MA 45: Spin-dependent Transport Phenomena II

Time: Thursday 15:00–18:00 Location: H 0112

MA 45.1 Thu 15:00 H 0112

D'yakonov-Perel' spin dephasing in metallic films — •N. H. Long, P. Mavropoulos, D. S. G. Bauer, B. Zimmermann, Y. Mokrousov, and S. Blügel — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The D'yakonov-Perel' mechanism for spin dephasing of conduction electrons is prominent in systems with broken space-inversion symmetry, where spin-orbit coupling induces a **k**-dependent Zeeman-type field, the *spin-orbit field* $\mathbf{\Omega_k}$. The electron spin precesses around $\mathbf{\Omega_k}$, while momentum scattering into a different state $\mathbf{k}'$ results in a new precession axis $\mathbf{\Omega_{k'}}$, eventually leading to spin dephasing. The mechanism is well-studied in semiconductors but not in metals that usually have inversion symmetry, which is, however, lifted in metallic films deposited on a substrate.

In this work we employ density-functional theory and a linear response approach for the calculation of the spin-orbit fields in supported metallic films typically used in spintronics, such as Au(111) or Pt(111). A kinetic equation is applied to derive the dephasing time that is found to be smaller than the Elliott-Yafet spin-relaxation time, e.g., 100 ns in 24-layer Au(111) films with self-adatom impurities. We discuss the importance of the mechanism in systems of varying film thickness and impurity concentration.

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MA 45.2 Thu 15:15 H 0112

Description of magneto-optics of disordered alloys from first principles — •Kristina Chadova[1], Rudolf Sykora[2], Dominik Legut[2], Diemo Ködderitzsch[1], Hubert Ebert[1], and Jan Minár[1,3] — [1]Department of Chemistry, Physical Chemistry, Ludwig-Maximilians University Munich, Germany — [2]Nanotechnology Centre VSB - Technical University of Ostrava, 17. Listopadu 15/2172, 708 33 Ostrava-Poruba, Czech Republic — [3]NewTechnologies-Research Center, University of West Bohemia, Pilsen, Czech Republic

The optical properties of pure - as well as disordered - alloys have received a lot of interest as they play an important role, for example in storage applications. We present a first-principle approach to calculate magneto-optical properties based on the Kubo formula implemented within the fully relativistic KKR (Korringa-Kohn-Rostoker) formalism in combination with coherent potential approximation accounting for chemical disorder in substitutional random alloys. The implemented formalism allows to calculate the full frequency dependent conductivity tensor and to discuss on this basis the magneto-optical effects. The first results will be presented for ferromagnetic transition metal alloys.

MA 45.3 Thu 15:30 H 0112

Compton profiles of random $Fe_{0.5}Ni_{0.5}$ alloy, evidence for the interplay of disorder and correlation in momentum space — •Liviu Chioncel[1,2], Diana Benea[3,4], Hubert Ebert[4], and Jan Minar[4,5] — [1]Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D - 86135 Augsburg, Germany — [2]Augsburg Center for Innovative Technologies, University of Augsburg, D-86135 Augsburg, Germany — [3]Faculty of Physics, Babes-Bolyai University, Kogalniceanustr 1, Ro-400084 Cluj-Napoca, Romania — [4]Chemistry Department, University Munich, Butenandstr. 5-13, D-81377 München, Germany — [5]New Technologies - Research Center, University of West Bohemia, Univerzitni 8, 306 14 Pilsen, Czech Republic

We study the magnetic Compton profile of the disordered $Fe_{50}Ni_{50}$ alloy and discuss the interplay between structural disorder and electronic correlations. The disorder distribution is described within the Coherent Potential Approximation while local electronic correlations are captured with the Dynamical Mean Field Theory. The disorder induced changes in the experimental magnetic Compton profiles are well described by the theoretical calculations only when both components Fe and Ni are subject to considerable electronic correlations.

MA 45.4 Thu 15:45 H 0112

Current Induced Domain Wall Depinning in Non-Local Spin Valve Half Ring Structures — •Alexander Pfeiffer[1], William Savero Torres[2], Nils Richter[1], Laurent Vila[2], Jean Philippe Attané[2], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]Institut Nanosciences et Cryogénie, Université Grenoble Alpes & CEA, France

We demonstrate current induced domain wall depinning and phase transitions in non-local spin valve Permalloy/Aluminium half ring structures. With our optimized geometry by patterning a notch acting as a pinning center in one half ring, we are to able study the influence of Oersted fields, Joule heating and the spin transfer torque. We find a complete depinning event at zero applied external field for a charge current density of 600 GA/m^2, showing that our geometry can be used for low power domain wall manipulation.

MA 45.5 Thu 16:00 H 0112

Electronic transport from ab-inito linear response – a generalized Kubo-Bastin approach — •Diemo Ködderitzsch, Kristina Chadova, and Hubert Ebert — Department Chemie, Ludwig-Maximilians-Universität, 81377 München, Germany

Starting from a Kubo-Bastin like linear response expression we present a general approach to describe various linear response phenomena from ab-inito. Within a fully relativistic KKR framework in a spin-density functional formulation we treat among other things the full (spin-) conductivity tensor including its antisymmetric components and thereby spin-orbit induced transverse transport phenomena like the spin- and anomalous Hall effects. Both Fermi-sea and Fermi-surface terms are described on the same footing. Employing the coherent potential approximation allows to treat, besides pure systems, disordered alloys through the whole concentration range. Within this approach intrinsic as well as extrinsic contributions are fully accounted for without any model assumptions. In this context the role of vertex corrections and their importance will be discussed. Applications to transition-metals and their alloys will be presented.

15 min. break

MA 45.6 Thu 16:30 H 0112

Transverse transport and magneto-optical properties of noncollinear antiferromagnets — •Sebastian Wimmer, Ján Minár, Sergiy Mankovsky, Diemo Ködderitzsch, and Hubert Ebert — Ludwig-Maximilians-Universität München, München, Deutschland

Recently, a number of investigations on the anomalous Hall effect (AHE) in materials having nontrivial spin structures, such as noncollinear antiferromagnets, have been performed [1-4]. One especially striking result is the prediction of the AHE for a system with zero net magnetization [3]. We revisit and extend these studies employing a combined group theoretical and first principles approach.

Based exclusively on symmetry considerations the occurence of transverse transport and related optical effects for a given magnetic order of a solid can be predicted. Numerical studies using a first principles electronic structure method in the framework of Korringa-Kohn-Rostoker (KKR) multiple scattering theory and subsequent calculation of response quantities using a Kubo-type linear response formalism are performed to independently cross-check the group theoretical predictions. Our results in part confirm previous findings and furthermore give first numerical estimates of the magnitude of magneto-optical properties experimentally not observed so far.

[1] S. Yoshii, S. Iikubo, T. Kageyama, K. Oda, Y. Kondo, K. Murata, and M. Sato, JPSJ **69**, 3777 (2000). [2] T. Tomizawa and H. Kontani, PRB **82**, 104412 (2010). [3] H. Chen, Q. Niu, and A. H. MacDonald, PRL **112**, 017205 (2014). [4] J. Kübler and C. Felser, arXiv:1410.5985 [cond-mat.mtrl-sci] (2014).

MA 45.7 Thu 16:45 H 0112

Sign change in tunnel magnetoresistance of Fe_3O_4/MgO/CoFeB magnetic tunnel junctions depending on annealing temperature and interface treatment — Luca Marnitz[1], Karsten Rott[1], Stefan Niehörster[1], Christoph Klewe[1], Daniel Meier[1], Savio Fabretti[1], Matthäus Witziok[2], Andreas Krampf[2], Olga Schuckmann[2], Tobias Schemme[2], Karsten Kuepper[2], Joachim Wollschläger[2], Andy Thomas[1], Günter Reiss[1], and •Timo Kuschel[1] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]Physics Department, Osnabrück University, Germany

Magnetite (Fe_3O_4) is a promising candidate for magnetic tunnel junc-

tions (MTJs) since it shows a high spin polarization at the Fermi level as well as a high Curie temperature of 585°C. However, MTJs with magnetite electrodes have not shown a large tunnel magnetoresistance (TMR) so far. It is reported in literature for magnetite on MgO that Mg^{2+} ions diffuses into the magnetite at growth temperatures above 250°C, replacing parts of the Fe^{2+} ions. In typical magnetite MTJs MgO is used both as substrate as well as barrier material.
In this study, a sign change in the TMR of Fe_3O_4/MgO/CoFeB MTJs is observed after annealing at temperatures between 200°C and 280°C which can be explained by Mg interdiffusion from the MgO barrier into the magnetite. Additionally, different treatments of the magnetite interface during the preparation of the MTJs have been studied regarding their effect on the performance of the MTJs. A maximum TMR of up to -12% was observed despite exposing the magnetite surface to atmospheric conditions prior to the deposition of the MgO barrier.

MA 45.8 Thu 17:00 H 0112

Tunneling Anisotropic Magnetoresistance in oxide heterostructures — •Nico Homonnay[1], Johannes Lotze[1], Robert Göckeritz[1], Alexander Müller[1], Tim Richter[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany

We have investigated tunneling anisotropic magnetoresistance (TAMR) [1] in hybrid structures consisting of an epitaxial stack of a ferromagnetic oxide ($La_{0.7}Sr_{0.3}MnO_3$, LSMO) and an oxide tunnel barrier ($SrTiO_3$, STO) fitted with a non-magnetic metal contact. The oxide stack was deposited by pulsed laser deposition and metallization was done without breaking UHV conditions using various metals for different samples. The layers were processed to vertical tunneling devices with lateral dimensions of approx. 10 μm and the devices were investigated at low temperature in a 4He bath cryostate equipped with a 3D vector magnet. In all devices we observe TAMR which strongly depends on temperature, bias voltage and thickness of the tunnel barrier. The TAMR signal can be larger than 50 % which is more than 10 times bigger than reported for inorganic systems [1]. The magnetoresistance is clearly identified as TAMR by in-plane magnetic field sweeps at different angles. The TAMR signal persists up to a bias voltage of approx. 1 V and up to a temperature of 240 K which is well below the Curie temperature of the LSMO. [1] Gould et al., Phys. Rev. Lett. 93, 117203 (2004)

MA 45.9 Thu 17:15 H 0112

Spin-dependent Fano effect and two-stage Kondo effect in T-shaped double quantum dots with ferromagnetic leads — •Krzysztof P. Wójcik and Ireneusz Weymann — Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland

We analyze the influence of ferromagnetism of the leads on the transport properties of T-shaped double quantum dots. The calculations are performed by using the numerical renormalization group method. We focus on two particularly interesting phenomena occurring in such systems: the Fano-like interference causing a strong antiresonance in the dependence of the linear conductance on the gate voltage, and the two-stage Kondo effect. The latter effect is related with a nonmonotonic dependence of the linear conductance on temperature T: with lowering T below the Kondo temperature the conductance is first enhanced, but then at the second stage it becomes suppressed due to the formation of spin singlet state between two singly occupied quantum dots. We find that spin-resolved tunneling can suppress the second stage of the Kondo effect for appropriately chosen dots' energy levels. Moreover, we show that the presence of ferromagnets results in spin-dependent conditions for the Fano destructive interference, which gives the possibility of tuning the spin polarization of the linear conductance in the range $[-1, +1]$.

MA 45.10 Thu 17:30 H 0112

The influence of Coulomb interactions on spin-dependent thermoelectric transport through double quantum dot system with Rashba spin-orbit coupling — •Łukasz Karwacki and Piotr Trocha — Faculty of Physics, Adam Mickiewicz University, Poznań, Poland

We investigate theoretically a double quantum dot system embedded into an Aharonov-Bohm ring and coupled to two electronic reservoirs. The magnetic potential present in the system due to the Aharonov-Bohm device leads to spin-independent phase factors in terms related to coupling between the dots and the electrodes. Furthermore, we assume additional spin-dependent phase factors arising from Rashba spin-orbit interaction. We show the influence of the aforementioned phases and that of the Coulomb blockade on the dots on such basic thermoelectric parameters as charge and spin conductances, electronic contribution to heat conductance, charge and spin thermopower and the resulting thermoelectric effectiveness factor.

In our approach we focus on the linear response regime, where the thermoelectric parameters are functions of transmission coefficient. To derive this coefficient we employ equation of motion for non-equilibrium Green's function method.

The results indicate a possibility for an efficient spin-dependent Seebeck generator. Tuning the Rashba spin-orbit interaction leads to pure spin current through the system. In both cases Coulomb blockade leads to enhancement of thermoelectric transport.

MA 45.11 Thu 17:45 H 0112

Tunable Thermoelectric Power Factors of Magnetoresistive Nanowires — •Anna Niemann[1], Tim Böhnert[1], Ann-Kathrin Michel[1], Svenja Bässler[1], Johannes Gooth[1], Bence G. Tóth[2], Katalin Neuróhr[2], László Péter[2], Imre Bakonyi[2], Victor Vega[3], Victor M. Prida[3], and Kornelius Nielsch[1] — [1]Universität Hamburg, Hamburg, Germany — [2]Hungarian Academy of Sciences, Budapest, Hungary — [3]Universidad de Oviedo, Oviedo, Spain

We present spin-caloric transport in single Co-Ni alloy and multilayered Co-Ni/Cu nanowires, including magnetoresistance (MR) and magneto-thermopower (MTP) measurements. Co-Ni alloy nanowires show anisotropic MR while multilayered nanowires show predominant giant MR. MTP and MR are studied in a temperature range between 50 K and 325 K leading to effect sizes up to 6 % for Co-Ni alloy samples and up to 15 % for multilayered samples at room temperature. While the thermopower describes a material's ability to convert temperature gradients into electrical voltage, thermoelectric power factors (PFs) give a measure of the electrical power generated from thermoelectric effects. The PFs of our nanowires can compete with common thermoelectric bulk materials like Bi_2Te_3. Additionally, a magnetic field-dependence of the nanowires' PFs can be observed. PFs of Co-Ni nanowires increase by 24 % in an external magnetic field, while PFs of multilayered nanowires can be increased by up to 40 %. This magnetic field dependence opens interesting opportunities to tune electrical power output according to applicational needs.