TT 56: Poster Session: Low-Dimensional Systems

Time: Wednesday 15:00–19:00 Location: P2-OG4

TT 56.1 Wed 15:00 P2-OG4

Oxidation and temperature dependent resistivity of VSe_2 flakes — •Benedikt Brechtken, Christopher Belke, Hennrik Schmidt, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover

Many 2D materials are of interest for the design of innovative devices. But some of them are chemically less stable than the well known graphene. The influence on the properties of VSe_2 flakes through oxidation in ambient air at room temperature is studied. Therefore VSe_2 flakes were fabricated with the scotch tape method under nitrogen atmosphere and Cr/Au-contacts were build on the flakes with e-beam lithography.

The surface oxidation was investigated via optical microscopy and atomic force microscopy. A slow oxidation and formation of small oxidhills on the flake surface could be observed. A two point measurement at room temperatur showed a resistance of 250 Ohm for a 30 nm thick flake.

Furthermore the temperature dependence of the resistivity was studied in a He cryostat. Between room temperature and the Debye temperature a linear dependance was measured. Under the Debye temperature the dependance showed a power-law relation. That is a classical metallic behavior as it was found in VSe_2 bulk material [1]. Around 95 K a charge-density-wave was expected [2]. That could not be measured, most likely because of the low mobility of the sample.

[1] A. Toriumi, and S. Tanaka, Physika **105B**, 141, (1981)
[2] J. Yang, et al., Applied Physics Letters **105**,063109 (2014)

TT 56.2 Wed 15:00 P2-OG4

Photoemission study of the bulk band dispersion in 1T-TaS_2 at 30 K — •Arlette S. Ngankeu[1], Sanjoy K. Mahatha[1], Marco Bianchi[1], Charlotte E. Sanders[1], Kai Rossnagel[2], and Philip Hofmann[1] — [1]Department of Physics and Astronomy, Aarhus University, 8000 Aarhus C, Denmark — [2]Institute for Experimental and Applied Physics, University of Kiel, 24098 Kiel, Germany

The ground states of many layered transition metal dichalcogenides, including 1T-TaS_2, are governed by charge density waves (CDWs) associated with periodic lattice distortions. These distortions are accompanied by changes of the electronic structure due to Brillouin zone reconstructions. In the case of 1T-TaS_2, the low-temperature commensurate CDW state even coexists with a Mott-insulating ground state. While many studies have addressed the origin of the CDW in 1T-TaS_2, there have been recent theoretical results specifically addressing the three-dimensional nature of the bands associated with the Mott state, finding that the Mott state leads to an insulating in-plane state while the out-of-plane dispersion of the state remains metallic.

We have investigated the electronic band structure of 1T-TaS_2 in the commensurate-CDW phase in all three dimensions by means of synchrotron radiation-based angle resolved photoemission spectroscopy. The measured in-plane band structure is consistent with previous results from the literature. We observe an out-of-plane dispersion of the lower Mott state, as predicted, but no Fermi crossing, such that a 3D insulating behavior is retained.

TT 56.3 Wed 15:00 P2-OG4

Charge and orbital order in 1T-TaS_2 — •Florian Heinsch[1,2], Helmuth Berger[3], Bernd Büchner[4], Thomas Cowan[1], Michal Dušek[5], Tobias Förster[1], Joachim Wosnitza[1], Klaus Koepernik[4], Václav Petříček[5], Tobias Ritschel[2], Marc Uhlarz[1], and Jochen Geck[2] — [1]HZDR — [2]TU Dresden — [3]EPFL — [4]IFW Dresden — [5]Institute of Physics, Prague

Recently discovered phenomena in thin films of 1T-TaS_2, like a laser induced ultra-fast switching to a hidden quantum states, offer great potential for future applications and prove that one has not yet unraveled the microscopic interactions behind the origin of the electronic order in this system completely [1].

One piece of the puzzle seems to be an orbital texture that is intertwined with the CDW in the commensurate state [2]. We investigated the incommensurate structural modulations of 1T-TaS_2, which occur above T=350K, by means of single crystal X-ray diffraction and refined the crystal structure in the formalism of a (3+2)-dimensional superspace. Based on these information, we performed DFT calculations for repeating clusters. The obtained highest occupied molecular orbitals imply an orbital ordering. Since those degrees of freedom are expected to affect the magnetic susceptibility as well, we also started to reinvestigate the magnetic field dependence of the CDW-instability in 1T-TaS_2. For the future we aim on time-resolved diffration experiments in high magnetic fields to gain insights into microscopical interactions.

[1] L. Stojchevska et al., Science 344.6180 (2014), pp. 177-180
[2] T. Ritschel et al., Nature Physics 11.4 (2015), pp. 328-331

TT 56.4 Wed 15:00 P2-OG4

Low energy dynamics in charge ordered $R_{0.5}Sr_{0.5}MnO_3$ (R = Nd and Pr) manganite thin films — •Rakesh Rana[1], Johannes Schmidt[1,2], Jörg Grenzer[1], Harald Schneider[1], Manfred Helm[1,2], and Alexej Pashkin[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany

Transition metal oxides exhibit complex interplay between the spin, charge, orbital and lattice degrees of freedom which may result in colossal magnetoresistance, superconductivity; charge ordered (CO) phases, etc. The half-doped $Pr_{0.5}Sr_{0.5}MnO_3$ manganite represents a unique stripe type CO-orbital order that induces transport and magnetic anisotropy whereas the CO in $Nd_{0.5}Sr_{0.5}MnO_3$ is charge-exchange (CE)-type which is isotropic in nature.

Epitaxial manganite thin films with a thickness of 200nm were grown on (100), (110), and (111) oriented $(LaAlO_3)_{0.3}(Sr_2TaAlO_6)_{0.7}$ substrates by pulsed laser deposition technique. Terahertz (THz) time-domain spectroscopic data reveal charge density wave (CDW) resonance centered around 5-6 meV for (110) oriented films and Drude-like conductivity for (100) and (111) oriented films. The CDW resonance frequency can be tuned from 4 meV to 6 meV for (110) oriented films and corroborate well with the magnetization measurements. The nonlinear conductivity related to the sliding of the pinned CDW character makes the studied systems promising candidates for ultrafast coherent control of charge transport by resonant THz pumping.

TT 56.5 Wed 15:00 P2-OG4

Correlation length in topological insulators: how different are a mug and a donut? — •Wei Chen, Markus Legner, Andreas Rüegg, and Manfred Sigrist — ETH Zurich, Zurich, Switzerland

We all know that a mug and a donut have the same topology. But how different are they? How different are two topological insulators that have the same topological invariant? We show that the correlation function that characterizes the topological insulators in 1D is a charge polarization correlation between Wannier states, and in 2D it is an itinerant circulation correlation between Wannier states. Suprisingly, these Wannier state correlation functions are nonzero in both topologically trivial and nontrivial states. The correlation function allows to extract a correlation length that characterizes the difference between topological insulators that are close to those that are far away from the topological phase transitions. The critical exponent of correlation length further suggests the existence of universality classes.

TT 56.6 Wed 15:00 P2-OG4

Mixed singlet-triplet and possible topological superconductivity in hole doped Sr_2IrO_4 — Mohammad-Hossein Zare[1], •Mehdi Biderang[2], and Alireza Akbari[2] — [1]Department of Physics, Qom University of Technology, Qom, Iran — [2]Asia Pacific Center for Theoretical Physics, POSTECH, Pohang, Korea

We investigate the potential existence of a superconducting phase in hole doped Sr_2IrO_4. Based on the mean field calculations, a mixed singlet-triplet superconductivity due to spin-orbit coupling has been found. Our calculation on a nanoribbon geometry shows possible existence of the topologically peotected edge states while the spin-triplet gap is larger than the spin-singlet one. Finally, we propose an innovative route for experimental observation of the edge states based on the quasiparticle interference (QPI) pattern.

TT 56.7 Wed 15:00 P2-OG4

Edge states at zigzag edges of Bi honeycomb bilayers on Nb(110) — •Fang Yang[1], Jasmin Jandke[1], Tim Storbeck[1], Timofey Balashov[1], Anuva Aishwarya[2], and Wulf Wulfhekel[1] —

[1]Physikalisches Institut, Karlsruhe Institute of Technology, Wolfgang-Gaede Str. 1, 76131 Karlsruhe, Germany — [2]Indian Insitute of Science, Bangalore, India

Islands of Bi showing (110)- and (111)-orientated facets were grown on Nb(110) and were studied with STM at low temperatures. On the (111) facets, both bilayer steps of zig-zag termination display topological edge states in contrast to that of single bilayer step-edges on bulk Bi. This is evidenced by locally resolved density-of-states near the edges revealing the characteristic distribution of edge states, i.e. dangling bond states and bulk-derived topological edge states. Further, we investigated the charge distribution of the surface state electrons on the Bi(110) surface. We find that the electronic states are highly anisotropic within the unit cell forming one dimensional stripes. Our findings indicate a causal link between the Bi(111) edge states and Bi(110) surface states as they are both related to the zig-zag termination of the honeycomb structure of Bi.

TT 56.8 Wed 15:00 P2-OG4

Topological charge pumping due to rotating magnetic fields in a Rashba spin-orbit coupled curved nanowire — •Sudhakar Pandey[1], Paola Gentile[2], Mario Cuoco[2], and Carmine Ortix[1,3] — [1]Institute for Theoretical Solid State Physics, IFW Dresden, 01069 Dresden, Germany — [2]CNR-SPIN and Dipartimento di Fisica "E. R. Caianiello", Universita di Salerno, I-84084 Fisciano (Salerno), Italy — [3]Institute for Theoretical Physics, Center for Extreme Matter and Emergent Phenomena, Utrecht University, Princetonplein 5, 3584 CC Utrecht, Netherlands

Topological charge pumping refers to transport of charge in a system due to an adiabatic temporal change in the periodic potential. The transported charge per pump cycle is quantized, and purely determined by the topology of the pump cycle, which can be characterized by a topological invariant: the Chern number. Although introduced originally more that three decades ago [1], its experimental realization has been achieved recently in ultracold bosonic [2] and fermionic [3] atoms loaded in the optical superlattices. In this work we demonstrate that a Rashba spin-orbit coupled curved wire subject to a rotating magnetic field can work as a topological charge pump. In a descretized system with N atoms per unit cell we find a Chern number C=2 at the band fillings n=1/N and (N-1)/N. The fact that these results are robust even in the continuum limit makes our proposal feasible experimentally.

[1] D.J. Thouless, Phys. Rev. B 27, 6083 (1983)
[2] M. Lohse et al., Nat. Phys. 12, 350 (2016)
[3] S. Nakajima et al., Nat. Phys. 12, 296 (2016)

TT 56.9 Wed 15:00 P2-OG4

Exact Tensor Network States for the Kitaev Honeycomb Model — •Philipp Schmoll and Román Orús — Institute of Physics, Johannes Gutenberg University, 55099 Mainz, Germany

The spin-1/2 Kitaev honeycomb model was originally proposed in the context of topological quantum computation. This analytically solvable model realizes a spin liquid and exhibits rich physical behaviour, such as abelian and non-abelian anyons as excitations. Our aim is to describe the eigenstates of the model using tensor network methods, which offer efficient descriptions of quantum many-body systems. In particular we exploit parity preservation and build a fermionic tensor network to express the eigenstates of the Hamiltonian in the ground-state vortex sector. We implement the network for small lattices with periodic boundary conditions in order to verify the approach for the model in the thermodynamic limit.

TT 56.10 Wed 15:00 P2-OG4

Thickness dependent electronic and structural transition in $BaBiO_3$ thin films on $SrTiO_3$ — •Michael Zapf, Sebastian Elsässer, Martin Stübinger, Jean Geurts, Michael Sing, and Ralph Claessen — Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany

$BaBiO_3$ (BBO), the parent material of the high-T_C superconductor $Ba_{1-x}K_xBiO_3$ (T_C=30 K), has recently been proposed to be a large gap topological insulator, when heavily n-doped. This state may be accessed experimentally by electric gating and doping of BBO thin films as single or multilayer structures.

To investigate, as a first step, the properties of pristine BBO in the thin film limit, we have grown a series of BBO films of various thicknesses on $SrTiO_3$ with pulsed laser deposition (PLD). We found significant modulations of the structural and electronic characteristics of the films. Raman spectroscopy indicates a reduction of the lattice symmetry from a cubic to a distorted perovskite lattice as in bulk-like BBO at a thickness of a few unit cells. Beyond this thickness, photoemission valence band spectra of the thin films resemble the spectral shape known from BBO single crystals. Further photoemission measurements show that this structural and electronic crossover is determined by significant stoichiometry deviations occurring at the beginning of BBO deposition.

TT 56.11 Wed 15:00 P2-OG4

Interface band engineering in $LaAlO_3/SrTiO_3$ heterostructures — •Judith Gabel[1], Philipp Scheiderer[1], Michael Zapf[1], Martin Stübinger[1], Christoph Schlueter[2], Tien-Lin Lee[2], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany — [2]Diamond Light Source Ltd., Didcot, United Kingdom

Novel two-dimensional electron systems at the interfaces of oxide heterostructures, as e.g. at the $LaAlO_3/SrTiO_3$ (LAO/STO) heterointerface, recently have attracted much attention. A key requirement for future applications is the controllability of the electronic interface properties. We show that these properties can be controlled in LAO/STO by the oxygen vacancy (V_O) concentration which can in turn be adjusted during photoemission experiments by means of synchrotron light irradiation and simultaneous oxygen dosing. In detail, the V_O concentration determines the density of mobile and trapped charge carriers as well as the band bending and alignment at the interface. We systematically investigate these properties on (001) and (111) oriented LAO/STO heterostructures with controlled V_O concentrations by depth profiling the film and substrate core levels by means of angle-dependent hard X-ray photoelectron spectroscopy, while resonant soft X-ray photoemission is used to probe the interfacial valence band states.

TT 56.12 Wed 15:00 P2-OG4

Emergence of interfacial conductivity in the $LaAlO_3$ capped $LaVO_3/SrTiO_3$ heterostructure — •Martin Stübinger, Judith Gabel, Philipp Gagel, Michael Sing, and Ralph Claessen — Universität Würzburg, Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), 97074 Würzburg, Germany

Akin to the well known oxide heterostructure $LaAlO_3/SrTiO_3$ (LAO/STO) a conducting interface is found also between the strongly correlated, polar Mott insulator $LaV^{3+}O_3$ (LVO) and the non-polar band insulator STO. Since $LaV^{3+}O_3$ tends to overoxidize to the thermodynamically more stable $LaV^{5+}O_4$ phase when exposed to air, a suitable passivation is required. Therefore, we have employed pulsed laser deposition thin film growth of LVO films with a crystalline LAO capping layer. *In situ* photoemission measurements of samples before and after being exposed to air show that the V oxidation state can indeed be stabilized by the LAO capping layer. By transport measurements, we identify an insulator-to-metal transition at a combined LAO/LVO overlayer thickness of 4 unit cells. The metallicity holds for different combinations of LAO and LVO thickness as long as the total overlayer thickness is 4 uc or higher. Thus, both LAO and LVO play a cooperative role in inducing interfacial conductivity in this system. We discuss these findings in terms of an interplay of the polar nature of LAO and LVO and defect states that provide mobile charge carriers.

TT 56.13 Wed 15:00 P2-OG4

Tuning the electric interface properties of amorphous $AlO_x/SrTiO_3$ interfaces — •Berengar Leikert, Judith Gabel, Michael Sing, and Ralph Claessen — Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany

Two dimensional electron systems (2DESs) at the interfaces of oxide heterostructures are considered a promising platform for future microelectronic technology which may utilize the rich electronic behavior emerging at the interfaces of transition metal oxides. A simple and cost-effective method to create a 2DES is to deposit Al on the surface of $SrTiO_3$. It reduces the first oxide layers and leads to an n-doping of the oxide surface. By changing the Al redox potential via growth in oxygen atmosphere we can tune the electronic interface properties, which are probed by x-ray photoelectron spectroscopy of the film as well as the substrate core levels. Complementary transport experiments yield information about charge carrier concentration and mobility which are also shown to depend on the Al redox potential. Comparing the results from spectroscopy to the transport measurements for samples with differing carrier mobility and concentration we

gain a deeper understanding of the properties governing transport at transition metal oxide interfaces.

TT 56.14 Wed 15:00 P2-OG4

Probing the dimensionality-driven metal-insulator transition in spin-orbit coupled $SrIrO_3$ thin films — •Philipp Schütz[1], Lenart Dudy[1], Judith Gabel[1], Martin Stübinger[1], Marius-Adrian Husanu[2], Vladimir Strocov[2], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany — [2]Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland

Although typically viewed to be disparate properties, the large spin-orbit-coupling (SOC) and relatively weak electronic correlations are roughly of the same order of magnitude in iridate compounds. The prototypical Ruddlesden-Popper iridates $Sr_{n+1}Ir_nO_{3n+1}$ have attracted special attention since they exhibit a SOC-induced Mott transition dependent on the value of n. Whereas the quasi-two-dimensional compound Sr_2IrO_4 ($n = 1$) shows a Mott-like insulating state, its three-dimensional analogue $SrIrO_3$ ($n = \infty$) is a correlated metal in proximity to a metal-insulator-transition. As an alternative to single crystal growth of Ruddlesden-Popper-iridates with different n, we investigate the effect of dimensionality through synthesis of atomically thin $SrIrO_3$ films by pulsed laser deposition, which analogously exhibit a metal-insulator-transition as function of thickness. We present a systematic investigation of the k-resolved electronic structure near the metal-insulator-transition by means of synchrotron-based soft x-ray angular-resolved photoemission spectroscopy (SX-ARPES), which sheds light on the intricate interplay between spin-orbit coupling, electronic correlations and dimensionality.

TT 56.15 Wed 15:00 P2-OG4

Tuning electronic phases and topological properties in 3*d*-oxide honeycomb lattices confined within the corundum structure — •Okan Köksal, Santu Baidya, and Rossitza Pentcheva — Fakultät für Physik and Center of Nanointegration (CENIDE), Universität Duisburg-Essen, 47057 Duisburg

Using density functional theory including an on-site Coulomb term, we explore electronic and possibly topologically nontrivial phases in 3*d* transition metal oxide honeycomb layers confined in the corundum structure (α-Al_2O_3) along the [0001] direction. Except for X=V, Cr and Fe, most of the systems exhibit a ground state that is distinct from the corresponding bulk X_2O_3 compound. In particular, ferromagnetic X=Ti, Mn, Ni and metastable Co exhibit a characteristic set of four bands with a Dirac crossing close to the Fermi level. Our results indicate that the Dirac point can be tuned to the Fermi level using strain. Switching on spin-orbit coupling, a finite anomalous Hall conductivity with values up to 0.75 e^2/h is obtained. Parallels to the perovskite analogons $LaXO_3/LaAlO_3(111)$ [1] are discussed.

Support by the DFG within priority program TRR80, project G3 and a computational grant at the Leibniz Rechenzentrum are gratefully acknowledged.

[1] D. Doennig, S. Baidya, W. E. Pickett, and R. Pentcheva, Phys. Rev. B **93**, 165145 (2016)

TT 56.16 Wed 15:00 P2-OG4

Magnetotransport properties of the organic superconductor κ-$(ET)_2Cu[N(CN)_2)]Cl$ near the Mott-insulating transition — •Sebastian Oberbauer[1,2], Michael Kunz[1], Werner Biberacher[1], Natalia D. Kushch[3], and Mark V. Kartsovnik[1] — [1]Walther-Meißner-Institut, Garching, Germany — [2]Technische Universität München, Garching, Germany — [3]Institute of Problems of Chemical Physics, Chernogolovka, Russia

κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$)]Cl belongs to the family of charge transfer salts and shows many interesting phenomena at low temperatures. Especially the existence of a superconducting phase at temperatures up to 12.8 K bordering a magnetically ordered Mott-insulating state are of big interest in current research. This metal-insulator transition (MIT) can be tuned by applying hydrostatic pressures $\leq$ 0.4 kbar. Together with its highly anisotropic conductivity, this makes the compound a model example of a quasi-two-dimensional correlated electronic system.

Here we report on a magnetotransport study of κ-(BEDT-TTF)$_2$-Cu[N(CN)$_2$)]Cl under pressure, in the vicinity of the MIT. A particular focus is put on tracing the behavior of Shubnikov - de Haas oscillations. While the oscillation frequencies only weakly change with pressure, the effective cyclotron masses exhibit a significant increase, accelerating towards the MIT. We compare the experimental data with those obtained on similar κ-type organic conductors and with theoretical predictions.

TT 56.17 Wed 15:00 P2-OG4

Transport and thermodynamic studies of the metal-insulator transition in κ-$(BEDT\text{-}TTF)_2Hg(SCN)_2Cl$ under He-gas pressure — •Caroline Delleske[1], David Zielke[1], Elena Gati[1], Harald Schubert[1], John A. Schlueter[2], and Michael Lang[1] — [1]Physikalisches Institut, SFB/TR49, Goethe Uni Frankfurt, DE — [2]Materials Science Division, NSF, Arlington, Virginia, USA

Organic charge-transfer salts show a wide variety of electronic phases resulting from strong electron correlations in low dimensions, such as superconductivity or multiferroicity. The members of the κ-$(BEDT\text{-}TTF)_2X$ family are representing model systems to investigate the interplay of strong on-site and inter-site Coulomb repulsion in 2D. Here we focus on the less intensively studied system κ-(BEDT-TTF)$_2$Hg(SCN)$_2$Cl [1, 2], showing a metal-insulator (MI) transition at $T_{MI} \approx 30$ K which has been assigned to charge-order [1]. We report on a detailed characterization of the material's low-temperature properties by transport and thermodynamic measurements at ambient pressure, as well as under finite He-gas pressure. We find a slightly broadened MI transition, consistent with literature [2], which can be rapidly suppressed with increasing pressure. Surprisingly, no indications for superconductivity can be found up to pressures of $p = 300$ MPa and temperatures down to $T = 2.4$ K. In addition, we will present thermodynamic studies of the specific heat and thermal expansion to unravel the role of spin and lattice degrees of freedom at T_{MI}.

[1] N. Drichko et al., PRB 89, 075133 (14)
[2] S. Yasin et al., Physica B 407, 1689 (12)

TT 56.18 Wed 15:00 P2-OG4

Pressure- and temperature-dependent optical investigations on α-(BEDT-TTF)2I3 — •Weiwu Li[1], Ece Uykur[2], Christine A. Kuntscher[2], Dieter Schweitzer[1], and Martin Dressel[1] — [1]1.Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Experimentalphysik II, Universität Augsburg, 86135, Augsburg, Germany

The two-dimensional organic conductor α-(BEDT-TTF)2I3 exhibits a metal-insulator transition at Tco=135K with a charge-ordered ground state. This system is considered to host massless Dirac electrons under hydrostatic pressure as high as 1.5 GPa, which has been confirmed both theoretically and experimentally. For better understanding of the charge dynamics in the Dirac state, pressure-dependent infrared measurements have been performed previously. Unfortunately, limited by a maximum pressure of 1 GPa, no final evidence of the Dirac electrons could be found. As an extension to the previous measurements, we performed reflectivity measurements under pressure (up to 4GPa) between 100 and 8000 cm-1 down to 6 K by using diamond anvil cell. As a result, with increasing pressure we observed a Drude component developed below 600 cm-1 at the expense of the suppression of the mid-infrared band. The charge order still exists up to 1.6 GPa, where the conductivity already shows metallic behavior. At the highest pressure (4 GPa), the optical conductivity shows almost no temperature dependence below 90 K with a Drude term below 500 cm-1 and a constant conductivity extends up to 1500 cm-1, which point out the coexistence of the massive charge carriers and the massless Dirac electrons.