MA 5: Spincaloric Transport

Time: Monday 11:00–12:45 Location: HSZ 04

MA 5.1 Mon 11:00 HSZ 04

Magneto Seebeck effect in Co-Fe-B/MgO/Co-Fe-B tunnel junctions — •Marvin Walter[1], Jakob Walowski[1], Vladyslav Zbarsky[1], Markus Münzenberg[1], Volker Drewello[2], Daniel Ebke[2], Günter Reiss[2], Andy Thomas[2], Patrick Peretzki[3], Michael Seibt[3], Michael Czerner[4], Michael Bachmann[4], and Christian Heiliger[4] — [1]I. Physikalisches Institut, Universität Göttingen — [2]Department of Physics, Bielefeld University — [3]IV. Physikalisches Institut, Universität Göttingen — [4]I. Physikalisches Institut, Universität Giessen

Co-Fe-B/MgO/Co-Fe-B devices showing a giant TMR effect are possible candidates for the generation of spin-currents by thermal heating. We present the observation of a magneto Seebeck effect in Co-Fe-B/MgO/Co-Fe-B magnetic tunnel junctions (MTJs). The effects could be used for thermal spin-injection and thermally driven spin-transfer torque.

The samples presented in this work consist of a minimal pseudo-spin-valve stack with sputtered Ta and Co-Fe-B layers and an e-beam evaporated MgO barrier. The MTJs are heated by a diode laser which achieves powers of up to 100 mW and is focused onto the sample in a standard confocal microscope setup. The heating is simulated by finite element methods and the experimental results are compared with ab initio calculations of the magneto-thermoelectric power and of the spin-Seebeck coefficient.

MA 5.2 Mon 11:15 HSZ 04

Experimental Study of the Anisotropic Magneto-Seebeck Effect in (Ga,Mn)As Thin Films — Matthias Althammer[1], Alexander T. Krupp[1], Thomas Brenninger[1], Deepak Venkateshvaran[1], Matthias Opel[1], Lukas Dreher[2], Wladimir Schoch[3], Wolfgang Limmer[3], Rudolf Gross[1], and •Sebastian T. B. Goennenwein[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Walter Schottky Institut, Technische Universität München, Garching, Germany — [3]Abteilung Halbleiterphysik, Universität Ulm, Ulm, Germany

In analogy to anisotropic magnetoresistance (AMR), the thermopower of ferromagnetic materials also characteristically depends on the orientation of the magnetization vector. This anisotropic magneto-thermopower – or anisotropic magneto-Seebeck effect (AMS) – has only scarcely been studied to date. Taking the ferromagnetic semiconductor (Ga,Mn)As with its large magneto-resistive effects as a prototype example, we have measured the evolution of both the AMR and the AMS effects at liquid He temperatures as a function of the orientation of a magnetic field applied in the (Ga,Mn)As film plane, for different, fixed magnetic field magnitudes. Our data show that the AMS effect can be adequately modeled only if the symmetry of the (Ga,Mn)As crystal is explicitly taken into account. We will quantitatively compare our AMR and AMS measurements with corresponding model calculations, and address the validity of the Mott relations linking the magneto-resistance and the magneto-Seebeck coefficients.

MA 5.3 Mon 11:30 HSZ 04

Ab initio calculations of spin caloritronics in magnetic tunnel junctions — Michael Czerner, Michael Bachmann, and •Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

The emerging research field of spin caloritronics [1] combines the spin-dependent charge transport with energy or heat transport. In comparison to thermoelectrics the spin degree of freedom is considered as well. We present ab initio calculations of the magneto-thermoelectric power (MTEP) and of the spin-Seebeck coefficient in MgO based tunnel junctions with Fe and Co leads. In addition, the normal thermopower is calculated and gives for pure Fe and Co a quantitative agreement with experiments. Consequently, the calculated values in tunnel junctions are a good estimation of upper limits. In particular, spin-Seebeck coefficients of more than 100μV/K are possible. The MTEP ratio exceeds several 1000% and depends strongly on temperature. In the case of Fe leads the MTEP ratio diverges even to infinity at certain temperatures. The spin-Seebeck coefficient as a function of temperature shows a non-trivial dependence. For Fe/MgO/Fe even the sign of the coefficient changes with temperature.

[1] G. E. W. Bauer, A. H. MacDonald, and S. Maekawac, Solid State Comm. 150, 459 (2010).

MA 5.4 Mon 11:45 HSZ 04

Spin injection via thermal gradients. — •Benedikt Scharf, Jaroslav Fabian, and Alex Matos Abiague — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Deutschland

The interplay between spin transport and thermoelectricity offers several novel ways of generating, manipulating, and detecting nonequilibrium spin in a wide range of materials. Here we present a phenomenological model in the spirit of the standard model of spin injection to describe the coupling of charge, spin and heat transport in electronic materials and then employ this model to analyze several different geometries: F/N and F/N/F junctions which are subject to thermal gradients. We find that temperature differences across the junctions can be used to generate pure spin currents which inject nonequilibrium spin into the N region of those junctions or extract nonequilibrium spin from it. This work is supported by the Deutsche Forschungsgemeinschaft via GRK 1570.

MA 5.5 Mon 12:00 HSZ 04

Thermally driven Magnetization dynamics in pseudo spin valve tunnel junctions — Marvin Walter[1], •Jakob Walowski[1], Vladyslav Zbarsky[1], Markus Münzenberg[1], Volker Drewello[3], Daniel Ebke[3], Günter Reiss[3], Andy Thomas[3], Patrick Peretzki[2], Michael Seibt[2], Michael Czerner[4], Michael Bachmann[4], and Christian Heiliger[4] — [1]I. — [2]IV. Physikalisches Institut, Universität Göttingen — [3]Department of Physics, Universität Bielefeld — [4]I. Physikalisches Institut, Universität Gießen

Currently, magnetic tunnel junctions are investigated as a possible memory technique for spin-transfer torque magnetic RAM. On the grounds of the pioneering work by Gravier [1], we investigate the spin-Seebeck effect in nanostructures by laser heating of pseudo spin valve tunnel junctions. The investigated tunnel junctions show a change in the thermal voltage, which originates from a temperature gradient ΔT, when both ferromagnetic layers are in the anti-parallel state. This change can be analyzed as the magneto-Seebeck effect.

We apply ultra short pulses from a Ti:Sapphire laser as a time dependent heat source on these tunnel junctions and get a time dependent ΔT. Consequently, we will be able to see how the heating influences the spin system in the parallel and the anti-parallel state. A comparison with the three-temperature model will give an insight into the time scales of the magneto-Seebeck effect, and allow us to compare the characteristic time scales of the laser heating with the Seebeck voltage.

[1] L. Gravier, et al., Phys. Rev. B **73** (2006) 024419.

MA 5.6 Mon 12:15 HSZ 04

Numerical studies of thermally driven domain wall dynamics — •Denise Hinzke, Ulrike Ritzmann, and Ulrich Nowak — Universität Konstanz, 78457 Konstanz

The understanding of the influence of thermal properties of magnetic materials on its magnetic behaviour opens new perspectives for the control of magnetic domains and domain walls. Recently it has been demonstrated that spatial temperature gradients can lead to spin accumulation via the so-called spin-Seebeck effect [1]. For the latter case two kinds of spin currents can exist in a ferromagnet; a spin polarised charge current due to electron motion or a pure angular momentum current driven by spin waves. For the latter one leads to pure thermomagnetic effects without any electron currents involved.

Two different approaches for the simulation of coupled thermomagnetic properties are introduced: the stochastic Landau-Lifshitz-Gilbert equation, applied to atomistic spin models, and the Landau-Lifshitz-Bloch equation describing the dynamics of the thermally averaged spin polarisation on micromagnetic length scales [2]. Both approaches are applied to study domain wall dynamics driven by spin currents caused by a temperature gradient. We find new type of domain wall dynamics, where pure spin currents following from a temperature gradient drag a domain wall into the hotter region.

We acknowledge financial support by the DFG through SFB 767.
[1] K. Uchida et al, Nature 455, 778 (2008). [2] N. Kazantseva et al, Phys. Rev. B 77, 184428 (2008).

MA 5.7 Mon 12:30 HSZ 04

Magnon mediated heat transport — •Vitaliy I. Vasyuchka, Alexander A. Serga, Andrii V. Chumak, and Burkard Hillebrands — FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

We report on measurements of heat transport mediated by a coherent magnon current in a magnetic medium. We used long-wavelength dipolar-dominated spin waves propagating along the magnetization direction in a tangentially magnetized yttrium iron garnet film. The temperature distribution in the film was visualized by means of an infrared thermography technique with a thermal sensitivity of 0.1 °C and a spatial resolution of 200 μm. A bias magnetic field of 1780 Oe was chosen to allow the effective excitation and propagation of magnons with wavevectors of the order of 100 rad/cm at 7 GHz frequency. In the presence of travelling magnons excited by applying a continuous microwave signal power of 100 mW, a strong heating of the sample (up to 23 °C) was observed around the input antenna. This heat is caused by the transfer of energy from the magnon system into the phonons. Detuning of the bias field to 1700 Oe when no magnons could be excited at the given frequency resulted in the disappearance of the observed heating effect. Comparing the obtained temperature distribution along the film with the heat profile created by a DC current in the antenna the efficiency of the travelling magnons in the process of heat transport was estimated.