MA 18: Spintronics

Time: Tuesday 15:00–17:15 Location: H47

MA 18.1 Tue 15:00 H47

Multilayer on-chip spintronic THz emitters — •Wolfgang Hoppe[1], Mohamed Amine Wahada[2], Stuart S. P. Parkin[2], and Georg Woltersdorf[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Von-Danckelmann-Platz 3, 06120 Halle, Germany — [2]Max Planck Institute for Microstructure Physics, Weinberg 2, 06120 Halle, Germany

Nanometer thin ferromagnet/heavy metal bilayers illuminated by intense, short laser pulses have proven to be a reliable source for THz emission [1]. When integrated into a gold waveguide structure, the bilayer can be used as an on-chip source for ultrafast current pulses, ranging from the GHz to the THz regime [2]. One possible application is the switching of the magnetization of an adjacent magnetic layer [3]. A way to achieve the needed threshold current density is by increasing the amplitude of the current-pulses. This can be accomplished by stacking the bilayers, each separated by a thin MgO interlayer impeding the formation of any spin-currents in between the individual bilayers [4]. Here, the charge current in all bilayers can add, leading to an enhanced signal. We demonstrate an increase by a factor of three for the optimal stacking configuration. The multilayers are investigated by electro-optic sampling.

[1] Seifert et al. Nature Photon 2016, 10, 483-488
[2] W. Hoppe et al. ACS Appl. Nano Mater. 2021, 4, 7, 7454-7460
[3] Y. Yang et al. Sci. Adv. 2017, 3, 11
[4] M. A. Wahada et al. ACS Nano Lett. 2022, 22, 9, 3539-3544

MA 18.2 Tue 15:15 H47

Ab initio studies of chiral crystals for generalized linear response transport and x-ray absorption spectroscopy — •Alberto Marmodoro[1], Hubert Ebert[2], and Ondřej Šipr[1,3] — [1]Institute of Physics (FZU) of the Czech Academy of Sciences, Prague, Czech Republic — [2]Department of Chemistry, Ludwig-Maximilians-University (LMU), Munich, Germany — [3]New Technologies Research Centre, University of West Bohemia, Pilsen, Czech Republic

Materials with a chiral atomic arrangement exhibit specific electronic structure features [1]. The clock-wise or anti-clock-wise winding of sublattices has been associated with a radial spin texture of the Fermi surface in reciprocal space [2]. This provides interesting consequences for the response [3] to e.g. an applied electric field, for instance in terms of Edelstein effect and particularly its dependence on the sign of the perturbation. We report generalized linear response predictions [3] and theoretical x-ray spectroscopy cross-sections [4] for inorganic bulk crystals from first-principles studies performed within the frameworks of a spin-polarized relativistic Korringa, Kohn, Rostoker (SPRKKR) treatment.

[1] http://dx.doi.org/10.7566/JPSJ.83.061018
[2] http://dx.doi.org/10.1103/physrevlett.127.126602, http://dx.doi.org/10.1038/s42005-021-00564-w
[3] http://dx.doi.org/10.1103/PhysRevB.91.165132
[4] http://dx.doi.org/10.1107/S090904959801680X

MA 18.3 Tue 15:30 H47

Studying Spin Dynamics of Thin $Cr_2Ge_2Te_6$, using Superconducting Resonators — •Christoph W. Zollitsch[1], Safe Khan[1], Nam Vu Thanh Trung[2], Dimitrios Sagkovits[1], Ivan Verzhbitskiy[2], Goki Eda[2], and Hidekazu Kurebayashi[1] — [1]London Centre for Nanotechnology, University College London, London WC1H 0AH, United Kingdom — [2]Department of Physics, National University of Singapore, 2 Science Drive 3, Singapore 117551

Two-dimensional van der Waals material systems gained an increased interest in the field of spintronics, as they can maintain ferromagnetic order even down to the few monolayer regime. These materials naturally permit device miniaturization. An ideal test bed for new spintronics applications in the 2D limit is the ferromagnetic semiconductor $Cr_2Ge_2Te_6$, where intrinsic ferromagnetism has been discovered for atomic bilayers [1].

We investigate the spin dynamics of thin exfoliated flakes (11 - 150 nm) of $Cr_2Ge_2Te_6$, using superconducting lumped element resonators made of NbN. The flakes are transferred directly on top of several superconducting resonator structures, featuring resonance frequencies from 12 GHz to 18 GHz. We perform ferromagnetic resonance (FMR) at a temperature of 1.8 K and can easily resolve the response from the flakes, even down to a thickness of 11 nm. With our multi-resonator approach, can confirm a Kittel FMR behaviour for the full thickness range. The FMR data can very well be described with bulk values of the magnetic parameters.

[1] Cheng Gong et al., Nature 546, 265-269 (2017)

MA 18.4 Tue 15:45 H47

Spin wave spectrum asymmetry from nonlocal chiral renormalization of gyromagnetic ratio — •Ivan Ado[1,2] and Mikhail Titov[2] — [1]Institute for Theoretical Physics, Utrecht University, 3584 CC Utrecht, The Netherlands — [2]Institute for Molecules and Materials, Radboud University, 6525 AJ Nijmegen, The Netherlands

We present a new potential source of the spin wave spectrum asymmetry in metallic and semiconducting magnets. Such an asymmetry is often used to experimentally measure the Dzyaloshinskii-Moriya interaction (DMI) strength using Brillouin light scattering (BLS). We argue that there exists an additional contribution to the asymmetry that originates in coupling between magnetic moments and charge carriers. Moreover, this contribution is sensitive to electron scattering by impurities and depends on the parameters of the electron diffusive motion. We address the corresponding mechanism as "nonlocal chiral renormalization of gyromagnetic ratio". We analyze it both microscopically and using symmetry arguments, for a prototypical 2D metallic ferromagnet. The resulting contribution to the asymmetry scales quadratically with the scattering time and thus can be particularly strong in sufficiently clean systems. We suggest that experimental measurements of DMI by means of BLS may be inaccurate if one does not take this effect into account.

MA 18.5 Tue 16:00 H47

Influence of dusting layers on the magneto-ionic response of Ta/X/CoFeB/Y/MgO/HfO2 thin film stacks — •Tanvi Bhatnagar-Schöffmann[1], Aurélie Solignac[2], Djoudi Ourdani[3], Rohit Pachat[1], Maria-Andromachi Syskaki[5], Yves Roussigné[3], Shimpei Ono[6], Dafiné Ravelosona[4], Jürgen Langer[5], Mohamed Belmeguenai[3], and Liza Herrera Diez[1] — [1]Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, 91120 Palaiseau, France — [2]Université Paris-Saclay, CEA, CNRS, SPEC, 91191, Gif-sur-Yvette, France — [3]Laboratoire des Sciences des Procédés et des Matériaux, CNRS-UPR 3407, Université Paris 13, Sorbonne Paris Cité, 93430 Villetaneuse, France — [4]Spin-Ion Technologies, C2N, 10 Boulevard Thomas Gobert, 91120 Palaiseau, France — [5]Singulus Technologies AG, Hanauer Landstrasse 103, 63796 Kahl am Main, Germany — [6]Central Research Institute of Electric Power Industry, Yokosuka, Kanagawa 240-0196, Japan

Here,we present the room temperature magneto-ionic control of magnetic anisotropy,coercivity and DMI in Ta/X/CoFeB/Y/MgO/HfO2 ,where X and Y are dusting layers of heavy metal elements (Pt,W) sharing different interfaces with CoFeB. Dusting layers at the bottom interface (Y) can define a system locked in a PMA state allowing for a reversible magneto ionic control of coercivity, while samples with dusting layers at the top interface (X) can allow for a full and reversible spin-reorientation transition. The intercalation of dusting layers of heavy metal elements in Ta/CoFeB/MgO stacks has the potential to fine tune magnetic properties.

MA 18.6 Tue 16:15 H47

Anisotropic magnetoresistance in systems with non-collinear magnetic order — •Philipp Ritzinger and Karel Vyborny — Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 21 Prague 8, Czech Republic

Since its discovery in 1857 by William Thomson, the anisotropic magnetoresistance (AMR) has been in focus of many theoretical studies seeking to understand the microscopic mechanisms of this effect. Most attention has been paid to ferromagnets (FMs) and recently, the scope of research on AMR is extended to include also antiferromagnets (AFMs). AMR can be due to anisotropic scattering (extrinsic) or an anisotropic Fermi surface (intrinsic). Here we focus on the latter, much less investigated intrinsic mechanism, which is achieved by considering non-collinear magnetic order inspired by real materials such as CrSe, delta-FeMn, Mn3Ge or RbFe(MoO4)2. We explore various types of lattices on toymodel level amongst which are trigonal, tetraedral or Kagome lattice. Magnetic moments can be arranged in many different ways on such lattices and seemingly small changes alter the Fermi surface symmetry, spin texture and transport properites. We have investigated systematically the influence of magnetic ordering on these properties which allows to predict general features of spin texture and transport by only considering the symmetry of the underlying system. As an example of these effects we have shown that AFM systems without spin-orbit coupling on Kagome lattices can develop anisotropy in the electric conductivity under applied in-plane magnetic field. This does not occur in FMs without spin-orbit coupling.

MA 18.7 Tue 16:30 H47

Spin-split collinear antiferromagnets: a large-scale ab-initio study — •Yaqian Guo[1], Hui Liu[1,2], Oleg Janson[1], Cosma Fulga[1,2], Jeroen van den Brink[1,2], and Jorge I. Facio[1,3,4] — [1]Leibniz Institute for Solid State and Materials Research, IFW Dresden, 01069 Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany — [3]Centro Atómico Bariloche and Instituto Balseiro, CNEA, 8400 Bariloche, Argentina — [4]Instituto de Nanociencia y Nanotecnología CNEA-CONICET, Argentina

Collinear antiferromagnetic (cAFM) materials can break the spin degeneracy in momentum space based on their magnetic symmetry, giving rise to the so called AFM-induced spin splitting. In this mechanism, spin splitting originates neither from a non-zero net magnetization (Zeeman effect) nor spin-orbit coupling (SOC) in noncentrosymmetric materials (Rashba-Dresselhaus effect), but from the magnetic symmetries. In this work, we performed a systematic analysis for 62 cAFM compounds and investigated the AFM-induced spin splitting without considering SOC. We established three measures to analyze the average spin splitting. Based on our measures, we identified the compounds with sizable spin splitting, such as CoF_2 and $FeSO_4F$, and analyzed their electronic structure in detail. A similar analysis was performed for particular low-dimensional magnets, e.g. $LiFe_2F_6$ and antiferromagnetic metals with spin splitting, e.g. RuO_2, $CrNb_4S_8$ and CrSb.

MA 18.8 Tue 16:45 H47

Superparamagnetic tunnel junctions for neuromorphic computing — •Leo Schnitzspan[1,2], Gerhard Jakob[1,2], and Mathias Kläui[1,2] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Max Planck Graduate Center, Mainz

Superparamagnetic tunnel junctions (SMTJ) are promising candidates for the implementation of neuromorphic computing. In a SMTJ, the magnetic free layer can switch its orientation induced by thermal activation, leading to a random two-level resistance fluctuation with relaxation times in the order of a few nanoseconds [1]. Their intrinsic stochastic behaviour and additional tunability by external magnetic fields, Spin Transfer Torques (STT) or Spin Orbit Torques (SOT) are key ingredients for low-energy artificial neurons in neural networks. Non-conventional computing, like inverse logic for integer factorization already has been demonstrated based on SMTJs[2]. Measurements of the characteristic stochastic switching behaviour are highlighted and the quality of randomness (according to NIST Statistical Test Suite) for a SMTJ as a potential true random number generator is evaluated. New possible implementation ideas of a stochastic neural network based on SMTJs are proposed and their efficiency is studied in detail.

[1] Hayakawa, K. et al., Phys. Rev. Lett. 126, 117202 (2021). [2] Borders, W. A. et al., Nature 573, 390-393 (2019).

MA 18.9 Tue 17:00 H47

Simulation of Polymer Spintronics — •Shih-jye Sun — National University of Kaohsiung, Kaohsiung, Taiwan

We proposed a two-level model to simulate the spin-polarization current and the mobility in a field-effect transistor constructed by an antiferromagnetic-coupling polymer chain connected with the source, drain electrodes, and the oxide gate. This model is beyond the single-level model because of considering the inducing states in the polymer host by adding the magnetic functional side groups. We found that the double Coulombic excitations sensitively depend on the inducing states in the model significantly influencing the spin-polarization current and the mobility. Eventually, the workable organic spintronics can be realized based on our simulations.