# MA 41: Spintronics (Other Effects)

Time: Thursday 15:00–17:45 Location: H 2013

MA 41.1 Thu 15:00 H 2013

**thermal Hall effect from magnon many-body skew scattering** — •Dimos Chatzichrysafis and Alexander Mook — Johannes Gutenberg-Universität Mainz, Germany

The thermal Hall effect is a developing tool to investigate charge-neutral excitations, exposing the quantum many-body ground state of correlated materials. A significant aspect regards the nature of excitations (fermions versus bosons) [1]. Although a bosonic thermal Hall effect results from a Berry curvature of quasiparticles, there is mounting evidence that this intrinsic contribution is insufficient to describe experiments [2]. Here, we develop a theory for a magnonic thermal Hall effect driven by many-body skew scattering. To exclude intrinsic effects, we consider a chiral ferromagnet with a single magnon band. The Dzyaloshinskii-Moriya interaction gives rise to many-body interactions that break time-reversal symmetry. Within the framework of the semi-classical Boltzmann equation, we show that a transverse magnon current arises from the skew scattering caused by the interference of three-magnon and four-magnon scattering channels. We estimate that this novel contribution to the thermal Hall effect can be as large as (or even larger than) the intrinsic contribution. Thus, we believe that our work will help better explain related experimental results.

[1] Czajka, P., Gao, T., Hirschberger, M. et al., Nat. Mater. 22, 36-41 (2023)

[2] S. Suetsugu, T. Yokoi, K. Totsuka, T. et al., Phys. Rev. B 105, 024415 (2022)

MA 41.2 Thu 15:15 H 2013

**Temperature dependence of disorder effect on the spin current in insulator-metal layered systems** — •Mahsa Seyed Heydari, Wolfgang Belzig, and Niklas Rohling — Konstanz University, Konstanz, Germany

We investigate theoretically spin transport through the interface of a non-magnetic metal and an antiferromagnetic insulator driven e.g. by a spin accumulation generated by the spin Hall effect. Our study is motivated by experimental [1] and theoretical [2] work on spin transport through layered systems that include magnetically ordered insulators and non-magnetic metals. Specifically, there is a big interest in the role of thin antiferromagnetic layers. We describe the effect of the interface broadening on the spin current and investigate how disorder-induced broadening of scattering matrix elements with respect to the in-plane momentum influences the spin current. By using Fermi*s Golden rule the spin current can be computed [3]. Our results allow insights into the temperature dependence of the interface-disorder-induced influence on the spin current. In general, we find that increasing disorder leads to a decrease in spin current. Additionally, for a magnetically compensated interface, we find a thermal-gradient contribution to the spin current (spin Seebeck effect) only as a higher-order effect.

[1] Pati, Materials Letters 299, 130088 (2021)

[2] Gulbrandsen, Brataas, Phys. Rev. B 97, 054409 (2018)

[3] Fj*rbu et al., Phys. Rev. B 95, 144408 (2017)

MA 41.3 Thu 15:30 H 2013

**Non-hermiticity in spintronics: oscillation death and stochastic control of stability in coupled spintronic oscillators** — •Steffen Wittrock[1,2], Salvatore Perna[3], Romain Lebrun[2], Katia Ho[2], Roberta Dutra[4], Ricardo Ferreira[5], Paolo Bortolotti[2], Claudio Serpico[3], and Vincent Cros[2] — [1]Helmholtz-Zentrum Berlin, Berlin, Germany — [2]Unité Mixte de Physique CNRS, Thales, Palaiseau, France — [3]University of Naples Federico II, Naples, Italy — [4]Centro Brasileiro de Pesquisas Fésicas, Rio de Janeiro, Brazil — [5]International Iberian Nanotechnology Laboratory, Braga, Portugal

The potential of non-hermitian physics in spintronics is just about to be discovered and anticipated to uncover a manifold of intriguing phenomena and potential applications. In a system of coupled spintronic oscillators, we have just recently demonstrated the phenomenon of amplitude death to occur in the vicinity of an exceptional point, connecting nonlinear physics with the principles of non-hermiticity. Here, we present the control of the coupled oscillator stability and occuring stochastics in the vicinity of an exceptional point.

MA 41.4 Thu 15:45 H 2013

**Thin film heterostructures based on Co/Ni synthetic antiferromagnets on polymer tapes: towards a sustainable flexible spintronics** — •Mariam Hassan[1,2], Sara Laureti[2], Christian Rinaldi[3], Federico Fagiani[3], Gianni Barucca[4], Francesca Casoli[5], Alessio Mezzi[6], Eleonora Bolli[6], Saulius Kaciulis[6], Aladin Ulrich[1], Gaspare Varvaro[2], and Manfred Albrecht[1] — [1]University of Augsburg, Germany — [2]CNR-ISM, Italy — [3]Politecnico di Milano, Italy — [4]Politecnica delle Marche, Italy — [5]CNR-IMEM, Italy — [6]CNR-ISMN, Italy

Compared to platinum-group metal systems (PGMs), the PGMs-free Co/Ni-system offers several advantages for spin-based devices such as low damping and high spin polarization, and they contribute to a more sustainable future by relieving the demand for strategic raw materials. In this work, flexible synthetic-antiferromagnets with perpendicular-magnetic-anisotropy (PMA-SAFs) and GMR-spin-valves (SVs) containing a SAF-reference electrode and a Co/Ni-free layer were deposited on flexible polyethylene naphthalate tapes with different combinations of buffer and capping layers (Pt, Pd, Cu/Ta). High-quality SAFs with a fully compensated antiferromagnetic region and SVs with a sizeable GMR ratio were obtained. The best performances are achieved with PGMs used as buffer layer and Cu as capping layer[1]. The results indicate that complex Co/Ni-based heterostructures with reduced content of PGMs deposited on flexible tapes allow for the development of novel shapeable and sustainable spintronic devices. [1]ACS Appl. Mater. Interfaces. 14 (2022) 51496-51509.

MA 41.5 Thu 16:00 H 2013

**Oxygen-Vacancies-Driven Resistive Switching in Epitaxial $Fe_3O_4$ Thin Films** — •Yifan Xu[1,2], Connie Bednarski-Meinke[2], Steffen Tober[2], Asmaa Qdemat[2], Felix Gunkel[3], Regina Dittmann[3], Oleg Petracic[2,1], and Mai Hussein Hamed[2,4] — [1]Heinrich Heine University Düsseldorf, Faculty of Mathematics and Natural Sciences, Düsseldorf, Germany — [2]Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany — [3]Peter Grünberg Institute and JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany — [4]Faculty of Science, Helwan University, Cairo, Egypt

Resistive switching implies that the device can be switched between a High Resistance State (HRS) and Low Resistance State (LRS) upon application of an electric field. $Fe_3O_4$ emerges as a candidate for resistive switching due to the sensitivity of its magnetic and electronic properties on the presence of oxygen vacancies. Here we present the preparation and characterization of epitaxial $Fe_3O_4$ thin films grown on $TiO_2$ - terminated $Nb:SrTiO_3$ via pulsed laser deposition (PLD). We observe resistive switching using I-V measurements and magnetometry. We propose a mechanism in which redox reactions and the presence of oxygen vacancies are responsible for the resistive switching. This effect shows potential for next-generation magnetoionic device applications.

MA 41.6 Thu 16:15 H 2013

**Role of vibronic coupling in the chirality-induced spin selectivity effect in electron transport through chiral molecules** — •Rudolf Smorka, Yaling Ke, and Michael Thoss — Institute of Physics, University of Freiburg, Germany

The chirality-induced spin selectivity effect, which is the spin-dependent transmission of electrons through chiral materials, has attracted considerable interest for its potential applications in spintronics, electrochemistry, and optoelectronics, as well as shedding light on spin-selective chemical reactions and biological processes [1]. This effect, observed in various materials like double-stranded DNA, emerges from the interplay between geometrical helicity and spin-orbit interactions and is a nonequilibrium phenomenon.

Existing theoretical models, while reproducing experimental findings, often rely on unrealistic spin-orbit interaction parameters, possibly due to neglecting electron correlations. A recent vibrationally assisted spin-orbit coupling model shows promise for achieving high spin selectivities [2]. Our investigation of this model employs two methodologies: a mixed quantum-classical approach combining Ehrenfest dynamics with hierarchical equations of motion (HEOM), and a recently introduced numerically exact HEOM in matrix product state formulation [3], offering a comparative study of the role of vibrations on spin selectivity in this model.

[1] Evers, F. *et al.*, *Adv. Mater.* **34**, 2106629 (2022)
[2] Fransson, J., *Phys. Rev. B* **102**, 235416 (2020)
[3] Ke, Y., Borrelli, R., Thoss, M., *J. Chem. Phys.* **156.19** (2022)

**15 min. break**

MA 41.7 Thu 16:45 H 2013

**Spin-splitting in collinear antiferromagnetic MnTe : Inception and manifestations** — •Jan Minár[1], Sunil Wilfred Dsouza[1], Juraj Krempaský[2], Libor Šmejkal[3,4], Jan Hugho Dil[5,2], and Tomáš Jungwirth[4,6] — [1]New Technologies Research Centre, University of West Bohemia, Univerzitní 8, CZ-306 14 Pilsen, Czech Republic. — [2]Photon Science Division, Paul Scherrer Institut, CH-5232 Villigen, Switzerland. — [3]Institut für Physik, Johannes Gutenberg Universität Mainz, D-55099 Mainz, Germany. — [4]Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10, 162 00 Praha 6 Czech Republic. — [5]Institut de Physique, École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland. — [6]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom

We have explored Kramers spin non-degenerate states in MnTe by investigating the spin-polarized electronic structure of MnTe by means of one-step model Angle Resolved photoemission (ARPES) calculations within the fully relativistic multiple scattering Korringa-Kohn-Rostoker Green function approach. ARPES spectral weight related to non-symmorphic symmetry and signatures corresponding to the surface resonance contributions from Te and Mn states at respective binding energies were identified. Excellent agreement between theory and experiments reveals that the spin splitting stems from the local crystal anisotropy without requiring strong electronic correlations[1].

[1] J. Krempaský et al.,(2023),arXiv:2308.10681 (Accepted in Nature)

MA 41.8 Thu 17:00 H 2013

**Interfacial Engineering of the magnetism and spin transport in two-dimensional materials** — •Haichang Lu[1,2], John Robertson[2], Zhimei Sun[3], and Weisheng Zhao[1] — [1]Fert Beijing Institute, MIIT Key Laboratory of Spintronics, School of Integrated Circuit Science and Engineering, Beihang University, Beijing, 100191, China — [2]Engineering Department, Cambridge University, Cambridge CB2 1PZ, UK — [3]School of Materials Science and Engineering, Beihang University, Beijing 100191, China

Two-dimensional (2D) materials are promising candidates for the next generation of spintronic devices as they provide flat interfaces that embed many interesting physical effects. As the device size shrinks, properties such as magnetism and spin transport are not only determined by the materials but also by the interfaces. Here, we study the interfacial effects. For example, Fe4GeTe2 is a quasi-2D ferromagnet with an intrinsic Curie temperature (TC) approaching 300K. We show that by contacting with sapphire 001 surface, the Curie temperature can rise to 530K. We also study CrTe2, another ferromagnetic metal with TC approaching room temperature. We find spin frustration happens in monolayer CrTe2, but the substrate recovered the ferromagnetism. Apart from TC, we also show that the type of interface, such as physisorbed and chemisorbed interface, pose a significant impact on the spin transport. We investigate the tunnel magnetoresistance (TMR) effect of the hexagonal boron nitride (h-BN)/Co magnetic tunnel junction. TMR with physisorbed interfaces is 1000 times higher than that of chemisorbed interfaces.

MA 41.9 Thu 17:15 H 2013

**Search for ferromagnetism in Mn-doped lead halide perovskites** — •Maryam Sajedi[1], Chen Luo[1], Konrad Siemensmeyer[1], Maxim Krivenkov[1], Kai Chen[1,2], James M. Taylor[1,3], Marion A. Flatken[1], Florin Radu[1], and Oliver Rader[1] — [1]Helmholz-Zentrum Berlin für Materialien und Energie — [2]National Synchrotron Radiation Laboratory, university of Science and Technology of China, — [3]Fakultät für Physik, Technische Universität München,

Lead halide perovskites are new key materials in various application areas such as high efficiency photovoltaics, lighting, and photodetectors. Doping with Mn, which is known to enhance the stability, has recently been reported to lead to ferromagnetism below 25 K in methylammonium lead iodide (MAPbI3) mediated by superexchange. Two most recent reports confirm ferromagnetism up to room temperature but mediated by double exchange between Mn2+ and Mn3+ ions. Here we investigate a wide concentration range of MAMnxPb1*xI3 and Mn-doped triple-cation thin films by soft X-ray absorption, X-ray magnetic circular dichroism, and quantum interference device magnetometry. The X-ray absorption lineshape shows clearly an almost pure Mn2+ configuration, confirmed by a sum-rule analysis of the dichroism spectra. A remanent magnetization is not observed down to 2 K. Curie-Weiss fits to the magnetization yield negative Curie temperatures. All data show consistently that significant double exchange and ferromagnetism do not occur. Our results show that Mn is not suitable for creating ferromagnetism in lead halide perovskites.

MA 41.10 Thu 17:30 H 2013

**Strong tuning of Rashba spin-orbit coupling and crossover from weak localization to weak antilocalization in ionic-gated tellurium** — •Dorsa Fartab[1], José Guimarães[1,2], Marcus Schmidt[1], and Haijing Zhang[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]School of Physics and Astronomy, University of St Andrews, St Andrews KY16 9SS, United Kingdom

Electrostatic control of the charger carrier density inside the solids is an important factor to realize different phase transitions in two-dimensional materials such as insulator-metal transition and superconductivity. Moreover, the gate control of electron spin in materials with high spin-orbit coupling (SOC) is a key factor in the field of spintronics. Here, I will first provide a brief overview of electric double layer transistors (EDLTs) and highlight the advantages of utilizing ionic liquids as the dielectric medium over conventional solid dielectrics; then, I will present our experimental results of ionic liquid gated p-type tellurium (Te). Our results show the possibility of gate tuning insulator-metal transition and the crossover from weak localization (WL) to weak antilocalization (WAL) into the sample, implying an increased Rashba-like SOC in the material created by a strong electric field restricted to the solid/electrolyte interface in EDLTs. More interestingly, we have demonstrated the ability to control the electron spin and amplify the Rashba parameter by a factor of 4 through ionic gating Te, which could have potential applications in the field of spintronics.