TT 20: Topology: Poster Session

In case the presenters cannot be present at their posters for the full duration of the poster session, they are kindly requested to leave a note at their poster indicating when they will be available for discussion.

Time: Wednesday 15:00–18:00 Location: P1

TT 20.1 Wed 15:00 P1

Effects of in-plane polarised light on graphene: Band gap, spin and topological quantum numbers — •Frederik Bartelmann[1], Marta Prada[2], and Daniela Pfannkuche[1,3] — [1]University of Hamburg, I. Institute of Theoretical Physics — [2]University of Hamburg, Institute of Nanostructure and Solid State Physics — [3]The Hamburg Centre for Ultrafast Imaging

If it were not for the effects of spin-orbit interaction, the band gap in graphene would close at the K-points, resulting in perfect Dirac cones. In this work, a graphene tight-binding band structure involving atomic s-, p- and d-orbitals is modified by irradiation with light. The light is polarised in-plane to affect the d_{xz}- and d_{yz}-orbitals, which are coupled via spin-orbit interaction, and the p_z-orbitals, which are predominant in the valence and conduction band. Floquet formalism is used to obtain dressed states and an altered band structure. The changes to valence and conduction band and thus the band gap are studied for a range of frequencies in the PHz regime. Along these studies, the correlation between real- and sublattice spin is probed as well as topological properties and how they behave under a change of frequency. Since the focus lies on the effects due to changes in the orbital composition of the dressed states, inter-band couplings are prioritised over intra-band ones. The goal of the studies is to gauge the effect of different irradiated frequencies on graphene and to evaluate possible applications of dressed states for topological quantum computers.

TT 20.2 Wed 15:00 P1

Static and dynamic magnetism of $(MnBi_2Te_4)(Bi_2Te_3)_n$ $(n = 0, 1)$ probed by electron spin resonance technique. — •Alexey Alfonsov[1], Kavita Mehlawat[1,2], Jorge I. Facio[1], Ali G. Moghaddam[1,3], Rajyavardhan Ray[1], Alexander Zeugner[4,5], Manuel Richter[1,5], Anna Isaeva[1,6], Jeroen van den Brink[1,2,5], Bernd Büchner[1,2,5], and Vladislav Kataev[1] — [1]Leibniz IFW Dresden, 01069 Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat — [3]IASBS, Zanjan 45137-66731, Iran — [4]H.C. Starck Tungsten GmbH, 38642 Goslar, Germany — [5]TU Dresden, 01062 Dresden, Germany — [6]University of Amsterdam, 1098 XH Amsterdam, The Netherlands

$(MnBi_2Te_4)(Bi_2Te_3)_n$ $(n = 0, 1)$ are van der Waals materials which exhibit a coexistence of topologically nontrivial surface states with intrinsic magnetism. In this work we address static and dynamic magnetic properties of the title materials in the ordered and disordered states using multifrequency and high field electron spin resonance technique. We show that the spin dynamics of the magnetic building blocks of these compounds, the Mn-based septuple layers (SLs), is inherently ferromagnetic (FM) featuring persisting short-range FM correlations far above the magnetic ordering temperature as soon as the SLs get decoupled either by introducing a nonmagnetic quintuple interlayer, as in $MnBi_4Te_7$, or by applying a moderate magnetic field, as in $MnBi_2Te_4$. Additionally, $MnBi_2Te_4$ exhibits a strongly anisotropic Mn spin relaxation in the paramagnetic state, which we explain by the sensitivity of the local electronic structure to the Mn spin orientation.

TT 20.3 Wed 15:00 P1

Low-dimensional spin correlations in $Mn_2P_2S_6$ and $MnNiP_2S_6$ as revealed by ESR spectroscopy — •Yurii Senyk[1], Joyal John Abraham[1,2], Alexey Alfonsov[1], Yuliia Shemerliuk[1], Sebastian Selter[1,2], Saicharan Aswartham[1], Bernd Büchner[1,3], and Vladislav Kataev[1] — [1]Leibniz IFW Dresden, D-01069 — [2]Institute for Solid State and Materials Physics, TU Dresden, D-01069 — [3]Institute for Solid State and Materials Physics and Wurzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, D-01062

$Mn_2P_2S_6$ and $MnNiP_2S_6$ are members of the transition metal phosphorus trichalcogenide family which belongs to the layered van der Waals (vdW) materials class. Such compounds are considered to be attractive for designing novel spintronic devices due to their remarkable structural and magnetic properties. Here we report the electron spin resonance studies on single crystals of $Mn_2P_2S_6$ and $MnNiP_2S_6$ using an X-band (9.56 GHz) spectrometer. Measurements were done in a wide temperature range and at various angles between the applied magnetic field and crystal axes. The obtained spectra can be well fitted to the Lorentzian lineshape enabling an accurate determination of the linewidth and the resonance field. Remarkably, the angular temperature dependences of the linewidth show signatures of the low-dimensional spin-spin correlations in the pure Mn compound whereas the mixed compound demonstrates a rather three-dimensional behaviour.

TT 20.4 Wed 15:00 P1

Quantum anomalous hall devices on magnetically doped topological insulator films — •Roozbeh Yazdanpanah Ravari[1], Gertjan Lippertz[1,2], Anjana Uday[1], Andrea Bliesener[1], Alexey Taskin[1], and Yoichi Ando[1] — [1]University of Cologne, Cologne, Germany — [2]KU Leuven, Leuven, Belgium

Magnetic doping opens an exchange gap in the surface states of topological insulators (TIs) at the Dirac point by breaking time reversal symmetry. Such systems manifest the quantum anomalous Hall (QAH) effect which is characterized by quantized Hall resistance and zero longitudinal resistance. To explore this phenomena, devices are fabricated on thin films of V-doped $(Bi_{1-x}Sb_x)_2Te_3$. This contribution highlights our effort to better understand this effect, including a study of the QAH breakdown where in high current densities or small dimensions, the quantized state is lost. Another ongoing effort focuses on interfacing the quantum anomalous hall insulator (QAHI) system with a superconductor (SC) through devices with different geometries, where the obtained results suggest high transparency of the QAH/SC interface.

TT 20.5 Wed 15:00 P1

Entanglement spectrum of Su-Schrieffer-Heeger model — •Mahsa Alsadat Seyed Heydari[1] and Jahanfar Abouei[2] — [1]University of Konstanz, Germany — [2]Institute for Advanced Studies in Basic Sciences (IASBS), Iran

We investigate the ground state properties of a one dimensional topological insulator, the Su-Schrieffer-Heeger (SSH) chain in the absence/presence of an alternative spin-orbit coupling (SOC), employing single-particle entanglement spectrum (ES). In the presence of SOC, owing to the spin-flip processes, different topologically trivial and nontrivial phases appear in the ground state phase diagram of the model. Using the matrix of single-particle correlation functions, we obtain the single-particle ES as well as the entanglement entropy, and show that they behave differently in these phases. We introduce an indicator, called entanglement gap, defined as the difference between the lowest positive entanglement level and the highest negative level, and demonstrate that this indicator distinguishes the topological phases from the trivial phase of the model.

TT 20.6 Wed 15:00 P1

Current increase by weakening site-site interaction in SSH lattices — •Mirko Rossini, Brecht Donvil, and Joachim Ankerhold — Institute for Complex Quantum Systems and IQST, Ulm University, Germany

One of the simplest models supporting topologically protected states is the well-known Su-Schrieffer-Heeger (SSH) model. As a 1D chain with staggered NN hopping amplitudes, it can host two protected 0-energy modes when the distribution of hopping amplitudes is properly adjusted. These edge states are energetically relatively stable against ambient noise. thus providing natural protection from any excitation living on an edge of the chain.

In this poster, we show the realization of a current through such a chain, which in the topological regime could provide a naturally protected channel for the safe transport of excitations in space. The current is created by terminating the SSH chain at particle reservoirs. It has been shown that the edge-to-edge transport of particles in such a system is exponentially suppressed with respect to the length of the chain, preventing the practical use of this model for the stated purposes. Therefore we propose, after a brief introduction to the main properties of the SSH model, an extended model for the 1D lattice that, by weakening a small selection of hopping parameters along the chain, is able to increase the current through the edges while preserving some of the topological protection offered by the original SSH model.

TT 20.7 Wed 15:00 P1

Search for new europium-based intermetallic 122 materials with non-trivial topological properties — •Sarah Krebber, Kristin Kliemt, Cornelius Krellner, and Asmaa El Mard — Max-von-Laue Straße 1, 60438 Frankfurt am Main, Physikalisches Institut

Today, more and more Eu-based compounds come into focus of magnetic topological nontrivial materials. The first examples were thin films of EuS on Bi_2Se_3 [1]. In recent studies, the material $EuCd_2As_2$ has attracted a lot of attention due to emergence of a variety of topological phases and magnetic phenomena [2,3]. Recently, a spin fluctuation induced Weyl semimetal state in the paramagnetic phase of $EuCd_2As_2$ [2] and its tunability by pressure [4] was discovered. Furthermore, the similar material $EuCd_2P_2$ has been explored due to its strong colossal magnetoresistance effect [5]. In this work we present the single crystal growth and characterization of the related system EuT_2X_2, with T = Cd, Zn, Mn and X = P, crystallizing in the same trigonal structure (P-3m1) in order to search for similar effects in these materials. The physical properties of the compounds are explored via magnetization, electrical transport and heat capacity.

[1] Katmis et al., Nature 533, 513 (2016)
[2] Ma et al., Science Adv. 5, eaaw4718 (2019)
[3] Jo et al., Phys. Rev. B 101, 140402(R) (2020)
[4] Gati et al., Phys. Rev. B 104, 155124 (2021)
[5] Wang et al., Adv.Mater. 33, 2005755 (2021)

TT 20.8 Wed 15:00 P1

Band structure and effective masses of the topological semimetal PdGa — •F. Husstedt[1,2], B.V. Schwarze[1,2], M. Uhlarz[1], S. Chattopadhyay[1], K. Manna[3,4], S. Shekhar[3], C. Felser[3], and J. Wosnitza[1,2] — [1]Hochfeld-Magnetlabor Dresden (HLD-EMFL) and Würzburg-Dresden Cluster of Excellence ct.qmat, HZDR, Germany — [2]Institut für Festkörper- und Materialphysik, TU Dresden, Germany — [3]Max Planck Institute for Chemical Physics of Solids, Germany — [4]Indian Institute of Technology Delhi, India

De Haas-van Alphen (dHvA) measurements at low temperatures and fields up to 18 T provided insight into the band structure of the topological semimetal PdGa which is presented in this poster. Previous investigation of PtGa revealed the topological character [1] of this sister compound of PdGa. Hence, angle-resolved measurements of the dHvA effect were performed on PdGa and showed a good agreement with the calculated band structure. This revealed a multitude of Fermi surfaces and eight spin-splitted bands crossing the Fermi energy. In particular, the calculations show a similar band structure as for PtGa, including two topologically protected multifold degenerate band-touching nodes. Furthermore, we analyzed the temperature dependence of the dHvA oscillations to determine the effective masses for field aligned along the crystallographic [100] axis. The low masses also show a good agreement to the calculations and, therefore, indicate insignificant correlations of the electrons.

[1] M. Yao, K. Manna *et al.*, Nat. Commun. **11**, 2033 (2020).

TT 20.9 Wed 15:00 P1

Current phase relation of HgTe nanowire Josephson junctions in an axial magnetic field — •N. Hüttner[1], W. Himmler[1], D. A. Kozlov[2], N. N. Mikhailov[2], S. A. Dvoretsky[2], D. Weiss[1], and C. Strunk[1] — [1]Experimental and Applied Physics, University of Regensburg, D-93040 Regensburg, Germany — [2]Novosibirsk, Russia

Topological insulators (TIs) such as HgTe nanowires host topological surface states. Their band structure can be tuned to a Dirac shape via the application of an axial magnetic field ($B_{\|}$) [1]. For proximitized nanowires this is expected to tune between trivial and topological supercurrents as recent experiments suggest [2]. Here we directly probe the current phase relation (CPR) of a tunable TI Josephson junction. The TI junction consists of a HgTe nanowire proximitized by superconducting Nb contacts embedded into an asymmetric DC-SQUID together with an Al/AlOx/Al junction. Beeing in the short junction regime [2], the TI junction features a strongly anharmonic CPR [3,4] with a high average transparency of $D \approx 0.95$ for $n \approx 9 \pm 2$ channels [4]. Varying $B_{\|}$ controls the magnetic flux enclosed by the nanowire surface. In the range $0 - 1.5\Phi_0$ we observe a strong modulation of the critical current and interference of phase shifted contributions of individual channels creating a great variety of CPR shapes.

[1] A. Cook *et al.*, Phys. Rev. B **84**, 201105 (2011).
[2] R. Fischer *et al.*, Phys. Rev. Res. **4**, 013087 (2022).
[3] A. A. Golubov *et al.*, Rev. Mod. Phys. **76**, 411 (2004).
[4] C. Baumgartner *et al.*, Phys. Rev. Lett. **126**, 037001 (2021).

TT 20.10 Wed 15:00 P1

Ground-state splitting of parafermions zero modes at a finite distance — •Raphael L R C Teixeira[1,2], Amal Mathew[2,3], Roshni Singh[2,3], Solofo Groenedijk[2], Andreas Haller[2], Edvin G Idrisov[2], Luis G G V Dias da Silva[1], and Thomas L Schmidt[2] — [1]Instituto de Fisica - Universidade de Sao Paulo, Sao Paulo Brazil — [2]Department of Physics and Materials Science Université du Luxembourg, Luxembourg, Luxembourg — [3]Indian Institute of Technology, Bombay, India

Parafermion bound states can be regarded as fractional excitations that generalize Majorana bound states. Parafermions appear in strongly-correlated systems, and in particular, fractional Quantum Hall (FQH) edge states with induced superconductivity can be used to create localized $\mathbb{Z}_{2n}$ parafermion modes. Previous works have used the single-instanton approximation to calculate the ground-state energy splitting in the limit of a large distance between the parafermions. In this work, we go beyond this approximation to determine the energy splitting in shorter systems, paving the way to better understanding experimentally relevant systems. We discuss the implications of a finite length in the coupling between parafermions and how it goes beyond the corresponding effect for Majorana bound states.We The analytical results agreed with Monte Carlo simulations implying the corrections we found cannot be neglected.

TT 20.11 Wed 15:00 P1

Full counting statistics of electron transport through a Majorana single-charge transistor — •Eric Kleinherbers, Alexander Schünemann, and Jürgen König — Faculty of Physics and CENIDE, University Duisburg-Essen, 47057 Duisburg, Germany

We study full counting statistics of electron transport through a Majorana single-charge transistor (MSCT) [1]. The MSCT can host both Majorana bound states and Cooper pairs. In addition, the system is coupled to a superconducting and a metallic lead. A current through the system is realized by means of the Josephson-Majorana cycle [2], where sequential tunneling (normal and anomalous) of two electrons into the system is followed by the transfer of a Cooper pair into the superconductor. We find a highly correlated electron transfer which can be indicated by a sign violation of factorial cumulants. Moreover, when the superconductor is only weakly coupled to the MSCT, we find for large bias voltages a strong suppression of the electron current. This effect is explained by the excitation of a dark state that effectively decouples from the leads.

[1] A. Zazunov et al., Phys. Rev. B 84, 165440 (2011)
[2] N. Didier et al., Phys. Rev. B 88, 024512 (2013)