU Kaiserslautern

Spintronics is concerned with the development of devices which exceed the performance and energy efficiency of charge-based electronics by exploiting the electron's spin degree of freedom. Spin angular momentum, which is the information carrier in spintronics, can be transferred not only by the flow of electrons, but also by magnons: the quanta of spin waves (collective excitations of the spin lattice of a magnetic material). This opens a new research direction: magnon spintronics, a sub-field of spintronics in which information is transferred and processed using magnons. It can be implemented in an electric-isolator environment (yttrium iron garnet, YIG) fully avoiding Ohmic losses. I will give a tutorial style introduction into the main construction blocks of a magnon spintronics device: converters between information carried by the spin and the charge of electrons and magnons, magnon conduits, and physical phenomena allowing information processing by magnons. The most promising convertors for magnon spintronics are based on the spin pumping effect (which transforms spin waves into pure spin currents) and the inverse spin Hall effect (which converts spin currents into charge currents). I will present some selected results addressing magnetic insulator YIG - nonmagnetic Pt structures.

**Topical Talk** AGjDPG 6.2 Thu 10:30 BH 243

**Functional materials for spintronics, magnetic devices and magnetization dynamics** — •Günter Reiss[1], Andreas Hütten[1], Jan Schmalhorst[1], Markus Meinert[1], Daniel Ebke[1], Andy Thomas[1], Hans-Werner Schumacher[2], Markus Münzenberg[3], and Sergej Demokritov[4] — [1]Physics Department, Bielefeld University, Bielefeld, Germany — [2]PTB Braunschweig, Braunschweig, Germany — [3]Physics Department, Göttingen University, Göttingen, Germany — [4]Physics Department, Münster University, Münster, Germany

Spintronics uses the magnetic moment of electrons to process and store information or to sense magnetic fields. The corresponding devices are usually built from stacks of different thin films such as ferro-, ferri- and antiferromagnets, insulators, seed layers and conductors. The properties of the materials and the various interfaces are the key enablers for the device functionality. Using magnetic tunnel junctions (MTJs) capable of spin torque transfer switching as example we present the challenges of applications and discuss recent advances in using either traditional material combinations such as CoFeB/MgO or new materials such as Heusler alloys and magnetically perpendicular materials. In all stacks, magnetization and damping are key parameters and thus important dynamic properties will be discussed as well. In the last part, new memristive properties will be presented which could enable mimicking brain operations with MTJs.

AGjDPG 6.3 Thu 11:00 BH 243

**Revealing the significance of heating in the all-optical switching process** — •Sabine Alebrand, Daniel Steil, Alexander Hassdenteufel, Mirko Cinchetti, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67653 Kaiserslautern, Germany

It is well known that it is possible to switch the magnetic state of a ferrimagnetic GdFeCo sample all-optically, i.e. just by using one single circularly polarized laser pulse and without any additional external magnetic field [1]. In principle the laser pulse may fulfil two functions: delivering helicity and heating up the sample. Up to now it is still controversially discussed in literature if heating is necessary for the all-optical switching process [2,3].

To shed light on this issue: (i) we consider the dependence of the minimum laser fluence needed to obtain switching on the repetition rate of the laser pulses; and (ii) discuss the results of $\sigma$-$\pi$ experiments using one circularly pulse (acting as angular momentum source) and a linearly polarized pulse (acting as a heating pulse). We show that it is possible to switch all-optically by the combination of both pulses although the fluence of the circularly polarized laser pulse is below the minimum fluence threshold (determined for switching with only one circularly polarized pulse). Both of our experiments clearly favour the fact that heating contributes to the switching process.

[1] Stanciu et al. PRL 99, 047601, 2007 [2] Kirilyuk et al., Rev. of Mod. Phys. 82, 2010 [3] Vahaplar et al., PRL 103, 117201, 2009

AGjDPG 6.4 Thu 11:15 BH 243

**Large relaxation times in permalloy reprogrammable magnonic crystals** — •Rupert Huber, Thomas Schwarze, Georg Duerr, and Dirk Grundler — Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, James-Franck-Str., D-85748 Garching b. München, Germany

Stimulated by photonic crystals artificial band structures for magnons have attracted growing interest recently. The so called magnonic crystals are expected to have promising impact for nanometer sized spin wave logic elements. We have produced a one-dimensional densely packed ferromagnetic wire array by electron beam lithography and lift-off processing of 30 nm thick permalloy. This is based on a double exposure process, in order to avoid proximity effects at a period of 300 nm. We present data obtained by all electrical spin wave spectroscopy (AESWS). [1] Using a vector network analyzer and two collinear coplanar waveguides we measure spin wave propagation. The signals depend characteristically on an applied in-plane field reflecting the reprogrammable band structure [2]. We present quantitative data on velocities and relaxation times extracted from the phase information of the propagating spin wave.[1] We acknowledge financial support through the Nanoinitiative Munich (NIM) and the European Community*s Seventh Framework Programm (FP7/2007-2013) under Grant Agreement no. 228673 MAGNONICS. [1] Ballieul et al., APL, 83, 5 (2003) [2] J. Topp et al., PRL 104, 207205 (2010)

**Topical Talk** AGjDPG 6.5 Thu 11:30 BH 243

**Spin wave propagation and excitation, microwave assisted switching and non-linear magnetic resonance** — •Georg Woltersdorf, Hans G. Bauer, and Christian H. Back — Universität Regensburg, Regensburg, Germany

The control of the propagation properties of spin waves is essential for the successful implementation of magnon based logic devices. In addition since large excitation amplitudes are needed it is desirable to thoroughly understand the non-linear magnetization dynamics in such structures.

We use time resolved Kerr microscopy to study magnetic excitations on a sub-micron length scale. In doing so the spin wave propagation in magnetic wires and microwave assisted switching behavior in magnetic elements is studied. In addition we use X-ray magnetic circular dichroism experiments to determine precisely the number of magnons that are excited in Permalloy films. We show that commonly used models for non-linear resonance are actually not applicable at low bias fields. A simple non-linear model allows us to find the correct threshold field and the associated critical modes. This analysis explains our experimental findings and agrees with micro-magnetic simulations.