SKM-Symposium Spincaloric Transport (SKM-SYST)

jointly organized by
the Magnetism Division (MA),
the Semiconductor Physics Division (HL), and
and the Low Temperature Physics Division (TT)

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The application of temperature gradients to homogeneous ferromagnets or magnetic/nonmagnetic nanostructures gives rise to novel spin dependent phenomena. Prominent examples are the spin Seebeck effect reported for metallic, insulating and semiconducting ferromagnets, or the thermally induced spin transfer torque in nanopillar devices. Both theory and experiments suggest that spin caloric effects can substantially alter the thermal transport properties, the magneto-galvanic (magneto-resistive) response, and possibly even the magnetic configuration of magnetic materials. Technical applications might include improved heat management in spintronic devices and nanoscale heat engines. The symposium provides an overview over this emerging research field.

Overview of Invited Talks and Sessions

(lecture room TRE Ma)

Invited Talks

SKM-SYST 1.1	Mon	14:30–15:00	TRE Ma	**On the theory of the spin wave Seebeck effect** — •Gerrit Bauer
SKM-SYST 1.2	Mon	15:00–15:30	TRE Ma	**Spin Seebeck effect in metals and insulators** — •Ken-ichi Uchida, Eiji Saitoh
SKM-SYST 1.3	Mon	15:30–16:00	TRE Ma	**Spin-Seebeck effect: Local nature of thermally induced spin currents in GaMnAs** — •Roberto Myers
SKM-SYST 1.4	Mon	16:00–16:30	TRE Ma	**Heat conduction of low-dimensional quantum magnets** — •Christian Hess, Nikolai Hlubek, Patrick Ribeiro, Bernd Büchner, Surjeet Singh, Romuald Saint-Martin, Alexandre Revcolevschi
SKM-SYST 1.5	Mon	16:30–17:00	TRE Ma	**Evidence of spin polarized heat current acting on magnetization** — •Jean-Philippe Ansermet

Sessions

SKM-SYST 1.1–1.5	Mon	14:30–17:00	TRE Ma	**Spin Caloric Transport**

SKM-SYST 1: Spin Caloric Transport

Time: Monday 14:30–17:00 Location: TRE Ma

Invited Talk SKM-SYST 1.1 Mon 14:30 TRE Ma

On the theory of the spin wave Seebeck effect — •Gerrit Bauer — Kavli Institute of NanoScience, TU Delft, Netherlands

The spin Seebeck effect, discovered by Uchida et al. [1], has been observed in various ferromagnets, such as the metal Py [1], insulating Yttrium Iron Garnet (YIG) [2], the semiconductor GaAlMn [3] and the Heusler compound Co2MnSi [4]. Possibly, the effect is caused by the non-equilibrium spin wave dynamics induced by a thermal gradient, which leads to a net spin current injected by the ferromagnet into a normal metal contact [5,6]. This mechanism appears to explain experiments on the spin Seebeck effect in YIG [2]. This talk will address new theoretical developments to understand the spin (wave) Seebeck effect.

The reported results have been obtained in collaboration with J. Xiao, K. Xia, K. Uchida, E. Saitoh, and S. Maekawa and has been support by the Dutch FOM foundation.

[1] K. Uchida et al., Nature 445, 778-781 (2008).
[2] K. Uchida et al., Nature Mater. 9, 894 (2010).
[3] C.M. Jaworski et al., Nature Mater. 9 , 898 (2010).
[4] S. Bosu et al., unpublished.
[5] J. Xiao et al., Phys. Rev. B 81, 214418 (2010).
[6] H. Adachi et al., arXiv:1010.2325.

Invited Talk SKM-SYST 1.2 Mon 15:00 TRE Ma

Spin Seebeck effect in metals and insulators — •Ken-ichi Uchida and Eiji Saitoh — Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

Recent studies on spintronics and spin caloritronics have revealed that a spin current, a flow of spin angular momentum, is strongly coupled with a heat current in various magnetic systems. From both basic science and applied engineering points of view, the interplay of these two currents is of crucial importance. The spin-Seebeck effect (SSE) [1-6] is a phenomenon enabling the conversion of heat currents into spin voltage, a potential for driving nonequilibrium spin currents, in ferromagnets.

In this paper, we report the experimental observation of the SSE in ferromagnetic metals [1] and insulators [3,5]. The SSE drives a spin current flowing across an interface between a ferromagnet and an attached Pt film and the spin current is converted into electric voltage by the inverse spin-Hall effect [7] in the Pt film.

This work was supported by a Grant-in-Aid for Scientific research in Priority Area "Creation and Control of Spin Current" and Scientific Research A from MEXT, Japan.

[1] K. Uchida et al., Nature 455, 778 (2008). [2] J. Xiao et al., Phys. Rev. B 81, 214418 (2010). [3] K. Uchida et al., Nature Mater. 9, 894 (2010). [4] C. M. Jaworski et al., Nature Mater. 9, 898 (2010). [5] K. Uchida et al., Appl. Phys. Lett. 97, 172505 (2010). [6] H. Adachi et al., arXiv:1010.2325 (2010). [7] E. Saitoh et al., Appl. Phys. Lett. 88, 182509 (2006).

Invited Talk SKM-SYST 1.3 Mon 15:30 TRE Ma

Spin-Seebeck effect: Local nature of thermally induced spin currents in GaMnAs — •Roberto Myers — Department of Materials Science and Engineering, The Ohio State University, Columbus, Ohio, U.S.A.

The spin-Seebeck effect refers to a spatial distribution of spins in a ferromagnetic material induced by a thermal gradient. This macroscopic spatial distribution of spins is several orders of magnitude larger than the spin diffusion length. Here we describe measurements of the spin-Seebeck effect in the ferromagnetic semiconductor, GaMnAs, and a related ferromagnetic metal MnAs. The thermally induced spatial distribution of spins is inferred from the sign and magnitude of the inverse spin Hall voltage generated from local spin currents in platinum bars that are in electrical contact with the ferromagnetic material. From an experimental point of view, GaMnAs provides unique measurement geometries since the magnetic easy axes can be engineered in different directions and the low Curie temperature makes it convenient to perform spin-Seebeck measurements across the magnetic phase transition. Using different experimental configurations we measure either the isolated spin-Seebeck signal, the planar and transverse Nernst effect, or a combination of the spin-Seebeck and Nernst effects. One of the most intriguing aspects of the spin-Seebeck effect is the observation that the spatial distribution of spins is maintained across electrical breaks revealing that the effect does not arise from a longitudinal spin current of charge carriers.

Invited Talk SKM-SYST 1.4 Mon 16:00 TRE Ma

Heat conduction of low-dimensional quantum magnets — •Christian Hess[1], Nikolai Hlubek[1], Patrick Ribeiro[1], Bernd Büchner[1], Surjeet Singh[2], Romuald Saint-Martin[2], and Alexandre Revcolevschi[2] — [1]Leibniz-Institute for Solid State and Materials Research, IFW Dresden, Institute for Solid State Research, 01171 Dresden, Germany — [2]Laboratoire de Physico-Chimie de L'Etat Solide, ICMMO, UMR8182, Université Paris-Sud, 91405 Orsay, France

Some years ago, a new, magnetic mode of heat transport which occurs in low-dimensional $S = 1/2$ quantum magnets has been discovered and is intensely studied since then. The magnetic heat conductivity $\kappa_{\rm mag}$ of such quantum magnet materials can be exceptionally large (even at room temperature), dwarfs the phonon heat conduction and thereby leads to an overall magnitude of the heat conductivity which is comparable to that of metals. The analysis of $\kappa_{\rm mag}$ yields detailed information about the scattering processes which govern the magnon transport, such as scattering involving defects, phonons and magnons in the materials. After reviewing the main experimental findings, this talk focuses on recent experimental results on one-dimensional $S = 1/2$ Heisenberg chain materials. Evidence for ballistic magnetic transport and magnetic mean free paths of more than one micrometer is found in these materials, i.e. at the length scale of typical spin diffusion lengths in spintronic experiments. In our experiments we carefully study the effect of various disorder types (viz. bond disorder, magnetic and non-magnetic site disorder) on this transport phenomenon.

Invited Talk SKM-SYST 1.5 Mon 16:30 TRE Ma

Evidence of spin polarized heat current acting on magnetization — •Jean-Philippe Ansermet — EPFL, station 3, CH-1015 Lausanne, Switzerland

Nanomagnets of controlled geometry can be formed and contacted electrically by the method of electrodeposition in nanopores. The talk will focus on recent results, where Joule heating was used as a source of heating on a nanoscale. Evidence for thermal spin transfer torque was demonstrated (Haiming Yu, S. Granville, D. P. Yu, J.-Ph. Ansermet, Phys. Rev. Lett. 104, 146601 (2010)). Heat currents crossing the free layer of an asymmetric spin valve are shown to change its switching field. The data are accounted for with a thermodynamic model for the spin current accompanying heat transport.