MA 23: Spincaloric Transport I (jointly with TT)

Time: Wednesday 9:30–11:30 Location: H 0110

MA 23.1 Wed 9:30 H 0110

The Origin of spin Seebeck effect in Iron Garnet thin films — •Er-Jia Guo[1], Andreas Kehlberger[1], Gerhard Jakob[1], Matthias B. Jungfleisch[2], Burkard Hillebrands[2], Francesco D. Coletta[3], Hans Hübl[3], Stephan Geprägs[3], Sebastian Goennenwein[3], Rudolf Gross[3], and Mathias Kläui[1] — [1]Institute für Physics, Universität Mainz, 55099 Mainz, Germany — [2]Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [3]Walther-Meißner-Institut, Garching, Germany

The discovery of spin Seebeck effect (SSE) provides an exciting approach to generate spin currents, which are suggested to replace charge currents in order to reduce the power dissipation. However, the genuine origin of SSE is still under debate. Here, we present thickness and temperature dependences of SSE signals in Yttrium Iron Garnet (YIG) and Gadolinium Iron Garnet (GIG) films. Using Pt/YIG hybrid structures, the thickness dependence of the material shows that magnonic spin currents are the source of the SSE.[1] We find a thickness-dependent enhancement of the SSE at low temperatures, which agrees well with the thermal conductivity, implying the importance of the magnon-phonon drag. In contrast to YIG, the GIG films allow us to measure the SSE across the compensation point.[2] Two sign changes of the SSE are observed with temperature drop, revealing the SSE is not simply mirroring to the total magnetization but the magnons emitted from three interacting magnetic sub-lattices as well as the spin-mixing conductances depending on the atom type at the interface.[1]A.Kehlberger,et al.,arXiv:1306.0784 (2013)[2]S.Geprägs,et al.,arXiv:1405.4971(2014)

MA 23.2 Wed 9:45 H 0110

High tunnel magneto-Seebeck effect — •Alexander Boehnke[1], Marvin von der Ehe[2], Christian Sterwerf[1], Christian Franz[3], Michael Czerner[3], Karsten Rott[1], Andy Thomas[1], Christian Heiliger[3], Markus Münzenberg[2], and Günter Reiss[1] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, Germany — [3]1. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany

Semiconducting materials are known to have large Seebeck coefficients. This is mainly attributed to the gap in their band structure and the asymmetric position of the Fermi-level with respect to this gap. Accordingly, half-metals with a band-gap for only one spin-channel may have very different Seebeck coefficients for the majority and minority charge carriers. The tunnel magneto-Seebeck effect (TMS) is a powerful tool to investigate such spin-dependent Seebeck coefficients because separate spin-channels can be defined in magnetic tunnel junctions (MTJs).

Here, we probe the spin-dependent Seebeck coefficients of half-metallic Heusler compounds in Heusler/MgO/CoFe MTJs. For Co_2FeSi we found a TMS ratio of 96%, which is much larger than that of CoFeB/MgO/CoFeB MTJs (4%). Furthermore, we found an increase in the mean Seebeck voltage from 30μV in CoFeB to 3mV in Co_2FeSi based MTJs, which agrees with *ab initio* calculations. We will explain these findings by a Julliere-like model, which also shows the importance of the asymmetric Fermi-level position.

MA 23.3 Wed 10:00 H 0110

How to control and determine the direction of thermal gradients in spin caloric measurements? — •Timo Kuschel, Tristan Matalla-Wagner, Michel Bovender, Oliver Reimer, Daniel Meier, Jan-Michael Schmalhorst und Günter Reiss — CSMD, Physics Department, Bielefeld University, Germany

In *longitudinal* spin Seebeck effect (LSSE) measurements in magnetic insulators like $NiFe_2O_4$ or $Y_3Fe_5O_{12}$ with an out-of-plane thermal gradient ∇T additional magnetic proximity effects in the adjacent spin detector material (e.g. Pt) have to be taken into account and can be identified or excluded by e.g. x-ray resonant magnetic reflectivity [1]. In *transverse* SSE experiments with in-plane ∇T unintended out-of-plane ∇T can induce additional contributions as mainly Nernst effects in magnetic metals [2] and primarily LSSE in magnetic insulators [3]. Therefore, the control and the determination of thermal gradient directions in spin Seebeck experiments should be investigated in detail. Here, we present a new spin caloric setup which allows the rotation of in-plane thermal gradients based on the vectorial superposition of $\nabla_x T$ and $\nabla_y T$. We check the in-plane direction of ∇T by an infrared camera and will use the setup to study established and new spin caloric effects for different ∇T directions. We further show exemplarily that linear and quadratic Nernst effects in CoFeTb thin films can be used to estimate the effective direction of ∇T in all three spatial directions.

[1] T. Kuschel et al., submitted 2014, arxiv: 1411.0113
[2] D. Meier et al., Phys. Rev. B 88, 184425 (2013)
[3] D. Meier et al., submitted 2014, arxiv: 1411.6790

MA 23.4 Wed 10:15 H 0110

Spincaloric properties of epitaxial $Co_2MnSi/MgO/Co_2MnSi$ magnetic tunnel junctions — •Benjamin Geisler and Peter Kratzer — Fakultät für Physik and Center for Nanointegration, Universität Duisburg-Essen, 47048 Duisburg, Germany

Magnetic tunnel junctions (MTJs) with ferromagnetic, half-metallic electrodes are interesting spintronics devices due to their high tunnel magnetoresistance ratio. If a thermal gradient is applied to such a MTJ, the relative electrode magnetization can be detected by measuring the induced voltage, i.e., by exploiting the magneto-Seebeck effect [Nat. Mater. 10, 472 (2011)].

Here we present an *ab initio* viewpoint on transport and spincaloric properties of epitaxial $Co_2MnSi/MgO(001)/Co_2MnSi$ MTJs. We compare results calculated with the conventional Sivan-Imry approach to results obtained from solving the Landauer-Büttiker equation directly. The latter procedure circumvents the linear response approximation inherent in the Seebeck coefficient and provides the response of the system (current or voltage) to arbitrary thermal gradients. Moreover, thermal variations of the chemical potential in the leads and finite-bias effects can be readily included in this method, but are found to be negligible for this specific MTJ. We show how the spincaloric properties of the MTJs depend on the interface atomic structure and that they can be tailored by a targeted growth control. Finally, we briefly comment on the perturbing influence of thermally activated electrode phonons and interface magnons on the tunneling transport.

MA 23.5 Wed 10:30 H 0110

Coherent spin wave scattering at defects and localization phenomena — •Martin Evers and Ulrich Nowak — University of Konstanz, 78457 Konstanz, Germany

From studies of transport of particles and waves it is known that there are different transport regimes. Under ideal conditions, like in vacuum or in a perfect crystal, transport will be ballistic. However, in reality one has usually to deal with some kind of imperfections that induce disorder in the system. If this disorder is strong enough the transport will become diffusive. As Anderson showed back in 1958 in case of phase coherent scattering disorder can also lead to completely suppressed transport, known as Anderson Localization [1]. For the case of spin waves this could lead to a vanishing magnon propagation length, even without any damping mechanism.

In the framework of a classical spin model the effect of disorder on magnonic transport is studied utilizing the Landau-Lifshitz-Gilbert equation. Numerical investigations of one and two dimensional systems give insight to scattering properties of the systems, e. g. the mean free scattering time. We show directly the existence of Anderson localization in 1D and weak localization, which is a precursor for strong localization, in 2D, showing the ubiquitousness of Anderson Localization in wave physics.

[1] P. W. Anderson, Phys. Rev. 109, 1492 (1958)

MA 23.6 Wed 10:45 H 0110

Spin-Phonon Interactions and Magnetoelastic Modes — •Matthias Assmann and Ulrich Nowak — University Konstanz, 78457 Konstanz, Germany

For modern spin-caloritronic applications in insulators the interactions between the magnonic and the phononic system play the decisive role. We developed a model, which allows a coupling between these two thermodynamic sub-systems under strict observance of energy and angular momentum conservation laws. For this model we perform spin-molecular dynamics simulations, which take into account the spatial as well as the spin degrees of freedom. The coupling between the spin and lattice degrees of freedom is achieved by pseudo dipolar forces. A temperature gradient is applied by appropriate boundary condition and the excitation of magneto-elastic modes in form of a coupled transport of magnons and phonons in the temperature gradient is studied.

MA 23.7 Wed 11:00 H 0110

Anisotropic magnetothermopower in Co-based trilayers: A comparison between Cu, Pd, and Pt as heterostructure partners — •Voicu Popescu and Peter Kratzer — Faculty of Physics and CENIDE, University Duisburg-Essen, 47057 Duisburg, Germany

Within the framework of the spin-polarized relativistic Korringa-Kohn-Rostoker Green's function method we investigate the magnetothermopower (MTP) in a series of M/Co/M (M = Cu, Pd, and Pt) trilayer systems. As thermoelectric analogue of the conventional anisotropic magnetoresistance (AMR), the amplitude of the MTP signal is shown to depend on the asymmetry of the AMR around the Fermi energy. This asymmetry is sizable even if the magnetic layer itself displays only a small AMR, thus providing a path towards an efficient spin read-out thermoelectric device based on a single ferromagnetic layer. Our calculations establish a direct correlation between the strength of the spin-orbit coupling, modulated by the heterostructure partner M, and the MTP. The role of Co/M interface related effects such as structural relaxation and interdiffusion is also discussed.

MA 23.8 Wed 11:15 H 0110

Anisotropic magneto-thermopower in (Ga,Mn)As thin films — •Sibylle Meyer[1,2], Matthias Althammer[1], Wladimir Schoch[3], Rudolf Gross[1,2,4], and Sebastian T. B. Goennenwein[1,4] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, TU München, Garching, Germany — [3]Institut für Quantenmaterie, Universität Ulm, Ulm, Germany — [4]Nanosystems Initiative Munich, München, Germany

The resistance of ferromagnetic metals depends on the magnetization orientation. This is referred to as anisotropic magneto-resistance (AMR), and exploited in many applications. In close analogy, also the thermopower of magnetic metals depends on the magnetization orientation, i.e., the electrical field arising upon the application of a thermal gradient to the metal characteristically varies with the magnetization orientation (anisotropic magneto-thermopower AMTP). However, due to different symmetry restrictions, the evolution of AMR and AMTP with magnetization orientation is expected to be distinctly different. To experimentally test this conjecture, we measured the AMTP in (Ga,Mn)As single crystals. Our data show that the AMTP effect can be adequately modeled only if the symmetry of the (Ga,Mn)As crystal is explicitly taken into account. We quantitatively compare the AMTP with AMR data taken on the same (113)-oriented (Ga,Mn)As thin films and with corresponding model calculations.
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