JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Workshop

Spin caloritronics in insulators

SPINNET

MATERIALS SCIENCE IN MAINZ

October 9-10th, 2013

DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service

Bundesministerium für Bildung und Forschung

Date	Program
8.10.2013	Arrival
9.10.2013 Morning program (9:00-12:30)	
9:00 - 9:15	Welcome
Plenary talks	
9:15 - 10:30	Eiji Saitoh “From spin pumping to spin Seebeck effects”
10:30 – 11:30	Gerrit Bauer “Spintronics and spin caloritronics with magnetic insulators”
Research within the SSP	
11:45 – 12:30	Technical University of Kaiserslautern V.I. Vasyuchka “Magnon Caloritronics”
Lunch break 12:30 – 14:00	

Afternoon program (14:00-17:30)	
14:00 – 15:30	Combined presentation by University of Mainz & Konstanz Mathias. Kläui “Genuine spin Seebeck effect probed by the thickness dependence in YIG” Ulrich Nowak “Thermal Spin Currents: Lengthscales and Domain Wall Dynamics” Gerhard Jakob “Magnetic field dependence of the thermal conductivity of LCMO”
Coffee break 15:30 – 15:45	
15:45 – 17:30	University of Bielefeld Andy Thomas “Tunneling Magneto-Seebeck effect” Timo Kuschel “Nernst and spin Seebeck effects in NM/FM bilayers”
17:40 – 18:30	Labtour of the AG-Kläui
Dinner at the „Eisgrub“ 19:00	

10.10.2013 Morning program (9:00-12:00)	
9:00 – 9:30	Mathias Kläui “Foci and aims of the Priority program”
9:30 – 11:30	Poster and discussion session
Lunch break 11:30 – 12:30	
Afternoon program (13:00 – 18:45)	
12 : 30 – 13:15	Preparation of 2 Slides per group for the open discussion
13:20 - 14:30 or longer if necessary	Presentation of ideas and discussion

Plenary talks:

Wednesday 9.10.2013

9:15-11:30

From spin pumping to spin Seebeck effects

Eiji Saitoh[1-3]

[1]WPI-AIMR, Tohoku University, Sendai 980-8577, Japan

[2]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

[3]ASRC, Japan Atomic Energy Agency, Tokai 319-1195, Japan

Spin current, a flow of electrons' spins in a solid, is the key concept in spintronics that will allow the achievement of efficient magnetic memories, computing devices, and energy converters. I here review phenomena which allow us to use spin currents in insulators [1]: inverse spin-Hall effect [2,4], spin pumping, and spin Seebeck effect [4-6]. We found that spin pumping and spin torque effects appear at an interface between an insulator YIG and Pt. Using this effect, we can connect a spin current carried by conduction electrons and a spin-wave spin current flowing in insulators. We demonstrate electric signal transmission by using these effects and interconversion of the spin currents [1]. Seebeck effect (SSE) is the thermal spin pumping [5]. The SSE allows us to generate spin voltage, potential for driving nonequilibrium spin currents, by placing a ferromagnet in a temperature gradient. Using the inverse spin-Hall effect in Pt films, we measured the spin voltage generated from a temperature gradient in various ferromagnetic insulators.

This research is collaboration with K. Ando, K. Uchida, Y. Kajiwara, S. Maekawa, G. E.

W. Bauer, S. Takahashi, and J. Ieda.

REFERENCES

[1]. Y. Kajiwara & E. Saitoh et al. Nature 464 (2010) 262.

[2] E. Saitoh et al., Appl. Phys. Lett. 88 (2006) 182509.

[3] A. Ando & E. Saitoh et al., Nature materials 10 (2011) 655 -659.

[4] K. Uchida & E. Saitoh et al., Nature 455 (2008)778.

[5] K. Uchida & E. Saitoh et al., Nature materials 9 (2010) 894 - 897.

[6] K. Uchida & E. Saitoh et al., Nature materials 10 (2011) 737-741.

Spintronics and spin caloritronics with magnetic insulators

Prof. Gerrit Bauer

Tohoku University, Sendai 980-8577, Japan

Since the discovery that the magnetic order in insulators such as Yttrium Iron Garnets can be thermally and electrically actuated, these classical materials enjoy much recent attention. In this talk I will review recent developments on topics such as the spin Seebeck effect, spin Seebeck power generators, spin torque transistor, the spin Hall magnetoresistance etc. involving magnetic insulators from a theoretical point of view.

Research within the SSP

Wednesday 9.10.2013

11:30-17:30

Magnon Caloritronics

V.I. Vasyuchka

Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern,

67663 Kaiserslautern, Germany

The understanding of the underlying physics of magnon caloritronic effects requires the study of the interactions between magnons (the quanta of magnetization excitations) and phonons (the quanta of lattice vibrations). Magnetic insulators as yttrium iron garnet (YIG) films are ideal candidates for such studies due to the long life-time of magnons and their easy controllability via a bias magnetic field in combination with the excitation frequency and power. Magnon mediated caloritronic effects have been studied in thin YIG films using the infrared thermography technique in combination with the Brillouin light scattering spectroscopy. The experimental results have shown an energy transfer from the magnonic system to phonons leading to the formation of thermal gradients, which depends strongly on the energy of the magnons. We show that the heating by artificially excited magnons follows the character of non-reciprocal propagation with respect to the excitation antenna of surface magnons, while for backward volume magnons a symmetric thermal distribution was seen. Furthermore, at relatively low excitation microwave powers, a thermal gradient yielding an increase in temperature from the antenna to the end of the sample was observed in the case of surface magnons. This effect was understood as a result of the non-reciprocal nature of the surface magnons that drastically dissipate their energy in the process of reflection at the end of the sample.

Genuine spin Seebeck effect probed by the thickness dependence in YIG

Mathias Kläui

University Mainz, Mainz 55128, Germany

We investigated the thickness dependence of the longitudinal spin Seebeck effect in thick Yttrium Iron Garnet films. The films have been grown by pulsed laser deposition in a thickness range up to 300 nm. Identical interfaces, as well as an investigation of the magneto resistivity allow us to separate the genuine spin Seebeck effect from possible other contributions to the signals. We find a characteristic saturation of the produced ISHE-signals in the order of 100 nm. Atomistic simulation enables to deduce this behavior from a finite propagation length of thermally excited magnons, which reveals the origin of the spin Seebeck. By thus we are also able to show, that the spin Seebeck effect ordinates from the bulk of the material and not from the interface.

Thermal Spin Currents: Lengthscales and Domain Wall Dynamics

Ulrich Nowak

University Konstanz, Konstanz 78464, Germany

In ferromagnetic insulators spatial temperature gradients can lead to pure magnonic spin currents. Using atomistic spin model simulations we explore the propagation of thermally induced magnons and the characteristic lengthscale of magnon accumulation due to different temperature profiles. Furthermore we investigate domain wall motion due to temperature gradients.

Magnetic field dependence of the thermal conductivity of LCMO

Gerhard Jakob

University Mainz, Mainz 55128, Germany

We measured the out-of-plane thermal conductivity of LCMO using the differential three omega technique and found a magnetic field dependence of several percent. The effect is observed to be largest in the vicinity of the metal-insulator transition, since the enhancement in thermal conductivity is caused by the colossal magnetoresistance effect increasing the electronic contribution to the thermal conductivity. The temperature of this transition was adjusted by post-annealing the samples in an oxygen atmosphere.

Tunneling Magneto-Seebeck effect

Dr. Andy Thomas

University Bielefeld, Bielefeld 33501, Germany

We show the temperature dependent investigations of the tunneling magneto-Seebeck effect, supported by TEM studies of the microstructure, numeric simulations of the temperature profile in the junction and possible devices utilizing the tunneling magneto Seebeck effect.

Nernst and spin Seebeck effects in NM/FM bilayers

Dr. Timo Kuschel

University Bielefeld, Bielefeld 33501, Germany

We present investigations on the longitudinal spin Seebeck effect and spin Hall magnetoresistance in platinum/nickelferrite bilayers and how we can distinguish these effects from anomalous Nernst effect and anisotropic magnetoresistance. We further show how parasitic effects can influence transverse spin Seebeck effect measurements in platinum/permalloy bilayers.

Postersession:

Thursday 10.10.2013

9:30-11:30

Influence of heat flow directions on Nernst effects in magnetic thin films

Daniel Meier

University Bielefeld, Bielefeld 33501, Germany

In this work we report on the appearance of the anomalous Nernst effect in various magnetic materials obtained in different setups with in-plane and out-of-plane temperature gradients (local and integral heating) in order to correlate the effects to Nernst and spin Seebeck effects. Further, the anomalous Nernst effect is compared to anomalous Hall effect in magnetic multilayers.

Magnetic field dependence of the thermal conductivity of LCMO

Christoph Euler

University Mainz, Mainz 55128, Germany

We measured the out-of-plane thermal conductivity of LCMO using the differential three omega technique and found a magnetic field dependence of several percent. The effect is observed to be largest in the vicinity of the metal-insulator transition, since the enhancement in thermal conductivity is caused by the colossal magnetoresistance effect increasing the electronic contribution to the thermal conductivity. The temperature of this transition was adjusted by post-annealing the samples in an oxygen atmosphere.

Genuine spin Seebeck effect probed by the thickness dependence in YIG

Andreas Kehlberger

University Mainz, Mainz 55128, Germany

We investigated the thickness dependence of the longitudinal spin Seebeck effect in thick Yttrium Iron Garnet films. The films have been grown by pulsed laser deposition in a thickness range up to 300 nm. Identical interfaces, as well as an investigation of the magneto resistivity allow us to separate the genuine spin Seebeck effect from possible other contributions to the signals. We find a characteristic saturation of the produced ISHE-signals in the order of 100 nm. Atomistic simulation enables to deduce this behavior from a finite propagation length of thermally excited magnons, which reveals the origin of the spin Seebeck. By thus we are also able to show, that the spin Seebeck effect ordinates from the bulk of the material and not from the interface.

Spin wave mediated heat and spin transport in a magnetic insulator

Thomas Langner, V.I. Vasyuchka, B. Obry, A.V. Chumak, A.A. Serga and B. Hillebrands

Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern,

67663 Kaiserslautern, Germany

We present here the results on spin wave mediated heating in thin YIG films. We have found that the direction of the heat flow in the YIG sample can be controlled by an external magnetic field. It is understood as a result of the interplay between the unidirectional heating and the diffusion of heat into the cold part of the film. Furthermore the wavevector transformation of coherently excited spin waves in a thermal gradient along a YIG waveguide is shown.

Thermal Spin Currents: Lengthscales and Domain Wall Dynamics

Ulrike Ritzmann

University Konstanz, Konstanz 78464, Germany

In ferromagnetic insulators spatial temperature gradients can lead to pure magnonic spin currents. Using atomistic spin model simulations we explore the propagation of thermally induced magnons and the characteristic lengthscale of magnon accumulation due to different temperature profiles. Furthermore we investigate domain wall motion due to temperature gradients.

Magnon Temperature Measurements: New Insights into Spin Seebeck Effect

Milan Agrawal[1], V.I. Vasyuchka[1], A.A. Serga[1], A.D. Karenowska[2], G.A. Melkov[3], and B. Hillebrands[1]

[1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

[2]Department of Physics, University of Oxford, Oxford OX1 3PU, UK

[3]Faculty of Radiophysics, TS National University of Kyiv, 03127 Kyiv, Ukraine

Magnon and phonon temperature distributions in ferromagnets can explain the thermal spin transport phenomena of spin Seebeck effect. Here, we report on the measurement of the spatial distribution of the magnon temperature in a magnetic insulator imposed to a lateral thermal gradient. The experimental data is interpreted with the existing theoretical models and the typical length scale of phonon-magnon interaction is determined

Spin torque transistor with a magnetic insulator and spin Hall effect

Takahiro Chiba

Tohoku University, Sendai 980-8577, Japan

We theoretically study the operation of a 4-terminal device consisting of two lateral thin-film spin valves that are coupled by a magnetic insulator such as yttrium iron garnet via the spin transfer torque. By magnetoelectronic circuit theory we calculate the current voltage characteristics and find negative differential resistance and differential gain in a large region of parameter space. We demonstrate that functionality is preserved when the control spin valve is replaced by a normal metal film with a large spin Hall angle.

T.Chiba, et al., Appl. Phys. Lett., 102, 192412 (2013).

Magnetoelectric effect in topological insulator films beyond linear response regime

Dashdeleg Baasanjav

Tohoku University, Sendai 980-8577, Japan

We study the response of topological insulator films to strong magnetic and electric fields beyond the linear response theory. As a model, we use three-dimensional lattice Wilson-Dirac Hamiltonian where we simultaneously introduce both magnetic field through the Peierls substitution and electric field as a potential energy depending on lattice coordinate. We compute the electron energy spectrum by numerically diagonalizing this Hamiltonian and obtain quantized magnetoelectric polarizability. In addition, we find that the magnetoelectric effect vanishes as the film width decreases and applying gate voltage between the surfaces, we observe several quantized plateaus of theta term.

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Third floor, room number 03-122

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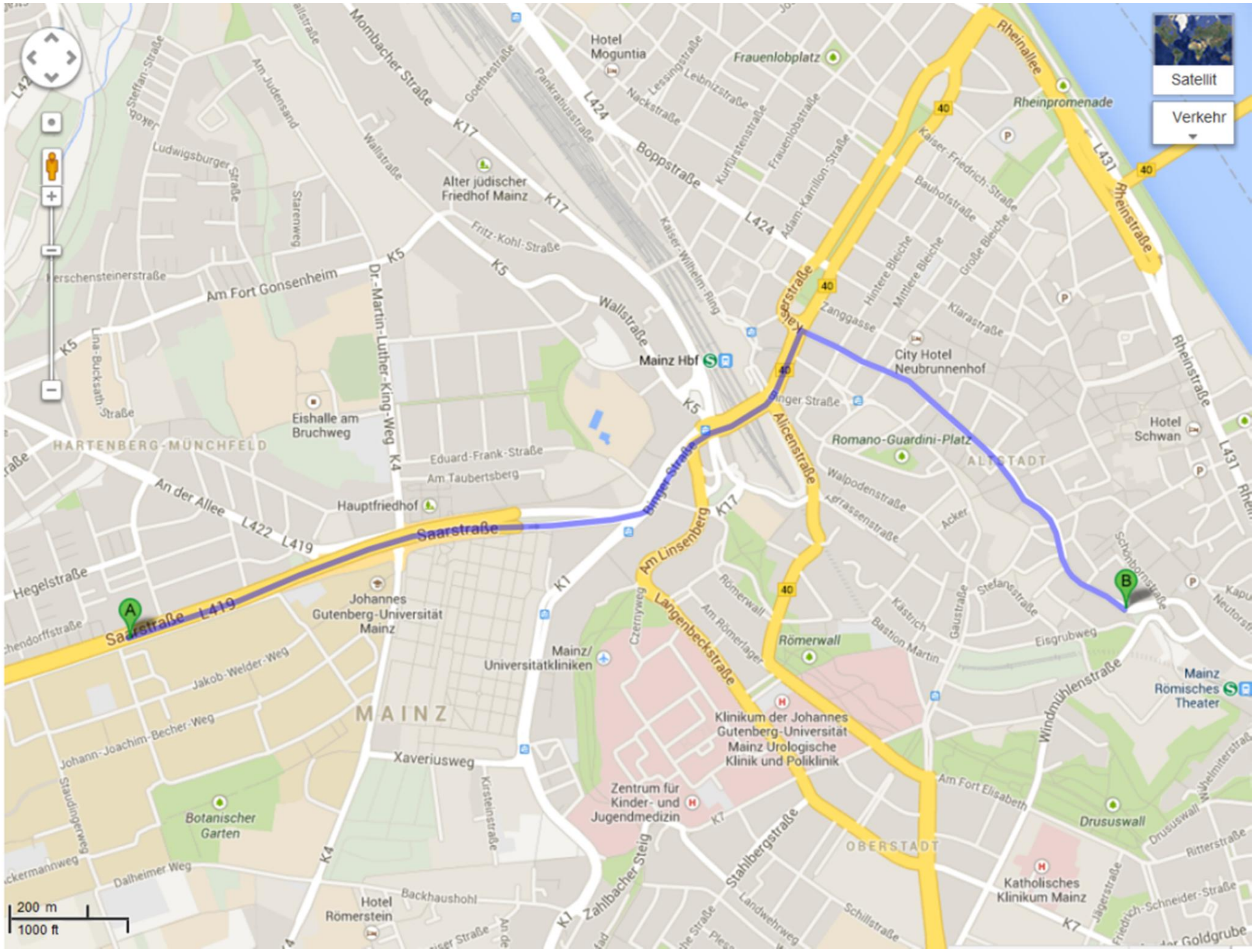

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