HL 47: Spintronics (organized by MA)

Time: Tuesday 13:45–16:00 Location: HSZ 401

HL 47.1 Tue 13:45 HSZ 401

Sound Waves in a Magnon Bose Einstein Condensate — •Patryk Nowik-Boltyk[1], Oleksandr Dzyapko[1], Vladislav E. Demidov[1], Sergej O. Demokritov[1], Vasyl Tyberkevych[2], and Andrej N. Slavin[2] — [1]Institute of Applied Physics, University of Muenster, Muenster, Germany — [2]Department of Physics, Oakland University, Rochester, USA

Magnon Bose-Einstein condensation (mBEC) in Yttrium-Iron-Garnet films is a spectacular room-temperature macroscopic quantum phenomenon, which is under investigation since recently [1]. Although the basic properties of mBEC such as temporal [2] and spatial [3] coherence have extensively been studied during the last 5 years, the perturbed dynamics of the condensate have not been addressed so far. Here we report an experimental study of sound waves in a magnon gas, above and below the threshold for mBEC, performed using a space- and time-resolved Brillouin light scattering technique. The magnon gas was prepared using microwave pumping of magnons, while the sound waves were excited by, an additional, localized, oscillating, RF magnetic field. We show that at small wave vectors sound waves exhibit a linear dispersion law with a density independent group velocity, while at large wave vectors the dispersion changes from a linear dependence into a quadratic one at the threshold for mBEC. We demonstrate that this sudden change is due to an additional scattering mechanism that arises when an mBEC is formed. [1] S.O. Demokritov et al. Nature 443, 430 (2006) [2] V.E. Demidov et al. Phys. Rev. Lett. 100, 047205 (2008) [3] P. Nowik-Boltyk et al. Nature Sci. Rep. 2, 482 (2012)

HL 47.2 Tue 14:00 HSZ 401

Antiferromagnetic spintronics — •I. Fina[1,2], X. Marti[3,4,5], D. Yi[3], C. Rayan-Serrao[3], J. Liu[3], J.-H. Chu[3], S.J. Suresha[3], J. Zelezny[5], T. Jungwirth[5,6], J. Fontcuberta[3], and R. Ramesh[3] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, Halle Germany — [2]Institut de Ciencia de Materials de Barcelona, ICMAB-CSIC, 08193 Bellaterra, Spain — [3]Department of Materials Science and Engineering, University of California, Berkeley, CA 94720, USA — [4]Dept. Condensed Matter Physics Charles University in Prague — [5]Institute of Physics ASCR, v.v.i., Cukrovarnick 10, 162 53 Praha 6, Czech Republic — [6]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom

Magnetic semiconductors entwine two of the most successful concepts in both fundamental physics and industrial applications. Recently antiferromagnets have been proposed as new and atractive material systems. Antiferromagnetic spintronics have been demonstrated by the fabrication of tunnel devices, atomic-size proof-of concepts, even devices without auxiliary ferromagnetic layers. Here we present the control of the electrical conductivity of an antiferromagnetic semiconductor by manipulating the magnetic state of a contiguous ferromagnetic.

We present an oxide-based fully epitaxial heterostructure, its structural characterization and the electrical measurements showing a direct link between state of the ferromagnetic gate and ohmic resistance of the semiconductor, even displaying distinct remnant resistance states. We will also show that distinct remnant states can also been obtained at room temperature, promising potential applicability.

HL 47.3 Tue 14:15 HSZ 401

Calculating spin transport and magnetization dynamics parameters in textured magnetic materials — •Zhe Yuan — Faculty of Science and Technology, University of Twente, Enschede, The Netherlands — Institute of Physics, Johannes Gutenberg-University Mainz, Mainz, Germany

First-principles calculations allow us to understand the electronic and magnetic properties of real materials in terms of their chemical composition, atomic structure and magnetic configuration by numerically solving the quantum mechanical equations that describe the motion of the electrons. We have developed a unique first-principles formalism of scattering theory that can be used to calculate quantities such as the resistivity, Gilbert damping, and spin-transfer torque for a wide variety of material systems. In this talk, I will focus on how magnetic domain walls (DWs) modify the above transport and magnetization dynamics properties in real materials. Taking the technologically important Ni80Fe20 magnetic alloy, as an example, we have studied the change in its resistance due to the presence of a DW. The Gilbert damping in a DW is found to be anisotropic and drastically enhanced by the magnetization gradient, which has significant effects on field- and/or current-driven DW motion.

HL 47.4 Tue 14:30 HSZ 401

Spin Solar Cell for Spin Injection into Semiconductors. — Bernhard Endres, Mariusz Ciorga, Maximilian Schmid, Martin Utz, Dominique Bougeard, Dieter Weiss, Christian Back, and •Günther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg

Optical spin pumping allows to create spin-polarized carriers in III-V semiconductors, but requires circularly polarized light of a well-defined wavelength. Here we describe a spin-generating solar cell without such limitations [1,2]. The device consists of a p-n junction with highly n-doped GaAs at the n-side and ferromagnetic (Ga,Mn)As at the p-side. Illuminating this junction creates a photo-voltage causing electrons to tunnel across the narrow barrier from the n-GaAs into the (Ga,Mn)As. Due to the spin-dependent tunneling probability a spin accumulation occurs in the n-GaAs. This spin solar cell effect is demonstrated with a laser beam generating electron-hole pairs and detecting the spin accumulation via the polar magneto-optic Kerr effect and by measuring non-local voltages. On applying a large negative bias the sign of the photo-induced spin polarization is reversed as expected due to the suppression of the tunneling current through a wider barrier. This mode of operation corresponds to a spin photodiode. The spin solar cell effect should equally work for metallic ferromagnets with a high Curie temperature and allow to convert unpolarized light into a spin current also in semiconductors without a direct band gap like Si and Ge.

[1] B. Endres et al., Nature Commun. 4, 2068 (2013).
[2] R. Jansen, Nature Mater. 12, 779 (2013)

HL 47.5 Tue 14:45 HSZ 401

Magnetic anisotropy in CoFe/MgO/CoFe magnetic tunnel junctions with ultrathin electrode layers and its composition dependence — •Jia Zhang, Christian Franz, Michael Czerner, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University, Giessen, Germany

MgO based magnetic tunnel junctions (MTJs) with ultrathin CoFeB magnetic electrodes can have perpendicular magnetic anisotropy and a low switching current. In addition, MgO-MTJs with perpendicular anisotropy may also be easier to switch by thermal spin transfer torque and may pave its potential application in Spincaloritronics. In this talk, the magnetic anisotropy in CoFe/MgO/CoFe-MTJs on different substrates for instance Cu, Au, MgO etc. and different CoFe alloy composition are discussed using full relativistic Korringa-Kohn-Rostoker and coherent potential approximation (CPA) first-principles calculations. The magnetic anisotropy energy (MAE) in CoFe/MgO/CoFe-MTJs was calculated by employing magnetic force theory. The calculated MAE in Co_xFe_{1-x}/MgO/Co_xFe_{1-x}-MTJs decreased with the increasing of Co composition. The $d_{zx}(d_{yz})$ and $d_{xy}(d_{x^2-y^2})$ orbital and its evolution in the spin down channel was found to be responsible for the rise of magnetic anisotropy and the composition dependence. The shape anisotropy energy was also calculated and thus the phase diagram with perpendicular anisotropy versus composition and thickness was determined. Finally, we will give a brief discussion on magneto resistance and spin-transfer torque in CoFe/MgO/CoFe-MTJs with perpendicular easy axis.

HL 47.6 Tue 15:00 HSZ 401

Magnetic and electronic properties of $Ni_2S_2O_2N_6C_{57}H_{78}P^+$ on Au(111) — •Kai Trepte, Claudia Martin, and Jens Kortus — Institute of Theoretical Physics, TU Bergakademie Freiberg, Germany

The electronic and magnetic properties of a Ni^{2+} dimer including a PPh_3- ligand in contact with a Au(111) surface have been measured [1]. We will present theoretical calculations using DFT (with and without van der Waals interactions) including only the PPh_3- ligand binding on the Au(111) surface in order to determine the magnetic exchange and anisotropy. We will discuss charge transfer and the bonding situation for the favored binding position in more detail. Finally we will compare these results with a calculation of the dimer on the surface including geometry changes and charge transfer.

[1] M. Golecki et al. Chemisorption of exchange-coupled $[Ni_2L(dppba)]^+$ complexes on gold by using ambidentate 4-(diphenylphosphino)benzoate co-ligands. *Chemistry - A European Journal*, 19(24):7787-7801, 2013.

HL 47.7 Tue 15:15 HSZ 401

Manipulating the coupling between metal and molecule in hybrid structures by changing of organic anchor groups — •Simon Liebing, Torsten Hahn, and Jens Kortus — Institut of Theoretical Physics, TU Bergakademie Freiberg, 09599 Freiberg

There are theoretical and experimental works which propose to the use of amino anchor groups [1] instead of the more often used thiol [2] ones. So far there is no systematic study comparing the properties of different anchor groups. The present study investigates the properties of amino, cyano, furan, hydroxyl, pyrol thiol and thiophen in a break junction like geometry. The anchor groups are attached to a novel molecular system based on an anthraquinone-core with conjugated spacers to form a model system. These anchor groups include also some that could form π-like bonds and allow fully and cross-conjugated electron systems.

The molecular structures are constructed with Avogadro [3] and optimized by all-electron DFT-code NRLMOL [4]. The device structures are than optimized with the GPAW program package [5] an plane wave augmented wave again. The same software is used for the calculation of the transport properties by means of the NEGF-formalism.

References

1 Angela. D. et. al. Nano Letters 10, no. 7 (2010), 2 Markussen, T. et al. JCP 132 , 224104 (2010), 3 Hanwell, M. D. et al. Journal of Cheminformatics 4, 17 (2012), 4 Pederson, M. et. al. Phys. Status Solidi b 217, 197. (2000), 5 Enkovaara, J. et al. Journal of Physics: Condensed Matter 22, 253202 (2010)

HL 47.8 Tue 15:30 HSZ 401

Barrier dependent tunneling magnetoresistance in carbon nanotubes — •Carola Meyer[1,2], Cate Morgan[1,2], Dominik Metten[3], Sebastian Heedt[1,2], Thomas Schäpers[1,2], and Claus M. Schneider[1,2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technologies — [3]Institut de Physique et Chimie des Matériaux de Strasbourg and NIE, UMR 7504, Université de Strasbourg and CNRS, France

Carbon nanotubes (CNTs) are a material of interest in spintronics, because in addition to exhibiting ballistic transport, the low atomic number and low abundance of ^{13}C nuclei in CNTs is expected to lead to low spin orbit coupling and hyperfine interaction indicating a long spin relaxation time. However, the size of the magnetoresistance (MR) observed depends strongly on the current regime and on the type of CNT device measured. In the single-electron-tunneling regime, typically only a few percent MR can be reached. MR in multiwalled CNTs with a large diameter has shown to be as large as 60% for contacts with high polarization [1].

We present a way to compare the MR of different devices from single-wall and multiwalled CNTs with respect to the current regime. Temperature dependent data confirm tunneling MR as the main effect. The size of the MR measured depends on the strength of the tunnel barrier and follows the Slonczewski model. Finally, the presence of the Hanle effect proves successful spin injection.

[1] L. E. Hueso et al., Nature 445, 410 (07)

HL 47.9 Tue 15:45 HSZ 401

Transport properties of multiferroic tunnel junctions in an embedded Green-function approach — •Andera Neroni, Daniel Wortmann, Ersoy Sasioglu, Stefan Blügel, and Marjana Ležaić — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Multiferroics tunnel junctions are promising structures for spintronic devices due to their transport properties. From the theoretical point of view the study of transport in Metal/Ferroelectric/Metal needs to deal with several degrees of freedom. Structural distortions at the interface, polarization and magnetization directions, presence of oxides at the interface and strong correlations must be taken into account. We focus on the tunneling properties of a Fe/BTO/Fe barrier obtained in an embedded Green-function approach [1] implemented with the framework of the full-potential linearized augmented plane-wave (FLAPW) method `FLEUR` [2]. Electronic charge self-consistency is achieved in the same approach. Strong correlations are taken into account employing the LDA+U approach within the framework of the density functional theory (DFT) with a Hubbard U parameter determined by constrained random phase approximation (cRPA) [3].

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[1] www.flapw.de
[2] D. Wortmann, H. Ishida, and S. Blügel, PRB **65**, 165103 (2002)
[3] E. Şaşıoğlu, C. Friedrich, and S. Blügel, PRB **83**, 121101(R) (2011)