MA 54: Spin: Transport, Orbitronics and Hall Effects II

Time: Thursday 15:00–17:45 Location: HSZ 403

MA 54.1 Thu 15:00 HSZ 403

Temperature dependence of the Spin-Charge Conversion in Highly-doped π-conjugated Polymer PBTTT — •Mohammad Qaid[1], Olga Zadvorna[2], Henning Sirringhaus[2], and Georg Schmidt[1] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle — [2]Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom

We present an intensive study addressing the temperature dependence of the spin-to-charge conversion in highly doped π-conjugated polymer PBTTT. The polymer is deposited on a ferrimagnetic YIG thin film and doped with F4TCNQ [1]. In ferromagnetic resonance a spin current is injected from the YIG into the PBTTT and the ISH-voltage is measured in the organic semiconductor. We have performed an ISHE thickness-dependence study at low temperatures which provides insight into the spin relaxation mechanisms in PBTTT. This study enabled us to extract some of the key parameters of the spin relaxation in highly-doped PBTTT, namely spin diffusion length and spin relaxation time. Our results indicate that the spin relaxation in PBTTT can be explained by Elliot-Yafet mechanism. Besides that, the change of the spin life-time with temperature indicates that the spin is more likely conserved in the hopping events and the spin flip occurs at the thermally reduced trapping events.

References [1]- Wang, Shu-Jen, et al, Nature Electronics 2, 98-107(2019)

MA 54.2 Thu 15:15 HSZ 403

Paramagnetic molecules on Fe_3O_4 as a spin-current detector — •Tanja Strusch[1], Ralf Meckenstock[1], Yulia Nalench[2], Maxim Abakumov[2], Michael Farle[1], and Ulf Wiedwald[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany — [2]National University of Science and Technology NUST MISIS, Moscow, Russian Federation

Pure spin current based devices are considered for future low dissipation electronics. An interfacial molecular paramagnet has been used as a spin current detector (IMPSD) [1] as an alternative detection scheme for the inverse spin Hall effect [2]. We extended the IMPSD to enhance the sensitivity, by enclosing an electron spin resonance (EPR) marker to a ferromagnetic interface which has two overlapping distinguishable EPR centers. Thus, we detect the influence of the spin current on the EPR centers resulting in an additional contribution to the power dependence of the two EPR modes. The chosen sample system is a Fe_3O_4 nanoparticle (NP) with oleic acid (OA) as a surfactant. The first EPR mode S1 is directly located at the OA-Fe_3O_4 interface and the second S2 at the double bond in the carbon chain [1]. If the ferromagnetic resonance of the Fe_3O_4-NP is tuned to the resonance field of the EPR line S1 (short lifetime), the number of excited paramagnetic centers increased. Due to the larger lifetime of S2 the additional excitation of S1 leads to an even stronger excitation of S2.

[1] T. Marzi et al., Phys. Rev. Applied 10, 054002 (2018).
[2] E. Saitoh et al., Appl. Phys. Lett. 88, 182509 (2006).

MA 54.3 Thu 15:30 HSZ 403

Phenalenyl-based Organic Barriers for Tunnel Junctions — •Neha Jha[1], Christian Denker[1], Anand Pariyar[2], Pavan K. Vardhanapu[2], Heba S. Mohamad[1], Amir Azinfar[1], Arne Ahrens[3], Ulrike Martens[1], Christiane A. Helm[1], Michael Seibt[3], Swadhin K. Mandal[2], and Markus Münzenberg[1] — [1]Institut für Physik, Universität Greifswald, Germany — [2]Department of Chemical Sciences, IISER, Kolkata, India — [3]IV. Physikalisches Institut, Universität Göttingen, Germany

Phenalenyl (PLY) based molecules are appealing for spintronics as demonstrated by the formation of a spinterface, showing tunnel magneto-resistance close to room temperature [1].

Here, we compare different kinds of molecules (PLY, ZMP, PLY-Cu[2]) as barrier material. In addition, we introduce a new 3-D shadow mask technology allowing for junction sizes down to 3x6 μm^2. AFM and TEM imaging indicate sharp interfaces. Consequently, the current depends non-linearly on the voltage. The resistance depends exponentially on the barrier-thickness and shows no significant temperature dependence. This evidences tunneling as conduction mechanism. Magneto-resistive characteristics appear applying a few mV, while memristive properties require voltages in the volt range. Memristive resistance changes up to a factor of 2 are found for all three types of PLY, while magneto-resistive changes differ for the types of molecules and can also be as high as a factor of 2.

[1] K. V. Raman et al., Nature 493, p. 509 (2013)
[2] A. Mukherjee et al., J. Chem. Sci., 123, p. 139 (2011)

MA 54.4 Thu 15:45 HSZ 403

Conductivity and Hall effect in a ferromagnetic kagome metal Fe_3Sn_2 — •Lilian Prodan[1,2], Vladimir Tsurkan[1,2], and István Kézsmárki[1] — [1]EP V, EKM, University of Augsburg, D-86135 Augsburg, Germany — [2]Institute of Applied Physics, MD-2028 Chisinau, Moldova

Metallic ferromagnet Fe_3Sn_2 with a rhombohedral *R-3m* structure and a kagome lattice of Fe ions is promising to host massive Dirac fermionic states and topological magnon bands. We report the preparation, as well as magnetization, magnetoresistance and Hall effect measurements on Fe_3Sn_2 single crystals. The longitudinal resistivity ρ_{xx} shows a metallic behavior with a residual resistivity ratio ρ_{300K}/ρ_{2K} varying between 15 and 30, depending on the quality of samples. Both longitudinal and transverse magnetoresistance (MR) for magnetic fields H perpendicular to the *c*-axis are negative in the temperature range 305-50 K and become positive below 50 K. The transverse MR for H parallel to the *c*-axis is significantly higher than for the in-plane configuration and reaches 14% at 10 K in 9 T. The Hall effect measurements revealed a significant anomalous contribution at 300 K which decreases with decreasing of temperature. A quadratic dependence of the anomalous Hall resistivity on longitudinal resistivity was observed. The experimental data were analyzed with particular attention to intrinsic and extrinsic contributions to anomalous Hall conductivity related to Berry-phase and extrinsic mechanisms, respectively.

MA 54.5 Thu 16:00 HSZ 403

Spin orbit torques in Weyl semimetal /Ferromagnet and TMDC/ Ferromagnet bilayers — •Avanindra Kumar Pandeya, Amilcar Bedoya Pinto, Banabir Pal, Pranava Keerthi Sivakumar, Binoy Krishna Hazra, and Stuart Parkin — Max Planck Institute of Microstructure Physics

Weyl semimetals (WSMs) and Transition Metal Dichalcogenides (TMDCs) are two classes of quantum materials that are expected to have high spin-to-charge conversion efficiency. We have grown TaP/Py and NbSe2/Py bilayers using molecular beam epitaxy (MBE) which gives us precise control of the layer thickness and high-quality interfaces required for efficient spin transfer and spin-to-charge conversion experiments. In this work, we use the second harmonic Hall measurement to explore the spin-orbit torques (SOTs) produced by the WSMs and the TMDCs. We disentangle the different torque contributions by performing angular and field-dependent measurements in the bilayer devices, extracting the net spin-orbit torques related to effective charge-to-spin conversion efficiency in both material systems. Finally, we compare our results with the ones obtained by a different technique i.e. spin-torque ferromagnetic resonance (ST-FMR).

15 min. break.

MA 54.6 Thu 16:30 HSZ 403

New Interpretation of the High-field Magnetoresistance of Graphite — •Christian Eike Precker and Pablo David Esquinazi — Division of Superconductivity and Magnetism, Felix Bloch Institute, University of Leipzig, Leipzig, Germany.

The study of electrical properties in graphite shows that every sample exhibits differences between each other due to the contribution of 2D interfaces that are not homogeneously distributed. For thick enough samples, where the contribution of 2D interfaces always takes place, the magnetic field dependence shows qualitatively the same behavior, namely: at low fields the samples show a positive magnetoresistance, reaching a maximum at some field, which is sample dependent (normally between 15 T and 30 T). At fields above that maximum a negative magnetoresistance appears. At higher fields ($B \sim 40$ T), electronic phase transitions mounted on the negative magnetoresistance appear. With a parallel resistance model we can clarify several details of this complicated behavior. Our results indicate that the high conducting 2D interfaces are the main reason for the behavior observed in the high field magnetoresistance of graphite.

MA 54.7 Thu 16:45 HSZ 403

Record-breaking Magnetoresistance at the Edge of a Microflake of Natural Graphite — •Christian Eike Precker[1], José Barzola-Quiquia[1], Pablo David Esquinazi[1], Markus Stiller[1], Mun Chan[2], Marcelo Jaime[2], Zhipeng Zhang[3], and Marius Grundmann[3] — [1]Division of Superconductivity and Magnetism, Felix Bloch Institute, University of Leipzig, Leipzig, Germany. — [2]National High Magnetic Field Laboratory, Los Alamos National Laboratory, Los Alamos NM, USA. — [3]Semiconductor Physics Group, Felix Bloch Institute, University of Leipzig, Leipzig, Germany.

Using reactive ion etching on a micrometer-sized Sri Lankan natural graphite sample, sharp edges were created and several electrodes were placed parallel to the c axis at distances comparable to the size of the internal crystalline regions. Electrical transport measurements in this configuration revealed record values for the change of the resistance under applied magnetic field. At low temperatures and at $B \sim 21$ T the magnetoresistance (MR) reaches $\sim 10^7$ %. The MR values exceed by far all earlier reported ones for graphite and they are comparable or even larger (at $T > 50$ K) than the largest reported in solids including the Weyl semimetals. The origin of this large MR lies in the way the electrodes were build, sensing regions with the existence of highly conducting 2D interfaces aligned, parallel to the graphene planes.

MA 54.8 Thu 17:00 HSZ 403

Excitation of spin superfluids in easy-plane magnets — •Martin Evers and Ulrich Nowak — University of Konstanz, D-78457 Konstanz

It is long known that easy-plane magnets exhibit an order parameter with SO(2) symmetry, which is equivalent to the U(1) gauge symmetry of the macroscopic wave function of a Bose condensate. For small out-of-plane components the magnetic equations take then a form similar to the Gross-Pitaevski equation, describing the time evolution of a Bose condensate and, hence, superfluidity. Because of this very resemblance, there is a specific type of transport in such magnets called "spin superfluidity" [1-2]. It is characterized by a well defined precession frequency ω_0 for all spins and a spin accumulation that spans under ideal conditions over the entire magnet. ω_0 basically sets the strength of the spin-superfluid excitation, addressed in this talk.

In a first step we analytically estimate ω_0 of spin superfluids in easy-plane ferro- and antiferromagnets. The next step is use atomistic spin simulations to investigate the excitation with respect to changes in the driving strength and the geometry not covered by the analytical theory. We find that in particular the exact geometry of the excited magnet does play a major role on the resulting spin-superfluid response. However, ferro- and antiferromagnets behave in almost aspect very much alike, expect for a lower spin accumulation in antiferromagnets. [3]

[1] B. I. Halperin et al., Phys. Rev. **188**, 898 (1969)
[2] S. Takei et al., Phys. Rev. Lett. **112**, 227201 (2014)
[3] M. Evers et al., arXiv: 1911.12786

MA 54.9 Thu 17:15 HSZ 403

Origin of the Magnetic Spin Hall Effect: Spin Current Vorticity in the Fermi Sea — •Alexander Mook[1], Robin Richard Neumann[2], Annika Johansson[2], Jürgen Henk[2], and Ingrid Mertig[2,3] — [1]Department of Physics, University of Basel, CH-4056 Basel — [2]Institut für Physik, Martin-Luther-Universität, D-06120 Halle — [3]Max-Planck-Institut für Mikrostrukturphysik, D-06120 Halle

The interplay of spin-orbit coupling and magnetism gives rise to a plethora of charge-to-spin conversion phenomena that harbor great potential for spintronics applications. In particular, in addition to the spin Hall effect, magnets may exhibit a magnetic spin Hall effect [1,2].

Herein [3], we unveil the origin of the magnetic spin Hall effect and connect it to the spin current vorticity, i.e., to the tendency of the spin current to rotate, shear or curve in reciprocal space. This suggests the following illustrative explanation: Magnetic materials feature spin current whirlpools (or vortices) in reciprocal space for each of the three spin directions. Similar to water whirlpools (in real space), whose handedness leads to an asymmetric deflection of plane water waves, the spin current whirlpools (in reciprocal space) cause an asymmetric deflection of the respective spin components.

[1] J. Železný *et al.*, Phys. Rev. Lett. **119**, 187204 (2017); [2] M. Kimata *et al.*, Nature **565**, 627-630 (2019); [3] A. Mook, R. R. Neumann, A. Johansson, J. Henk, and I. Mertig, preprint arXiv:1910.13375

MA 54.10 Thu 17:30 HSZ 403

Magnetization dynamics in nanofiber networks — •Tomasz Blachowicz[1], Pawel Steblinski[1,2], Jacek Grzybowski[1], and Andrea Ehrmann[3] — [1]Silesian University of Technology, Institute of Physics - Center for Science and Education, 44-100 Gliwice, Poland — [2]Faculty of Electronics and Informatics, Koszalin University of Technology, 75-453 Koszalin, Poland — [3]Bielefeld University of Applied Sciences, Faculty of Engineering and Mathematics, Bielefeld, Germany

Magnetic nanofibers are of high interest for applications like data transport and storage as well as in basic research. Especially bent nanofibers, as they can unambiguously be produced by electrospinning [1], show a broad spectrum of possible magnetization reversal processes, depending on bending radius, geometry, magnetic field orientation, etc. [2].

Besides these quasistatic processes, dynamic investigations are necessary for investigating data transport properties of magnetic nanofibers. We report on domain wall transport through nanowires with different bending radii, starting from single nanowires to networks with multiple data inputs and outputs. Our results show diverse phenomena which have to be taken into account during these dynamic processes, such as domain wall instabilities or interference between converging signals, and suggest possible architectures of nanowire-based logics.

[1] C. Döpke, T. Grothe, P. Steblinski, M. Klöcker, L. Sabantina, D. Kosmalska, T. Blachowicz, A. Ehrmann, Nanomaterials 9, 92 (2019)
[2] T. Blachowicz, A. Ehrmann, J. Appl. Phys. 124, 152112 (2018)