MA 29: Spintronics (incl. quantum dynamics) (jointly with HL, TT)

Time: Wednesday 9:30–12:15 Location: H32

MA 29.1 Wed 9:30 H32

Valley polarization in magnetically doped single-layer transition-metal dichalcogenides — •Udo Schwingenschlögl, Yingchun Cheng, and Qingyun Zhang — PSE Division, KAUST, Thuwal 23955, Saudi Arabia

We demonstrate that valley polarization can be induced and controlled in semiconducting single-layer transition-metal dichalcogenides by magnetic doping, which is important for spintronics, valleytronics, and photonics devices. As an example, we investigate Mn-doped MoS_2 by first-principles calculations. We study how the valley polarization depends on the strength of the spin orbit coupling and the exchange interaction and discuss how it can be controlled by magnetic doping. Valley polarization by magnetic doping is also expected for other honeycomb materials with strong spin orbit coupling and the absence of inversion symmetry. Reference: Phys. Rev. B **89**, 155429 (2014).

MA 29.2 Wed 9:45 H32

Giant Rashba-type spin splitting in ferroelectric GeTe(111) — •Marcus Liebmann[1], Christian Rinaldi[2], Domenico Di Sante[3], Jens Kellner[1], Christian Pauly[1], Rui Ning Wang[4], Jos Emiel Boschker[4], Alessandro Guissani[4], Stefano Bertoli[2], Matteo Cantoni[2], Lorenzo Baldrati[2], Marco Asa[2], Ivana Vobornik[5], Giancarlo Panaccione[5], Dmitry Marchenko[6], Jaime Sanchez-Barriga[7], Oliver Rader[7], Raffaella Calarco[4], Silvia Picozzi[3], Riccardo Bertacco[2], and Markus Morgenstern[1] — [1]II. Inst. Phys. B, RWTH Aachen University — [2]Politecnico di Milano, Italy — [3]Consiglio Nazionale delle Ricerche, L'Aquila, Italy — [4]Paul-Drude-Institut für Festkörperelektronik, Berlin — [5]Consiglio Nazionale delle Ricerche, Trieste, Italy — [6]Physikalische und Theoretische Chemie, Freie Universität Berlin — [7]Helmholtz-Zentrum für Materialien und Energie, BESSY, Berlin

The ferroelectric semiconductor GeTe has been proposed to exhibit a giant spin splitting of bulk Rashba bands with spin rotation direction coupled to the dielectric polarization [1]. We probe GeTe(111) grown by MBE using in-situ angular-resolved photoelectron spectroscopy (ARPES). We identify a novel Rashba-split surface band with giant spin splitting and find signatures of the bulk Rashba band by comparison with density functional theory calculations [2]. The ferroelectric polarization, as determined by piezo force microscopy, agrees with the predicted helical spin-momentum relation of the Rashba bands.

[1] D. Di Sante *et al.*, Adv. Mater. **25**, 509 (2013).

[2] M. Liebmann *et al.*, Adv. Mater. 2015, 10.1002/adma.201503459.

MA 29.3 Wed 10:00 H32

Spin Mapping of Surface and Bulk Rashba States in Ferroelectric α-GeTe(111) Films — •H. J. Elmers[1], R. Wallauer[1], M. Liebmann[2], J. Kellner[2], M. Morgenstern[2], R.N. Wang[3], J.E. Boschker[3], R. Calarco[3], O. Rader[4], D. Kutnyakhov[1], S.V. Chernov[1], K. Medjanik[1], C. Tusche[5], M. Ellguth[5], H. Volfova[6], J. Braun[6], J. Minar[6], H. Ebert[6], and G. Schönhense[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]II. Physikalisches Institut B and JARA-FIT, RWTH Aachen — [3]Paul-Drude-Institut für Festkörperelektronik, Berlin — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin — [5]Max Planck Institute for Microstructure Physics, Halle — [6]Department Chemie, Ludwig-Maximilians-Universität München

Ferroelectric semiconductors like GeTe promise a switchable Rashba-parameter for electronic bulk states. A comprehensive mapping of the spin polarization of the electronic bands in α-GeTe(111) films has been performed using a time-of-flight momentum microscope equipped with an imaging spin filter that enables a simultaneous measurement of more than 10.000 data points. In addition to the Rashba type splitting of surface bands we observe a spin splitting of bulk bands with opposite spin helicity of the inner and outer Rashba bands revealing the complex spin texture at the Fermi energy that determines electronic transport.

MA 29.4 Wed 10:15 H32

Optically and thermally driven spin dynamics and quantum Otto cycles on Ni_4 structures — •Stefan Sold[1], Bhaskar Kamble[2], Georgios Lefkidis[1], and Wolfgang Hübner[1] — [1]Departement of physics, University of Kaiserslautern and Research Center OPTIMAS, Germany — [2]Asia Pacific Center for Theoretical Physics, Pohang, Korea

We present two different kinds of combined optical and thermodynamic processes on the chain-like prototypical Ni_4 cluster, described on the basis of high-level quantum chemistry. The one consists of incoherent spin relaxation and thermalization processes, the other one of a nano Otto engine.

First, we model various temperature profiles by coupling to one or two temperature baths. The system dynamics is mathematically described with the Lindblad superoperator [1]. We find that the inhomogeneous temperature profile, giving rise to non-equilibrium mixed states, induces non-uniform spin-density distribution (spin Seebeck effect on the nano scale).

Second, we propose a quantum Otto motor [2], which benefits from the spin degree of freedom and the energy discretization of the cluster, and may thus surpass the efficiency limit of classical Carnot cycles [3].

[1] G. Schaller and T. Brandes, Phys. Rev. A **78**, 022106 (2008)

[2] W. Hübner, G. Lefkidis, C. D. Dong, D. Chaudhuri, L. Chotorlishvili, and J. Berakdar, Phys. Rev. B **90**, 024401 (2014)

[3] C. D. Dong, G. Lefkidis, and W. Hübner, Phys. Rev. B **88**, 214421 (2013)

MA 29.5 Wed 10:30 H32

Theoretical aspects of the Edelstein effect for anisotropic 2DEGs and topological insulators — •Annika Johansson[1,2], Dmitry Fedorov[1,2], Jürgen Henk[2], and Ingrid Mertig[2,1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

A charge current driven through a two-dimensional electron gas (2DEG) with Rashba spin-orbit coupling [1] generates a spatially homogeneous spin polarization perpendicular to the applied electric field. This phenomenon is the Edelstein effect [2].

For selected model systems, we consider the Edelstein effect within the semiclassical Boltzmann transport theory. Its energy dependence is investigated, in particular the regime below the Dirac point of the 2DEG. In addition to an isotropic 2DEG [1], we analyze systems with anisotropic Fermi contours. We predict that the current-induced spin polarization vanishes if the Fermi contour passes through a Lifshitz transition. In addition, we corroborate that topological insulators provide a very efficient conversion of charge to spin current [3].

Our findings for paradigmatic Rashba systems call for experimental verification.

[1] Y. Bychokov and E. Rashba, J. Phys. C, **17**, 6039 (1984) [2] V. M. Edelstein, Solid State Commun., **73**, 233 (1990) [3] J. C. Rojas Sánchez *et al.*, ArXiv: 1509.02973 (2015)

15 min. break

MA 29.6 Wed 11:00 H32

Spin superfluidity and long-range transport in thin-film ferromagnets — Hans Skarsvåg, •Cecilia Holmqvist, and Arne Brataas — Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

In ferromagnets, magnons may condense into a single quantum state. Analogous to superconductors, this quantum state may support transport without dissipation. Recent works suggest that longitudinal spin transport through a thin-film ferromagnet is an example of spin superfluidity. Although intriguing, this tantalizing picture ignores long-range dipole interactions; here, we demonstrate that such interactions dramatically affect spin transport. In single-film ferromagnets, "spin superfluidity" only exists at length scales (a few hundred nanometers in yttrium iron garnet) somewhat larger than the exchange length. Over longer distances, dipolar interactions destroy spin superfluidity. Nevertheless, we predict the re-emergence of spin superfluidity in tri-layer ferromagnet-normal metal-ferromagnet films that are ~1 micrometre in size. Such systems also exhibit other types of long-range spin transport in samples that are several micrometers in size.

MA 29.7 Wed 11:15 H32

Ultra-long electron and hole spin lifetimes in monolayer WSe_2 — Sammy Pissinger, •Robin de Winter, Christopher

Franzen, Manfred Ersfeld, Sebastian Kuhlen, Christoph Stampfer, and Bernd Beschoten — 2nd Institute of Physics and JARA-FIT, RWTH Aachen University, Germany

There is strong interest in optical generation and detection of valley spin polarizations in transition metal dichalcogenides. We report on time-resolved two color pump probe Kerr rotation measurements on mechanically exfoliated monolayer WSe_2 crystals. We find electron and hole spin lifetimes of up to 100 ns at low temperatures. These values are in good agreement with exciton lifetimes extracted from all-optical time-resolved reflectivity indicating that the spin lifetimes are limited by exciton recombination times in our crystals. Electron spin precession in Voigt geometry furthermore reveals inhomogeneous spin dephasing caused by a large spread in the local g factors.

MA 29.8 Wed 11:30 H32

Bulk Spin-Orbit Torques at finite temperatures in Bulk Half-Metallic Heuslers from First Principle — •Jacob Gayles[1], Libor Šmejkal[2], Jakub Železny[2], Frank Freimuth[3], Zhe Yuan[1], Yuriy Mokrousov[3], Tomas Jungwirth[2], and Jairo Sinova[1] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, D-55099 Mainz, Germany — [2]Institute of Physics ASCR, v.v.i., Cukrovarnicka 10, 162 53 Praha 6 Czech Republic — [3]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

We predict bulk spin-orbit torques in the half-metallic Heuslers NiMnSb and PtMnSb, using symmetry arguments in conjunction with first principle calculations. We present under uniaxial growth strain a linear dependence of the even torque and that can be tuned to zero while observing a sizable odd torque is independent of strain. Furthermore, these effects are seen to be two orders of magnitude larger in the PtMnSb. The even torque is strongly dependent on the temperature decreasing by 75% at room temperature where finite temperature is taken into account in the frozen phonon approximation. We show the equivalence of two widely used methods, the Landauer-Bütikker and the Kubo linear response formalism giving confidence in our result for experimental measurements in bulk magnetic Heusler compounds breaking inversion symmetry.

MA 29.9 Wed 11:45 H32

Dynamics of bound monopoles in artificial spin ice: How to store energy in Dirac strings. — •Elena Vedmedenko — University of Hamburg, Hamburg, Germany

Dirac strings in spin-ices are lines of reversed dipoles joining two quasi-particle excitations. These excitations behave themselves as unbound emergent monopoles if the tension of Dirac strings vanishes. In this work analytical and numerical analysis are used to study dynamics of two-dimensional dipolar spin ices, artificially created analogs of bulk spin-ice, in the regime of bound monopoles. It is shown that in this regime strings rather than monopoles are effective degrees of freedom explaining the finite-width band of Pauling states. A measurable prediction of path-time dependence of endpoints of stretched and then released Dirac string is made and verified via simulations. It is shown that string dynamics is defined by the characteristic tension-to-mass ratio, which is determined by the fine structure constant and lattice dependent parameter. It is proposed to use string tension to achieve spontaneous magnetic currents. A concept of energy storing device on the basis of this principle is proposed and illustrated by an experimental demonstration. A scheme of independent measurement at the nanoscale is proposed.

MA 29.10 Wed 12:00 H32

Spin-orbit torque in antiferromagnets — •Jakub Zelezny[1], Frank Freimuth[2], Yuriy Mokrousov[2], Jacob Gayles[3], Jairo Sinova[3], and Tomas Jungwirth[3] — [1]Institute of Physics of the Czech Academy of Sciences, Czech Republic — [2]Forschungszentrum Julich and JARA, Germany — [3]Institut fur Physik, Johannes Gutenberg Universitat Mainz, Germany

Antiferromagnets are common in nature and just like ferromagnets posses a long-range magnetic order. Unlike ferromagnets though, they have found little practical applications so far, primarily due to their lack of total magnetization. However, development of spintronics opens up ways how they could be used. Antiferromagnets have some advantages over ferromagnets, in particular ultrafast magnetization dynamics and wide range of materials available, including many semiconductors. One of the key problems for application of antiferromagnets in spintronics remains manipulation of the spin-axis. Recently we have predicted that in some bulk antiferromagnets, electrical current can effectively manipulate the magnetic moments [1]. Switching of an antiferromagnet using this method have recently been observed experimentally [2]. The effect is analogous to the spin-orbit torque in ferromagnets. Here we discuss the symmetry of the torques, especially the necessary conditions for their existence and show results of microscopic calculation of the torques in various antiferromagnets.

[1] J. Železný et al., PRL 113 (15), 157201 [2] P. Wadley et al., Science, to be published, arXiv:1503.03765