MA 20: Spintronics (other effects)

Time: Tuesday 15:00–17:45 Location: HSZ 401

MA 20.1 Tue 15:00 HSZ 401

Ab initio studies of chiral crystals for generalized linear response transport and x-ray absorption spectroscopy — •Alberto Marmodoro[1], Hubert Ebert[2], and Ondrej Sipr[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 20.2 Tue 15:15 HSZ 401

Crystallisation behaviour of Yttrium Iron Garnet thin films — •Sebastian Sailler[1], Michaela Lammel[1], Gregor Skobjin[1], Heike Schlörb[2], Andy Thomas[2,3], and Sebastian T.B. Goennenwein[1] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Institute for Integrative Nanosciences, Leibniz Institute of Solid State and Materials Science, 01069 Dresden, Germany — [3]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01069 Dresden, Germany

Yttrium Iron Garnet (YIG) is a ferrimagnetic insulator commonly used in spin transport and spin dynamics. To obtain highly crystalline thin films we use RF-magnetron sputtering at room temperature to deposit amorphous films and a subsequent annealing step to crystallise them. However, the crystallisation from the amorphous state has not been systematically studied. We therefore analyse the crystallisation behaviour on different substrates utilizing extensive time and temperature series. Structural characterisation using X-ray techniques as well as electron diffraction allow to differentiate between amorphous, polycrystalline and epitaxial films, and to determine the optimal annealing parameters for each substrate. Additionally, we correlate the crystalline state with the resulting magnetic properties inferred from magnetometry and Kerr-microscopy. Our results provide a precise tunability of the structural and magnetic properties of YIG by a rigorous control over the crystallization induced by the subsequent annealing step.

MA 20.3 Tue 15:30 HSZ 401

Excited-state exchange interaction in NiO determined by high-resolution resonant inelastic x-ray scattering at the Ni $M_{2,3}$ edges — •Chun-Yu Liu[1,2], Kari Ruotsalainen[1], Karl Bauer[1], Régis Decker[1], Annette Pietzsch[1], and Alexander Föhlisch[1,2] — [1]Institute for Methods and Instrumentation for Synchrotron Radiation Research (PS-ISRR), Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB), Albert-Einstein-Strasse 15, 12489 Berlin, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam, Germany

The electronic and spin excitations of bulk NiO have been determined using the $^3A_{2g}$ to $^3T_{2g}$ crystal-field transition at the Ni $M_{2,3}$ edges with high resolution resonant inelastic x-ray scattering. We extract an effective exchange field of 89±4 meV in the $^3T_{2g}$ excited final state from empirical two-peak spin-flip model, which is further confirmed with crystal-field model calculations using exchange fields of 60-100 meV. The lower exchange parameter in the excited state is discussed in terms of the modification of the orbital occupancy and of the structural dynamics: (A) With pure electronic effects, the lower exchange energy is attributed to the reduction in effective hopping integral. (B) With no electronic effects, we use the S = 1 Heisenberg model to derive a second-nearest-neighbor exchange constant $J_2 = 14.8\pm0.6$ meV. Based on the linear correlation between J_2 and the lattice parameter from pressure-dependent experiments, an upper limit of 2% local Ni-O bond elongation during the fs scattering duration is derived.

MA 20.4 Tue 15:45 HSZ 401

Strongly coupled magnon-plasmon polaritons in graphene-2D ferromagnet heterostructures — •António Costa[1], Mikhail Vasilevskiy[1,2], Joaquín Fernández-Rossier[1], and Nuno Peres[1,2] — [1]International Iberian Nanotechnology Laboratory (INL) — [2]Department of Physics, Center of Physics, University of Minho

Magnons and plasmons are two very different types of collective modes, acting on the spin and charge degrees of freedom, respectively. At first sight, the formation of hybrid plasmon-magnon polaritons in heterostructures of plasmonic and magnetic systems would face two challenges, the small mutual interaction, via Zeeman coupling of the electromagnetic field of the plasmon with the spins, and the energy mismatch, as in most systems plasmons have energies in the eV range, orders of magnitude larger than magnons. Here we show that graphene plasmons form polaritons with the magnons of two-dimensional ferrromagnetic insulators, placed up to to half a micron apart, with Rabi couplings in the range of 100 GHz (dramatically larger than cavity QED magnonics). This strong coupling is facilitated both by the small energy of graphene plasmons and the cooperative super-radiant nature of the plasmon-magnon coupling afforded by phase matching. We show that the Rabi coupling can be modulated both electrically and mechanically and we propose an attenuated total internal reflection experiment to implement ferromagnetic resonance experiments on 2D ferromagnets driven by plasmon excitation.

MA 20.5 Tue 16:00 HSZ 401

Doping induced ferromagnetism in EuTiO3 and STO/ETO/LAO heterostructures by ab-initio calculations — •Payal Wadhwa and Alessio Filippetti — Department of Physics, University of Cagliari, Sardinia, Italy

The emergence of 2DEG at oxide interfaces such as LaAlO3 (LAO) and SrTiO3 (STO) raised an immense interest in the community of oxide electronics, because of depicting outstanding properties such as field-effect driven superconductivity, high electron mobility, and magnetoresistance. An old dream of the spintronic community, remained eluded so far, has been to spin-polarize the 2DEG by introducing a magnetic layer at the interface of LAO/STO heterostructure, which may enable it to be a paramount material for spintronics and spin-orbitronic technology. A potential candidate as magnetic interlayer is EuTiO3 (ETO), having an identical lattice constant to STO. It is reported that ETO possesses G-type AFM ground state below Tn = 5.3 K, while becomes FM under tensile strain or doping. We have employed an ab-initio approach to study structural, electronic, and magnetic properties of ETO bulk and the STO/ETO/LAO heterostructure. We found, for increasing electron doping, a progressive enhancement of the FM phase in bulk ETO. Since conduction electrons can also be added to the ETO by creating a heterointerface, so we also compared the n-doped bulk ETO results with the STO/ETO/LAO heterostructure. Overall, our results for n-doped ETO and STO/ETO/LAO heterostructure depict them to be potential candidates for electronic transport and magneto-transport applications.

15 min. break

MA 20.6 Tue 16:30 HSZ 401

Magnetism and proximity-induced Rashba effect at Mn-3d bands of asymmetric $BaMnO_3|KTaO_3$ heterojunction — •Vivek Kumar and Nirmal Ganguli — Indian Institute of Science Education and Research Bhopal, Bhauri, Bhopal 462066, India

Rashba-like spin-orbit interaction (SOI) at oxide heterostructures emerges as a much sought-after feature in the context of oxide spintronics and spin-orbitronics. $KTaO_3$ (KTO) is one of the best substrates available for the purpose, owing to its strong SOI and alternating $+1|-1$ charged layers along the (001) direction. We visualize the Rashba-like interaction in the KTO (001) surface with the help of spin texture plotted directly from DFT calculations along with the

isoenergetic contours, providing a confirmatory test of the presence of only linear Rashba interaction [1]. We use *ab initio* DFT to examine the asymmetric $BaMnO_3|KTaO_3$ (BMO|KTO) oxide heterostructure where the inequivalent bottom and top interfaces break the inversion symmetry due to their opposite polar discontinuities. We observe Rashba-like splitting for the bands of Mn-3*d* near the Fermi level of *C*-type antiferromagnetic (AFM) BMO|KTO owing to the proximity to Ta atoms from the 5*d* series. We comprehensively analyze Rashba-like SOI with the help of three-dimensional band dispersion and projected spin textures for Rashba-like Mn-3*d* bands. Our results reveal reasonably strong linear Rashba interaction in the heterostructure. The rigorous analysis of spin textures of the AFM heterostructure presented here may be crucial for spintronics. [1] V. Kumar and N. Ganguli, Phys. Rev. B 106, 125127 (2022).

MA 20.7 Tue 16:45 HSZ 401

Spin-mixing states at finite temperature — •Danny Thonig[1,2], Simon Streib[2], Ramon Cardias[3], Sumanta Bhandary[4], Yaroslav Kvashnin[2], and Olle Eriksson[2,1] — [1]Örebro University, Sweden — [2]University Uppsala, Sweden — [3]KTH Royal Institute of Technology, Sweden — [4]Trinity College Dublin, The University of Dublin, Ireland

In spintronics, the electron spins are used as information carriers and, thus, the description of spin relaxation is of fundamental relevance. Spin relaxation characterises how rapidly the non-equilibrium spin population decays due to spin mixing [1], which wise versa depends on the magnetic moment length and on the temperature simulated by disorder acting on the magnetic state. But the latter phenomenons is barely understood.

We quantify the presence of spin-mixed states in spin and lattice disordered magnetic 3d transition metals by calculating the Elliot-Yafet spin-mixing parameter b^2. Here, we are using a self-consistent, relativistic, Slater-Koster parametrized tight-binding electronic structure model.

We, first, compare our results of the collinear order in itinerant magnets with density functional theory calculations and experiment. After, we analyse b^2 at finite temperature, finding a drastic increase by a factor > 10. This can be understood since both spin orbit coupling and disorder have a similar impact on the electronic potential [2].

[1] D. Steiauf et al., *Phys. Rev. B* **79** 140401 (2009)
[2] L. Nordström et al., *Phys. Rev. Lett.* **76** 4420 (1996)

MA 20.8 Tue 17:00 HSZ 401

Spin-caloritronics using spin-polarized scanning tunneling microscopy — •Cody Friesen and Roland Wiesendanger — Department of Physics, University of Hamburg, Hamburg, Germany

The study and control of magneto- and thermoelectric effects have long been of fundamental importance, from the perspectives of both basic condensed matter research and technological development. More recently, driven by the discovery of the spin-Seebeck effect, a growing amount of research is being done at the intersection of these transport channels; a field known as spin-caloritronics [1]. The possible applications of these effects, e.g. the efficient conversion of waste heat into spin or charge currents, or the magnetic control of heat transfer on the atomic scale, have far-reaching implications for future technology.

Using spin-polarized scanning tunneling microscope (SP-STM) we have investigated magneto-Seebeck tunneling, i.e. the spin-dependent tunneling of electrons across a magnetic tunnel junction driven by a temperature gradient [2]. By scanning a (relatively) heated magnetic probe tip in tunneling contact with a magnetic sample, at cryogenic temperatures the spin-resolved thermopower of the junction can be resolved with atomic-scale lateral resolution [3,4].

In this talk I will present the experimental requirements, challenges, and advantages of using SP-STM for studies of spin-caloritronics. Following this, the expansion of this approach to the measurement of thermal spin-transfer torque, as well as further development of SP-STM as a tool for spin-caloritronic studies, will be discussed.

MA 20.9 Tue 17:15 HSZ 401

Fractional Landau-Lifshitz-Gilbert equation — Robin C. Verstraten[1], •Tim Ludwig[1], Rembert A. Duine[1,2], and Cristiane Morais Smith[1] — [1]Institute for Theoretical Physics, Utrecht University, Princetonplein 5, 3584CC Utrecht, The Netherlands — [2]Department of Applied Physics, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands

Gaining a deeper understanding of magnetization or spin dynamics is of great interest to improve modern technological devices. In particular, a deeper understanding of dissipation could help to improve device efficiency. Magnetization dynamics is often described by the Landau-Lifshitz-Gilbert equation with phenomenological Gilbert damping. Using the Caldeira-Leggett approach, we can re-derive Gilbert damping for a specific type of environment (Ohmic) but, in general, we find fractional Gilbert damping. Fractional Gilbert damping is similar to Gilbert damping but the time derivative is replaced by a fractional time derivative. Finally, we discuss experimental consequences of fractional Gilbert damping with a focus on ferromagnetic resonance experiments.

MA 20.10 Tue 17:30 HSZ 401

Driving a magnetic texture by magnon currents — •Michael Vogel[1,2], Bernhard Zimmermann[1], Johannes Wild[1], Felix Schwarzhuber[1], Claudia Mewes[3], Tim Mewes[3], Josef Zweck[1], and Christian H. Back[1,4] — [1]Department of Physics, Regensburg University, Regensburg, Germany — [2]Institute for Materials Science, Kiel University, Kiel, Germany — [3]Department of Physics and Astronomy, The University of Alabama, Tuscaloosa, USA — [4]Department of Physics, Technical University Munic, Munich, Germany

Thermally-induced spin dynamics in solids have sparked broad interest in both fundamental physics and spintronic applications. As theoretically proposed, thermally excited magnons created by temperature gradients can be used to manipulate spin textures such as topological magnetic solitons. However, in practice, the effectiveness of such thermomagnonic torques has remained a problem. Here the dynamics of magnetic vortex cores driven by thermomagnonic torques are explored by high-resolution Lorentz Transmission Electron Microscopy. Large deflections of the magnetic vortex core transverse to the direction of the temperature gradient are observed. The magnitude of the contribution of the associated torques is determined using a generalized Thiele equation model. Our findings pave the path for thermomagnonic currents to manipulate magnetic domains and shed light on the relationship between temperature and spin. The authors gratefully acknowledge financial support from the DFG within SpinCaT (SPP 1538) and the BMBF.