MA 7: Topological Phenomena (joint session MA/TT)

Time: Monday 9:30–11:30 Location: POT 6

MA 7.1 Mon 9:30 POT 6

Complex magnetism and colossal magnetoresistance in wallpaper fermion candidate Eu5In2Sb6 — •Marein Rahn[1,2], Sonia Francoual[4], Alessandro Bombardi[5], Pascal Manuel[6], Larissa Veiga[7], Morgan Allison[1], Marc Janoschek[3], Jochen Geck[1], Filip Ronning[2], and Priscila Rosa[2] — [1]IFMP, Technische Universität Dresden, 01069 Dresden, Germany — [2]LANL, Los Alamos, NM 87545, USA — [3]PSI, 5232 Villigen, Switzerland — [4]DESY, 22607 Hamburg, Germany — [5]Diamond Light Source, Didcot OX11 0DE, UK — [6]ISIS Neutron an Muon Source, Didcot OX11 0QX, UK — [7]LCN, University College London, London WC1H 0AH, UK

A new type of hourglass topological surface state has been predicted to be protected by non-symmorphic structural symmetries in Ba5In2Sb6. Following this prediction, we synthesized the isostructural Eu5In2Sb6, which promises to combine the potential for novel electronic topology with the 8 muB magnetic moment of Eu2+. Indeed, we find unusual unusual electronic properties, such as 99% negative magnetoresistance and a two-step magnetic ordering process. We present our complementary use of neutron powder diffraction, Eu L3-edge resonant elastic x-ray scattering and muon spin-rotation to reveal the mechanism of this unusual magnetic ground state, which may form a basis for understanding of the relevance of topological surface states in this material.

MA 7.2 Mon 9:45 POT 6

Large magnetic gap at the Dirac point and spin polarization control in $Bi_2Te_3/MnBi_2Te_4$ heterostructures — •Friedrich Freyse[1], Emile Rienks[1], Stefan Wimmer[2], Andreas Ney[2], Hubert Steiner[2], Valentine Volobuev[2], Heiko Groiss[2], Günther Bauer[2], Andrei Varykhalov[1], Oliver Rader[1], Gunther Springholz[2], and Jaime Sánchez-Barriga[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, BESSY II, Berlin, Germany — [2]Institut für Halbleiter und Festkörperphysik, Johannes Kepler Universität, Linz, Austria

Using spin- and angle-resolved photoemission, we investigate the electronic and spin structure of the topological surface state (TSS) of $Bi_2Te_3/MnBi_2Te_4$ heterostructures as a function of temperature. By cooling below the Curie temperature T_C, we observe how a magnetic surface gap opens at the Dirac point of the initially gapless TSS, a requirement which is crucial to enable the quantum anomalous Hall effect. The spectrum of the gapped Dirac point measured in remanence after field cooling (M+) is clearly spin polarized, with spin orientation perpendicular to the surface plane and spin split by a large value of $\Delta = 56 \pm 4$ meV at 6 K. Subsequent measurement at room temperature shows that the spin polarization completely disappears, whereas subsequent cooling in an oppositely oriented field (M-) leads to a reversal of the spin polarization.

[1] J.Sánchez-Barriga *et al.* Nature (2019), in press

MA 7.3 Mon 10:00 POT 6

Magnetic properties of antiferromagnetic topological insulators — •Martin Hoffmann[1], Mikhail M. Otrokov[2,3,4,5], Arthur Ernst[1], and Evgueni V. Chulkov[2,4,5,6] — [1]Institute for Theoretical Physics, Johannes Kepler Universität, Linz, Austria. — [2]Centro de Física de Materiales (CFM-MPC), Centro Mixto CSIC-UPV/EHU, San Sebastián, Spain. — [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain. — [4]Donostia International Physics Center (DIPC), San Sebastián, Spain. — [5]Saint Petersburg State University, Saint Petersburg, Russia. — [6]Departamento de Física de Materiales UPV/EHU, San Sebastián, Spain.

The doping of nonmagnetic topological insulators with magnetic transition metal elements exhibits less desired strongly inhomogeneous magnetic and electronic properties, which restricts the observation of important effects to very low temperatures. Well ordered intrinsic magnetic topological insulators can be the solution to those problems as they show higher magnetic phase transition temperatures as theoretically predicted and experimentally confirmed for the antiferromagnetic (AFM) topological insulator $MnBi_2Te_4$. Here, we report about the *ab initio* results and calculated magnetic properties of this prediction. $MnBi_2Te_4$ forms septuple-layer blocks including a Mn layer. A three-dimensional AFM order establishes below the Néel temperature of $T_N = 25.4$ K obtained by Monte Carlo simulations. This AFM order causes the different Mn layer to align their moments antiparallel due to weak out-of-plane magnetic exchange coupling constants, while the intralayer magnetic order is ferromagnetic.

MA 7.4 Mon 10:15 POT 6

A Family of Intrinsic Magnetic Topological Insulators $(MnBi_2Te_4)(Bi_2Te_3)_n$, n = 0, 1, 2 — •Anna Isaeva[1,2], Alexander Zeugner[3], Anja U. B. Wolter[1], Bernd Büchner[1], and Hendrik Bentmann[4] — [1]Institute for Solid State and Materials Research, Leibniz IFW Dresden, Dresden, Germany — [2]Faculty of Physics, Technische Universität Dresden, Dresden, Germany — [3]Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Dresden, Germany — [4]Experimental Physics VII, Universität Würzburg, Würzburg, Germany

In a quest to harness quantum effects for technological advances, new realizations of materials for quantum anomalous Hall effect are pursued. A family of van-de-Waals $(MnBi_2Te_4)(Bi_2Te_3)_n$ compounds derive from the 3D topological insulator Bi_2Te_3 and feature an ordered Mn sublattice. They are the first intrinsic magnetic topological insulators [1]. We obtain high-quality crystals for all n. $(MnBi_2Te_4)(Bi_2Te_3)_n$ are thermodynamically stable in narrow temperature ranges near 873 K. We establish ubiquitous off-stoichiometry of the materials, e.g. $Mn_{1-x}Bi_{2+2x/3}Te_4$ ($x = 0.15$). Temperature- and field-dependent magnetization measurements show a 3D antiferromagnetic order ($T_N = 24$ K) in $MnBi_2Te_4$. It originates from an AFM interlayer coupling of Mn(II) layers with ferromagnetic intralayer coupling. This magnetic ground state and a centrosymmetric space group $R\bar{3}m$ entail the $Z_2 = 1$ topological classification and render $MnBi_2Te_4$ the first AFM TI [1]. [1] M. Otrokov et al. Nature (2019), in press, arxiv.org: 1809.07389.

MA 7.5 Mon 10:30 POT 6

Intriguing magnetic ground state of $MnBi_4Te_7$: a Bi_2Te_3 derivative with a periodic Mn sublattice — •Laura T. Corredor-Bohórquez[1], Vilmos Kocsis[1], Anja U. B. Wolter[1], M. Hossein Haghighi[1], Nicolás Pérez[2], Jorge Facio[3], Bernd Büchner[1,4], and Anna Isaeva[1,4] — [1]Institute for Solid State and Materials Research, Leibniz IFW Dresden, 01069 Dresden, Germany — [2]Institute for Metallic Materials, Leibniz IFW Dresden, 01069, Dresden, Germany — [3]Institute for Theoretical Solid State Physics, Leibniz IFW Dresden, 01069, Dresden, Germany — [4]Faculty of Physics, Technische Universität Dresden, Dresden, Germany

Materials with a combination of non–trivial band topology and long-range magnetic order have been long desired, since it is expected the appearance of novel spintronic phenomena. Following theoretical advances material candidates are emerging. $MnBi_2Te_4$ is the first antiferromagnetic topological insulator [1] and the progenitor of a modular $(Bi_2Te_3)n(MnBi_2Te_4)$ series. For n = 1, it is established an antiferromagnetic state below 13 K followed by a state with net magnetization and ferromagnetic–like hysteresis below 5 K. Through static and dynamic magnetic characterization of single crystals, we build up a picture of the intriguing magnetic ground state of this new compound. Our results render $MnBi_4Te_7$ as a band inverted material with an intrinsic net magnetization and a complex magnetic phase diagram providing a versatile platform for the realization of different topological phases. [1] M. Otrokov et al. Nature (2019), in press. Arxiv.org:1809.07389.

MA 7.6 Mon 10:45 POT 6

Dynamic magnetic properties of a magnetic topological insulator material $MnBi_4Te_7$ — •Kavita Mehlawat[1,3], Alexey Alfonsov[1,3], Anna Isaeva[1,2,3], Bernd Buechner[1,2,3], and Vladislav Kataev[1,3] — [1]Institute for Solid State and Materials Research, Leibniz IFW Dresden, Dresden, Germany — [2]Faculty of Physics, Technische Universität Dresden, Dresden, Germany — [3]Würzburg-Dresden Cluster of Excellence ct.qmat

A van der Waals compound $MnBi_4Te_7$ belongs to the family of $(Bi_2Te_3)n(MnBi_2Te_4)$, (n = 0, 1, 2) heterostructures and is a candidate magnetic topological insulator [1]. It is the first magnetic material that features both, the intrinsic net magnetization and a band inversion. Static magnetic susceptibility (χ) and magnetization (M) measurements as a function of the applied field (H) on $MnBi_4Te_7$ single-crystals show an antiferromagnetic state at $T_N = 13$ K and

a ferromagnetic-like hysteresis occurring upon cooling below 5 K [1]. We performed electron spin resonance (ESR) spectroscopy measurements in wide frequency and temperature ranges to explore the dynamic magnetic properties of $MnBi_4Te_7$. From high-frequency ESR measurements, we obtain evidence that $MnBi_4Te_7$ is an easy-axis type ferromagnet and ferromagnetic spin correlations persist up to T = 30 K on the time scale of an ESR experiment (10^{-10} - 10^{-11} s). [1] Raphael C. Vidal et. al, Topological electronic structure and intrinsic magnetization in $MnBi_4Te_7$: a Bi_2Te_3-derivative with a periodic Mn sublattice, arXiv:1906.08394.

MA 7.7 Mon 11:00 POT 6

Spin orbit torque with topological insulator and ferro/antiferromagnetic heterostructures — •sumit ghosh[1,2] and aurelien manchon[2] — [1]PGI-1 and IAS-1, Forschungszentrum, Jülich 52425, Germany — [2]PSE, King Abdullah University of Science and Technology, Thuwal 23955, Saudi Arabia

Due to the robust spin-orbit coupling emerging at the surfaces, topological insulators like Bi2Se3 have become a strong source of spin-orbit torque [1,2]. However in the vicinity of a magnetic element the topological protection and hence the interfacial spin-orbit coupling change drastically. In this presentation, we are going to see some of the interesting phenomena arising at the interface of a topological insulator and ferro/antiferromagnet heterostructure [3,4]. Using a simplified tight binding model we are going to show how the interfacial spin texture is modified in the presence of a magnetic element and its impact on the non-equilibrium spin density within the linear response framework. We show how the non-equilibrium spin density changes while moving from surface dominated regime to bulk dominated regime. We also explain the origin of the large spin-Hall angle for the topological insulator ferromagnet heterostructure. Finally, we show their robustness against the scalar impurity to demonstrate their superiority against their heavy metal counterpart.

[1] A. R. Mellnik et. al., Nature, 511, 449 (2014).
[2] D. C. Mahendra et. al. Nature Materials, 17, 800 (2018).
[3] S. Ghosh and A. Manchon, Phys. Rev. B 97, 134402 (2018).
[4] S. Ghosh and A. Manchon, Phys. Rev. B 100, 014412, (2019).

MA 7.8 Mon 11:15 POT 6

Magneto-electrically controllable spin-orbit torque in topological insulator thin films — •Ali G. Moghaddam[1,2], Alireza Qaiumzadeh[3], Anna Dyrdal[4,2], and Jamal Berakdar[2] — [1]Department of Physics, Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan 45137-66731, Iran — [2]Institut für Physik, Martin-Luther Universität Halle-Wittenberg, D-06099 Halle, Germany — [3]Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway — [4]Faculty of Physics, Adam Mickiewicz University, ul. Umultowska 85, 61-614 Poznan, Poland

We investigate the inverse spin-galvanic effect (ISGE) in topological insulator thin films and the resulting spin-orbit torque (SOT) in the hybrid structures with magnetic layers. Considering in-plane magnetizations inside the magnetic layers which can shift the Dirac dispersion of surface states in the two sides, we find anisotropic ISGE and SOT with a strong dependence on the chemical potential and the magnetization. Then the magnetization-dependence of current-induced spin densities gives rise to a nonlinear field-like SOT which can be controlled by varying the magnetization and applying external gate voltages to change the chemical potential. Also, the mathematical relations between current-induced spin densities and the conductivity of this system results in similar anisotropic features in the magneto-conductance of TI thin film.