MA 4: Spin-Dependent 2D Phenomena

Time: Tuesday 10:00–11:15 Location: H5

Invited Talk MA 4.1 Tue 10:00 H5

2D Magnetic materials — •Alberto Morpurgo — University of Geneva

Exfoliation of thin crystals from van der Waals bonded parent compounds allows the realization of atomically thin layers, exhibiting new phenomena, properties and functionality. For atomically thin magnetic materials, this strategy has been followed only recently, and has led to multiple interesting results. In my talk I will mainly focus on the investigation of 2D semiconducting magnetic materials by means of transport measurements. I will discuss how we use atomically thin layers to realize tunnel barriers, and measure the temperature and magnetic field dependence of the tunneling resistance to extract detailed information about their magnetic phase diagram. In a first generation of experiments we have demonstrated the principle for diferent antiferromagnetic semiconductors (CrI_3, $CrCl_3$, $MnPS_3$), and extracted important microscopic information about the phase transitions occurring in these systems (and in some cases about the relevant exchnage integrals). More recently we have shown that the technique also works for ferromagnets such as $CrBr_3$, using which we are able to infer detailed information about the magnetic field and temperature dependence of the tubnneling resistance (both in the ferromagnetic and in the paramagnetic state).

MA 4.2 Tue 10:30 H5

Spin-polarised imaging and quasi-particle interference of the van-der-Waals ferromagnet Fe_3GeTe_2 — •Olivia Armitage[1], Christopher Trainer[1], Luke Rhodes[1], Harry Lane[2], Edmond Chan[2], Chris Stock[2], and Peter Wahl[1] — [1]SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, United Kingdom — [2]SUPA, School of Physics and Astronomy, University of Edinburgh, United Kingdom

Van-der-Waals ferromagnets have enabled the development of heterostructures with spintronics functionalities. However, information about the magnetic properties of these systems has come largely from macroscopic techniques, with little being known about the microscopic magnetic properties. Here, we use spin-polarised scanning tunnelling microscopy and quasi-particle interference imaging to study the magnetic and electronic properties of the metallic 2D vdW ferromagnet Fe_3GeTe_2. From comparison with Density Functional Theory calculations we can assign the quasi-particle interference to be dominated by spin-majority bands. We find a dimensional dichotomy of the bands at the Fermi energy: bands of minority character are predominantly two-dimensional in character, whereas the bands of majority character are three-dimensional. We expect that this will enable new design principles for spintronics devices.

MA 4.3 Tue 10:45 H5

Photocurrents in single-layer Fe3GeTe2 from first principles — •Maximilian Merte[1,2,3], Frank Freimuth[3,1], Theodoros Adamantopoulos[1], Dongwook Go[3,1], Tom Saunderson[3,1], Matthias Kläui[3], Stefan Blügel[1], and Yuriy Mokrousov[1,3] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics, RWTH Aachen University, 52056 Aachen, Germany — [3]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

We present a method for calculating laser induced currents [1], which are of second order in the electric field, by means of Wannier interpolation. Our method can be applied as a post-processing tool to the wannier90code [2], which is compatible with many ab-initio codes. We apply the developed method to study photocurrents in a single-layer of the van der Waals layered crystal Fe3GeTe2, which act as 2D ferromagnetic metals whose properties are being intensively explored nowadays [3]. Our calculations predict a very sizeable magnitude of photocurrents in this material, whose sign and properties can be tuned by doping or by the frequency of the pulse. We also uncover the importance of the scattering effects which are naturally taken care of within the Keldysh formalism that we use as the ground framework for our method. We acknowledge funding from Deutsche Forschungsgemeinschaft (DFG) through SFB/TRR 173 and 288. Simulations were performed with computing resources granted by JARA-HPC from RWTH Aachen University and Forschungszentrum Jülich under projects jara0161, jiff40 and jias1a [4]

[1] Frank Freimuth et al., arXiv: 1710.10480 (2017)
[2] www.wannier.org
[3] Y. Deng et al., Nature 563, 94 (2018).
[4] Jülich Supercomputing Centre. (2018). JURECA: Modular supercomputer at Jülich Supercomputing Centre. Journal of large-scale research facilities, 4, A132. http://dx.doi.org/10.17815/jlsrf-4-121-1

MA 4.4 Tue 11:00 H5

Charge density waves as enablers for chiral magnetism in two-dimensional $CrTe_2$ — •Nihad AbuAwwad[1,2], Manuel dos Santos Dias[1], Sascha Brinker[1], and Samir Lounis[1,2] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany — [2]Faculty of Physics, University of Duisburg-Essen, 47053 Duisburg, Germany

The discovery of two-dimensional (2D) van der Waals magnets opened unprecedented opportunities for the fundamental exploration of magnetism in quantum materials and the realization of next generation spintronic devices. Recently, thin $CrTe_2$ films were demonstrated to be ferromagnetic up to room temperature, with an intriguing dependence of the easy axis on the thickness of the material [1,2]. Here, we demonstrate using first-principles that the charge-density waves characterizing a single $CrTe_2$ give rise to chiral magnetism through the emergence of the Dzyaloshinskii-Moriya interaction (DMI). Utilizing atomistic spin dynamics, we perform a detailed investigation of the complex magnetic properties pertaining to this 2D material impacted by the presence of various types of charge density waves.

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[1] Zhang *et al.*, Nat. Commun. **12**, 2492 (2021); [2] Meng *et al.*, Nat. Commun. **12**, 809 (2021).