TT 61: Topology and Symmetry-Protected Materials (joint session O/MA/TT)

Time: Thursday 15:00–17:45 Location: H24

TT 61.1 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)

TT 61.2 Thu 15:15 H24

Magnetic and Electronic Structure of the proposed Antiferromagnetic Topological Insulator $MnBi_2Te_4$ — •Raphael Crespo Vidal[1], Hendrik Bentmann[1], Thiago Peixoto[1], Alexander Zeugner[2], Anna Isaeva[2], Anja Wolter[3], Bernd Büchner[3], Mikhail Otrokov[4], Evgueni Chulkov[4], and Friedrich Reinert[1] — [1]Chair for Experimental Physics VII, Universität Würzburg, Germany — [2]Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Germany — [3]Leibniz-Institute for Solid State and Materials Research, Dresden, Germany — [4]Centro de Fisica de Materials, Centro Mixto, Spain

The interplay auf 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 $MnBi_2Te_4$ [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 stochiometric 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 $\sim 100\,meV$.

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

TT 61.3 Thu 15:30 H24

XAS/XMCD study of magnetically doped $(Bi,Sb)_2Te_3$ — •Abdul-Vakhab Tcakaev, Volodymyr Zabolotnyy, Steffen Schreyeck, Karl Brunner, Charles Gould, and Vladimir Hinkov — University Würzburg, Am Hubland, 97074 Würzburg

The magnetic topological insulators Cr:$(BiSb)_2Te_3$ and V:$(BiSb)_2Te_3$ 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.

TT 61.4 Thu 15:45 H24

Laser-based ARPES and pressure dependent magneto-transport studies of BiSbTe3 topological insulator — •Shiv Kumar[1], Vinod Kumar Gangwar[2], Yufeng Zhang[3,4], Prashant Shahi[5], Hitoshi Takita[1], Swapnil Patil[2], Eike Fabian Schwier[1], Kenya Shimada[1], Yoshiya Uwatoko[4], and Sandip Chatterjee[2] — [1]Hiroshima Synchrotron Radiation Center, Hiroshima University, Higashi-Hiroshima City, 739-0046, Japan — [2]Dept. of Physics, Indian Institute of Technology (BHU) Varanasi 221005, India — [3]School of Physics and Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 211189, China — [4]ISSP, University of Tokyo, Kashiwa, Chiba 277-8581, Japan — [5]Dept. 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 TT 61.5 Thu 16:00 H24

Luttinger liquid in a box: electrons confined within MoS_2 mirror twin boundaries — •Wouter Jolie[1,2], Clifford Murray[1], Philipp Weiss[3], Joshua Hall[1], Fabian Portner[3], Nicolae Atodiresei[4], Arkady Krasheninnikov[5,6], Carsten Busse[1,2,7], Hannu-Pekka Komsa[6], Achim Rosch[3], and Thomas Michely[1] — [1]II. Physikalisches Institut, University of Cologne, Germany — [2]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Germany — [3]Institute for Theoretical Physics, University of Cologne, Germany — [4]Peter Grünberg Institute and Institute for Advanced Simulation, Forschungszentrum Jülich, Germany — [5]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [6]Department of Applied Physics, Aalto University, Finland — [7]Department 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 (MoS_2). 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.

TT 61.6 Thu 16:30 H24

Structure and electronic properties of antimonene layers on Bi2Se3 interfaces — •Kris Holtgrewe[1], Conor Hogan[2], and Simone Sanna[1] — [1]University of Giessen, Germany — [2]CNR-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 Bi_2Se_3 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. Sheverdyaeva, P. Moras, Z. S. Aliev, M. B. Babanly, E. V. Chulkov, C. Carbone, and F. Ronci, Nanotechnology **29**, 065704 (2018)

Invited Talk TT 61.7 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 $Mo_xW_{1-x}Te_2$ (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.

TT 61.8 Thu 17:15 H24

Bulk and Surface Electronic Structure of the Weyl-Semimetals TaP and TaAs — •Tim Figgemeier[1], Chul-Hee Min[1], Phillip Eck[2], Jennifer Neu[3], Maximilian Uenzelmann[1], Domenico Di Sante[2], Theo M. Siegrist[3,4], Giorgio Sangiovanni[2], Hendrik Bentmann[1], and Friedrich Reinert[1] — [1]Experimentelle Physik VII, Universitaet Wuerzburg — [2]Theoretische Physik I, Universitaet Wuerzburg — [3]National High Magnetic Field Laboratory, Tallahassee, Florida — [4]College of Engineering, 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)

TT 61.9 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 Hoffmann[3], Bernd Zimmermann[3], Gustav Bihlmayer[3], Stefan Blügel[3], and Claus Michael Schneider[1,2] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Fakultät für Physik, Universität Duisburg-Essen, 47057 Duisburg, Germany — [3]Peter 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-drived 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.