

MA 50: Topology and Symmetry-Protected Materials (joint session O/MA/TT)

Time: Thursday 15:00–17:45

Location: H24

MA 50.1 Thu 15:00 H24

Structural and electronic characterization of thin Fe(Se,Te) films on the quaternary (Bi,Sb)Se_xTe_{1-x} 3D topological insulator — ●PHILIPP KAGERER, THIAGO R. F. PEIXOTO, CELSO FORNARI, HENDRIK BENTMANN, and FRIEDRICH REINERT — Experimental Physics VII, Julius Maximilian University of Würzburg

The combination of an s-wave superconductor iron-chalcogenide and a 3D-topological insulator (TI) has become a vivid research topic in condensed matter physics due to the proposed emergence of bound Majorana zero modes at the interface under the presence of a time-reversal-breaking magnetic field [1]. Owing to its simple cubic structure and good growth properties, thin FeSeTe layers on (Bi,Sb)Se_xTe_{1-x} pose a promising platform to test this prediction.

Here we report on the epitaxial growth and characterization of thin layers of Fe(Se,Te) on a quaternary (Bi,Sb)(Se,Te) TI single-crystal. LEED and XPS experiments as well as STM and STS scans confirm the formation of a few monolayers of Fe(Se,Te) on top of the TI substrate. Using ARPES we show the arising of the FeSeTe valence bands near the Fermi level, along with the heavily n-doped band structure of the underlying TI. In addition, photon-energy-dependent and resonant measurements using synchrotron radiation allow a distinction between substrate and overlayer bands, and show indications for strong electron correlation and a Hubbard-gap in the material [2].

- [1] L.Fu, C.L. Kane, Phys. Rev. Lett. 100, 096407 (2008)
[2] M.D.Watson et al., Phys. Rev. B 95, 081106(R) (2017)

MA 50.2 Thu 15:15 H24

Magnetic and Electronic Structure of the proposed Antiferromagnetic Topological Insulator MnBi₂Te₄ — ●RAPHAEL CRESPO VIDAL¹, HENDRIK BENTMANN¹, THIAGO PEIXOTO¹, ALEXANDER ZEUGNER², ANNA ISAEVA², ANJA WOLTER³, BERND BÜCHNER³, MIKHAIL OTROKOV⁴, EVGUENI CHULKOV⁴, and FRIEDRICH REINERT¹ — ¹Chair for Experimental Physics VII, Universität Würzburg, Germany — ²Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Germany — ³Leibniz-Institute for Solid State and Materials Research, Dresden, Germany — ⁴Centro de Física de Materiales, Centro Mixto, Spain

The interplay of magnetism and topology gives rise to new topological quantum phases with broken time-reversal symmetry like the quantum anomalous Hall state.

Here we will present single-crystal measurements on the magnetic and electronic structure of MnBi₂Te₄ [1], a van der Waals bonded system composed of septuple layers stacked along its [0001]-axis. The layered structure results in a high accessibility for surface science methods, while its stoichiometric nature leads to intrinsic magnetism without the need of free parameters like dopand concentration. By X-Ray magnetic circular dichroism, linear dichroism and bulk magnetization measurements we determine an out of plane A-type antiferromagnetic ordering below T_N = 24 K. Angle-resolved photoemission spectroscopy shows a massive Dirac-like state with an energy gap of ~100 meV.

- [1] M. Otrokov et al., ArXiv., 1809.07389 (2018)

MA 50.3 Thu 15:30 H24

XAS/XMCD study of magnetically doped (Bi,Sb)₂Te₃ — ●ABDUL-VAKHAB TCAKAEV, VOLODYMYR ZABOLOTNYI, STEFFEN SCHREYECK, KARL BRUNNER, CHARLES GOULD, and VLADIMIR HINKOV — University Würzburg, Am Hubland, 97074 Würzburg

The magnetic topological insulators Cr:(BiSb)₂Te₃ and V:(BiSb)₂Te₃ have been extensively studied as realizations of the quantum anomalous Hall (QAH) effect. While the QAH state in V-doped films is found to be significantly superior, the differences in the electronic structure and in the mechanisms of magnetic ordering for V- and Cr-doping remain under intensive debate. Here we combine x-ray absorption (XAS) and x-ray magnetic circular dichroism (XMCD) to trace element-specific contributions to the electronic and magnetic properties of these systems. We use *ab initio* density functional theory (DFT) based multiplet ligand field theory calculations (MLFT) at Cr and V L_{2,3} edges for understanding and interpreting experimental results and determine local electronic and magnetic properties of these topological insulators.

MA 50.4 Thu 15:45 H24

Laser-based ARPES and pressure dependent magneto-transport studies of BiSbTe₃ topological insulator — ●SHIV KUMAR¹, VINOD KUMAR GANGWAR², YUFENG ZHANG^{3,4}, PRASHANT SHAHI⁵, HITOSHI TAKITA¹, SWAPNIL PATIL², EIKE FABIAN SCHWIER¹, KENYA SHIMADA¹, YOSHIYA UWATOKO⁴, and SANDIP CHATTERJEE² — ¹Hiroshima Synchrotron Radiation Center, Hiroshima University, Higashi-Hiroshima City, 739-0046, Japan — ²Dept. of Physics, Indian Institute of Technology (BHU) Varanasi 221005, India — ³School of Physics and Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 211189, China — ⁴ISSP, University of Tokyo, Kashiwa, Chiba 277-8581, Japan — ⁵Dept. of Physics, D.D.U. Gorakhpur University, Gorakhpur 273009, India

In recent years, 3D topological insulators (TIs), have drawn significant attention in condensed matter physics. Many TIs are known as good thermoelectric (TE) materials. We have grown single-crystal BiSbTe₃ 3D TI sample and studied structural, TE as well as pressure dependent magnetotransport properties. Large positive Seebeck coefficient confirmed the p-type nature of BiSbTe₃, which is consistent with Hall measurement. We have also studied the electronic band structure using Laser-based ARPES, which revealed the existence of a Dirac-cone like metallic surface state in BiSbTe₃ with a Dirac Point situated exactly at the Fermi level. The large Seebeck coefficient and good TE performance at room-temperature attract great attention for the application in TE devices. Additionally, superconductivity emerges under pressure of 8 GPa with a critical temperature of ~2.5 K.

Invited Talk

MA 50.5 Thu 16:00 H24

Luttinger liquid in a box: electrons confined within MoS₂ mirror twin boundaries — ●WOUTER JOLIE^{1,2}, CLIFFORD MURRAY¹, PHILIPP WEISS³, JOSHUA HALL¹, FABIAN PORTNER³, NICOLAE ATODIRESEI⁴, ARKADY KRASHENINNIKOV^{5,6}, CARSTEN BUSSE^{1,2,7}, HANNU-PEKKA KOMSA⁶, ACHIM ROSCH³, and THOMAS MICHELY¹ — ¹II. Physikalisches Institut, University of Cologne, Germany — ²Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Germany — ³Institute for Theoretical Physics, University of Cologne, Germany — ⁴Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich, Germany — ⁵Helmholtz-Zentrum Dresden-Rossendorf, Germany — ⁶Department of Applied Physics, Aalto University, Finland — ⁷Department Physik, Universität Siegen, Germany

Two- or three-dimensional metals are usually well described by weakly interacting, fermionic quasiparticles. This concept breaks down in one dimension due to strong Coulomb interactions. There, low-energy excitations are expected to be collective bosonic modes, which fractionalize into independent spin and charge density waves.

In this talk I will present how we construct a well-isolated, one-dimensional metal of finite length using mirror twin boundaries in molybdenum disulfide (MoS₂). We demonstrate how scanning tunneling spectroscopy can identify the unique fingerprints of confined, strongly interacting states, thereby providing a direct and local experimental tool to investigate spin-charge separation in real space.

MA 50.6 Thu 16:30 H24

Structure and electronic properties of antimonene layers on Bi₂Se₃ interfaces — ●KRIS HOLTGREWE¹, CONOR HOGAN², and SIMONE SANNA¹ — ¹University of Giessen, Germany — ²CNR-ISM, Rome, Italy

Topological insulators (TI) exhibit unconventional physical effects that have attracted the interest of the scientific community, especially when coupled to trivial insulators. A topologically insulating Bi₂Se₃ substrate covered by the trivial insulator antimonene, is an ideal testbed to study the interfacial phenomena [1], and is furthermore interesting for applications such as topological pn-junctions [2].

Much research effort has been dedicated to surface preparation [3], recording of STM and ARPES images, as well as band structure calculations. However, the Sb-coverage dependent spin texture (e. g. position of Dirac states, Rashba splitting) is still not fully understood. Our work is dedicated to the theoretical investigation of the relationships between structural motifs, band structures and STM pattern. Thereby we show that including both spin-orbit coupling and van-der-Waals interaction in our density functional theory based approach is

crucial for the correct modelling of the system.

[1] K. Jin et al, Phys Rev B **93**, 075308 (2016)

[2] S. Kim et al., ACS Nano **11**, 9671 (2017)

[3] R. Flammini, S. Colonna, C. Hogan, S. K. Mahatha, M. Papagno, A. Barla, P. M. Sheverdyeva, P. Moras, Z. S. Aliev, M. B. Babanly, E. V. Chulkov, C. Carbone, and F. Ronci, Nanotechnology **29**, 065704 (2018)

Invited Talk

MA 50.7 Thu 16:45 H24

Quasiparticle interferences on Type I and Type II Weyl semimetal surfaces — ●HAO ZHENG — School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China

A Weyl semimetal is a new topological phase of matter that extends the topological classification beyond insulators, exhibits quantum anomalies, possess exotic surface Fermi arc electron states and provides the first ever realization of Weyl fermions in physics. In a Weyl semimetal, the chirality of the Weyl nodes give rise to topological charges, which can be understood as monopoles and anti-monopoles of Berry flux in momentum space. They are separated in momentum space and are connected only through the crystal boundary by an unusual topological surface state, a Fermi arc. The surface of a Weyl semimetal has been predicted to exhibit interesting tunneling and transport properties, leading to potential electronic and spintronic applications.

We employed scanning tunneling microscopy/spectroscopy to directly visualize the coherent quasiparticle interferences on both type-I and type-II Weyl semimetal surfaces. On NbP (type-I Weyl) surface, we reveal that the surface interference channels are restricted by their surface spin and/or orbit textures and discover the existence of surface Dirac cones. On $\text{Mo}_x\text{W}_{1-x}\text{Te}_2$ (type-II Weyl), the topological Fermi arc derived quantum interference is clearly discerned. Our results may pave a new way towards the future research on a Weyl fermion related surface transport phenomena and devices.

MA 50.8 Thu 17:15 H24

Bulk and Surface Electronic Structure of the Weyl-Semimetals TaP and TaAs — ●TIM FIGGEMEIER¹, CHUL-HEE MIN¹, PHILLIP ECK², JENNIFER NEU³, MAXIMILIAN UENZELMANN¹, DOMENICO DI SANTE², THEO M. SIEGRIST^{3,4}, GIORGIO SANGIOVANNI², HENDRIK BENTMANN¹, and FRIEDRICH REINERT¹ — ¹Experimentelle Physik VII, Universitaet Wuerzburg — ²Theoretische Physik I, Universitaet Wuerzburg — ³National High Magnetic Field Laboratory, Tallahassee, Florida — ⁴College of Engi-

neering, FAMU-FSU, Tallahassee, Florida

Tantalum Arsenide (TaAs) and Tantalum Phosphide (TaP) are prototypical Weyl-Semimetals. We examine the electronic band structure using Angle-Resolved Photoemission Spectroscopy over a broad range of excitation energies from the VUV to the Soft X-Ray regime. With this high flexibility in photon energies, we are able to analyse the entire complex band structure of TaP in detail. In particular the surface states and the bulk band structure are identified at different photon energies and compared to first principles DFT calculations. By use of linear polarized light, we disentangle the orbital character of the Fermi arcs and other electronic states in the Fermi surface along with their connection to the bulk band structure [1].

[1] Min et al., "Orbital Fingerprint of Topological Fermi Arcs in a Weyl Semimetal", arXiv:1803.03977 (2018)

MA 50.9 Thu 17:30 H24

Exploring the spin-orbital texture in a Dirac heavy metal by spin-resolving momentum microscopy — ●YING-JIUN CHEN^{1,2}, CHRISTIAN TUSCHE^{1,2}, MARKUS HOFFMANN³, BERND ZIMMERMANN³, GUSTAV BIHLMAYER³, STEFAN BLÜGEL³, and CLAUS MICHAEL SCHNEIDER^{1,2} — ¹Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — ²Fakultät für Physik, Universität Duisburg-Essen, 47057 Duisburg, Germany — ³Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Entanglement of spin and orbital degrees of freedom in strongly spin-orbit coupled materials creates exotic spin/orbital textures in momentum space such as Rashba and topological protected surface states. Dichroism in spin-polarized photoemission plays a crucial role in understanding the influence of spin-orbit coupling on the electronic wave functions. By virtue of the recent invention of the spin-resolving Momentum Microscope, the spin-detection efficiency and momentum resolution has been improved tremendously. This development makes it now possible to probe the photoelectron spin polarization as well as linear and circular dichroism in the angular distribution over the whole Brillouin zone. In addition to the d-electron-driven Dirac-type helical spin texture, we directly characterize the momentum-dependent spin-orbital entangled states on W(110) throughout the entire surface Brillouin zone by using differently polarized light. Comparison between theory and experiment provides insights into the large anisotropy of spin relaxation in the prototype Dirac heavy metal.