MA 38: Spin hall effects

Time: Wednesday 17:15–19:00 Location: H52

MA 38.1 Wed 17:15 H52

Spin-Charge Conversion in NiMnSb Alloy Films — Zhenchao Wen[1,2], Zhiyong Qiu[2,3], •Sebastian Tölle[4], Cosimo Gorini[5], Takeshi Seki[2], Dazhi Hou[2], Takahide Kubota[2], Ulrich Eckern[4], Eiji Saitoh[2], and Koki Takanashi[2] — [1]NIMS, Tsukuba, Japan — [2]Tohoku University, Sendai, Japan — [3]Dalian University of Technology, Dalian, China — [4]University of Augsburg, Germany — [5]University of Regensburg, Germany

Heterostructures with half-metallic ferromagnets (HMF) such as NiMnSb represent an interesting platform for various spin-charge conversion processes since (1) perfect HMFs have the unique property that their conduction electrons are fully spin-polarized at zero temperature, and (2) the interface can exhibit spin-orbit effects, e.g., Rashba spin-orbit coupling. In this work, we study the spin to charge conversion in NiMnSb/YIG bilayers, with YIG serving as a spin pump. Due to spin-orbit coupling, the injected spin current results in a transverse voltage which shows an unusual temperature dependence with a thickness-dependent sign change. We explain this behaviour by two competing contributions, a temperature independent one due to the interface and a bulk contribution, different in sign, which originates from minority-spin electrons due to thermally excited magnons.

MA 38.2 Wed 17:30 H52

Ab initio theory of the spin Hall effect and its application to random Pt-based alloys — •Ilja Turek[1], Josef Kudrnovsky[2], and Vaclav Drchal[2] — [1]Institute of Physics of Materials, Czech Acad. Sci., Brno, Czech Republic — [2]Institute of Physics, Czech Acad. Sci., Prague, Czech Republic

In this contribution, we present our approach to the spin-dependent conductivity tensor in substitutionally disordered alloys based on the concept of intersite electron transport within the relativistic tight-binding linear muffin-tin orbital (TB-LMTO) method. This approach leads to non-random and spin-independent effective current (velocity) operators, which enables one to define easily the corresponding effective spin-current operators that are non-random as well. The configuration averaging of the Fermi-surface and Fermi-sea terms of the spin-dependent conductivity tensor is performed by means of the coherent potential approximation (CPA) in analogy with that formulated recently for the standard conductivity tensor. The developed theory will be illustrated by studies of the spin Hall effect in selected Pt-based alloys (Pt-Au, Pt-Re, Pt-Ta) focused on the values and concentration trends of the spin Hall conductivity and the spin Hall angle.

MA 38.3 Wed 17:45 H52

High-speed domain-wall motion driven by spin-orbit torques and Dzyaloshinskii-Moriya interaction in a magnetic insulator — •Saül Vélez[1,2], Jakob Schaab[1,2], Marvin Müller[1], Elzbieta Gradauskaite[1], Morgan Trassin[1], Manfred Fiebig[1], and Pietro Gambardella[1] — [1]ETH Zürich — [2]Equally contributing

Electrical manipulation of magnetic domains and domain walls (DWs) in magnetic films is an essential ingredient for the development of novel functional devices. Current-induced spin-orbit torques (SOTs) can deterministically switch thin magnetic films and drive Néel chiral DWs at high speeds. The recent addition of magnetic insulators (MIs) as SOT-switchable magnetic layers have prospects for the development of novel non-volatile magnonic logic circuits and memories. However, key aspects such as the dynamics of DWs induced by SOTs in MIs remain so far unexplored. Here, by implementing magneto-optical Kerr effect microscopy, we demonstrate efficient SOT-manipulation of chiral DWs in Tm3Fe5O12(TmIG)/Pt -stabilized by a small in-plane field-, with measured velocities of up to 400 m/s at current densities $\sim 1.5\times10^8$ A/cm^2. The high quality of the TmIG crystals leads to a very low current subthreshold for DW flow $\sim 5\times10^6$ A/cm^2, extremely small depinning fields (∼1-2 Oe) and to extraordinarily large DW displacements upon domain contraction. We also identify Dzyaloshinskii-Moriya interaction (DMI) in TmIG/Pt, with slightly favored left-handed Néel chiral DWs. All these findings point MIs as strong candidates to compete with metallic ferromagnets for spintronic applications, yet enabling the implementation of complementary functionalities.

MA 38.4 Wed 18:00 H52

Spin and anomalous Hall effect induced charge and spin currents in ferromagnetic/nonmagnetic heterostructures — •Albert Hönemann[1], Christian Herschbach[1], Dmitry V. Fedorov[2], Martin Gradhand[3], and Ingrid Mertig[1,4] — [1]Martin Luther University Halle-Wittenberg, Halle, Germany — [2]University of Luxembourg, Luxembourg, Luxembourg — [3]University of Bristol, Bristol, United Kingdom — [4]Max Planck Institute of Microstructure Physics, Halle, Germany

Transport phenomena caused by spin-orbit coupling such as spin Hall effect (SHE) and anomalous Hall effect (AHE) are highly relevant topics of current research. In ferromagnetic/nonmagnetic heterostructures, the interplay of spin-orbit and exchange interaction causes new phenomena like spin-orbit torques [1].

We use an *ab initio* approach based on a relativistic Korringa-Kohn-Rostoker method to determine the electronic structure [2] and solve the linearized Boltzmann equation to describe the electronic transport [3]. We apply these methods to a Co/Cu superlattice with different substitutional impurities delta-distributed within the individual atomic layers [4]. We investigate the AHE-induced charge current as well as the SHE-induced spin current perpendicular and parallel to the interface and report on the spatial distribution of charge and spin current with respect to the interface.

[1] Gambardella *et al.*, Phil. Trans. R. Soc. A **369**, 3175 (2011); [2] Gradhand *et al.*, PRB **80**, 224413 (2009); [3] Gradhand *et al.*, PRL **104**, 186403 (2010); [4] Hönemann *et al.*, arXiv 1807.06404 (2018);

MA 38.5 Wed 18:15 H52

Ultra-low switching current density in all-amorphous W-Hf/CoFeB/TaOx films — •Katharina Fritz and Markus Meinert — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Germany

In our previous work [1], we investigated the spin Hall effect of W-Hf thin films, which exhibit a phase transition from a segregated phase mixture to an amorphous alloy below 70% W. Accompanied by a jump in resistivity, the spin Hall angle shows a pronounced maximum at the composition of the phase transition. A maximum spin Hall angle of θ_{SH}=0.20 was obtained for amorphous W0.7Hf0.3. Due to their amorphous character, the films are expected to contain few pinning centers and, therefore, to show fast domain wall motion, making them interesting in the context of current induced SOT switching.

Using Kerr microscopy, we study the domain wall structure and magnetization switching of amorphous W-Hf/CoFeB/TaOx stacks with perpendicular magnetic anisotropy and large spin Hall angle. We observe current induced domain wall motion without an in-plane assist field, indicating Néel-type domain walls. Investigations of magnetization switching as a function of in-plane assist-field and current pulse-widths reveal switching current densities as low as 3×10^9 A/m^2 in the dc limit.

[1] K. Fritz, S. Wimmer, H. Ebert, and M. Meinert, Phys. Rev. B 98, 094433 (2018)

MA 38.6 Wed 18:30 H52

Impurity induced Spin-Dependent Transport in Uranium Thin Films — •Ming-Hung Wu and Martin Gradhand — H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, United Kingdom

Uranium, a light actinide with itinerant 5f-electrons has been investigated for decades due to its complex properties [1]. It crystallizes in a large variety of structures such as α (orthorhombic), β (bct), γ (bcc) and hcp phase, it shows superconductivity and is close to a ferromagnetic transition [2]. Furthermore, its strong spin-orbital coupling makes uranium a promising material for spintronics applications. Especially in magnetic multilayer systems the proximity of heavy, large spin-orbit coupling, and ferromagnetic materials promises interesting emergent behavior [3]. In order to shed light on the complex physics in multilayer systems, we focus on the spin-dependent transport of uranium thin film. In our ab initio calculations we analyze the spin Hall effect and anomalous Hall effect in bulk uranium incorporating Fe impurities. We extend this work to free standing uranium thin film and discuss the implications of magnetic as well as non-magnetic impurities on the spin-dependent transport in multilayers including ferromagnetic materials.

Reference
[1] S. Adak et al., Phys. B 406, 3342 (2011).
[2] J.-C. Griveau et al., C. R. Phys. 15, 599 (2014).
[3] R. Springell et al., Phys. Rev. B 77, 064423 (2008).

MA 38.7 Wed 18:45 H52

Transverse spin Hall magnetoresistance in Au/YIG —

•Tobias Kosub[1], Saül Vélez[2], Juan M. Gomez-Perez[2], Luis E. Hueso[2,3], Jürgen Fassbender[1], Fèlix Casanova[2,3], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [2]CIC nanoGUNE, Donostia-San Sebastian, Spain — [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

Magnetic insulators and nonmagnetic metals are both large classes of materials, but their combined application for insulator spintronics hinges on peculiar interface effects, such as spin Hall magnetoresistance (SMR). This effect is usually exploited for metals like Pt or Ta [1], which offer good chemical properties and large spin Hall angles.

However, many more metals can be employed in SMR applications when longitudinal and transverse resistances are properly separated [2] to routinely access smaller magnetoresistance effects.

We demonstrate this approach through a thorough study [3] of a Au thin film on the magnetic insulator $Y_3Fe_5O_{12}$ revealing both longitudinal and transverse magnetotransport signatures of the spin Hall magnetoresistance. An anomalous Hall effect due to proximity magnetization is not evident. We calculate spintronic quantities like spin mixing conductivities based only on static magnetotransport results using a meta-analysis.

[1] T. Kosub et al., *Nat. Commun.* **8**, 13985 (2017).
[2] T. Kosub et al., *Phys. Rev. Lett.* **115**, 097201 (2015).
[3] T. Kosub et al., *Appl. Phys. Lett.*, (2018), doi: 10.1063/1.5053902.