TT 59: Complex Oxides Interfaces and Charge Order

Time: Thursday 15:00–18:00 Location: H22

TT 59.1 Thu 15:00 H22

Anisotropic transport properties in LAO/STO nanostructures — •Mithun S Prasad[1] and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Von-Danckelmann-Platz 3, D-06120 Halle, Germany — [2]. Interdisziplinäres Zentrum für Meterialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, Heinrich-Damerow-Straße 4, D-06120 Halle, Germany

The high-mobility two-dimensional electron gas (2DEG) confined at the interface of two insulating complex oxides, LaAlO3 (LAO) and SrTiO3 (STO) provides new opportunities to explore nano electronic devices. In our group we have developed an industry compatible nano patterning technique [1] for the LAO/STO interface. Recent studies on this interface have revealed that at low temperature the current is confined to filaments which are linked to structural domain walls in the STO [2] with drastic consequences for example for the temperature dependence of local transport properties [3]. We have investigated magneto transport in nanostructures of different orientation with respect to the lattice. Our experiments show that not only the resistance but also the magnetoresistance varies with orientation. The magnetoresistance can even change sign strongly supporting the model of filamentary charge transport.

[1] M. Z. Minhas et al. , AIP Advances 6, 035002 (2016)

TT 59.2 Thu 15:15 H22

Tuning the superconducting transition of the $SrTiO_3$/$LaAlO_3$-interface with light — •Daniel Arnold, Dirk Fuchs, Karsten Wolff, and Roland Schäfer — Institute for Solid State Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

The conductance of the $SrTiO_3/LaAlO_3$ interface is sensitive to illumination by visible light [1,2]. We can tune the low temperature conductance of a sample in Hall bar geometry by up to a factor of 5 while we illuminate the sample at low temperatures in a controlled manner. Simultaneously the superconducting transition temperature shifts. The change in electrical conductance as well as the change in transition temperature persist even at low temperatures when the light is turned off. However, the initial state of the sample can be reestablished by increasing the temperature.

We present temperature and magnetic field dependent transport measurements and discuss the U/I characteristics regarding the inhomogeneous nature of the superconducting state.

[1] M. Huijben et al., Nat. Mater. 5 (2006)
[2] M. Yazdi-Rizi, PRB 95 (2017)

TT 59.3 Thu 15:30 H22

Comparative study of the two-dimensional electron gas at the $EuTiO_3$(001) and $SrTiO_3$(001) surfaces — •manish verma[1], m. salluzzo[2,3], m. radovic[3], j.h. dil[4], and rossitza pentcheva[5] — [1]Department of Physics and Center for Nanointegration (CENIDE), University of Duisburg-Essen, Germany — [2]Dipartimento di Fisica, Università di Napoli Federico II, Italy — [3]CNR-SPIN, Italy — [4]Swiss Light Source and SwissFel, PSI, Switzerland — [5]Institute of Condensed Matter Physics, Ecole Polytechnique Fédérale de Lausanne, Switzerland

Since the discovery of the two-dimensional electron gas (2-DEG) at the interface between the two band insulators $LaAlO_3$ and $SrTiO_3$ or at the $SrTiO_3$(001) surface, rich and intriguing physics has been uncovered at oxide interfaces. A significant effort concentrates on finding further possibly magnetic 2DEG oxide systems. $EuTiO_3$ serves as a suitable candidate in this direction, as it exhibits an antiferromagnetic ground state below 5.5K switchable to a ferromagnetic one by doping or lattice strain. In a combined density functional theory+U calculations with a Hubbard U on Eu $4f$ and Ti $3d$ states and angle resolved photoemission spectroscopy we explore the properties of the 2DEG at $EuTiO_3$(001) surface and compare to the much studied $SrTiO_3$(001) surface. In particular we focus on the effect of spin-orbit coupling on the 2DEGs at the two surfaces.

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TT 59.4 Thu 15:45 H22

Magnetism and pseudo gap physics in $SrVO_3$ | $SrTiO_3$ heterostructures — •Matthias Pickem, Jan M. Tomczak, and Karsten Held — Institute of Solid State Physics, TU Wien, Austria

Modern atomic layer-by-layer deposition techniques allow for the study of materials in restricted geometries. Resulting effects of quantum confinement, e.g., in ultra-thin films are expected to be particularly pronounced for systems with strong electronic correlations. Indeed, the conventional Fermi-liquid state of bulk $SrVO_3$ was recently discovered to be destroyed in films below a critical thickness.

On the basis of these result we perform state-of-the-art density functional theory (DFT) + dynamical mean-field theory (DMFT) calculations. We first compute susceptibilities within DMFT and find antiferromagnetic ordering in the undoped cases and evidence of competing phases when doping, opening perspectives for oxide-based spin-tronic devices.

In order to properly describe possible non-local correlation effects stemming from the reduced dimensionality and the (potential) proximity of long-range ordered phases, we additionally apply the dynamical vertex approximation — a promising method beyond DMFT — that was recently extended to realistic materials calculations. Preliminary results suggest the presence of pseudo-gap physics, vaguely reminiscent of cuprate superconductors. The encountered large self-energy corrections to the local (DMFT) descriptors advocate for further studies of thin films and heterostructure in both theory and experiment.

TT 59.5 Thu 16:00 H22

Coupled charge density wave and magnetism in $TbTe_3$ — •Shravani Chillal[1], Enrico Schierle[1], Eugen Weschke[1], Jens Uwe Hoffmann[1], Fabiano Yokaichiya[1], Alexandre Vassiliev[2], Olga Volkova[2], Pierre Monceau[3], and Bella Lake[1,4] — [1]Helmholtz-Zentrum-Berlin für Materialien und Energie, Germany — [2]M.V. Lomonosov Moscow State University, Russia — [3]Université Grenoble Alpes, CNRS, Grenoble INP, Institut NEEL, France — [4]Technische Universität Berlin, Germany

$TbTe_3$ is a quasi-two dimensional system displaying a rich combination of quantum cooperative phenomenon including two charge density wave orders, complex incommensurate and commensurate magnetic orders as well as unconventional superconductivity under pressure. Hence, a delicate interplay of the three collective states is expected similar to the copper-oxide high-T_c superconductors leading to a novel phase diagram. Here, we present the interaction of the CDW and magnetic orders in $TbTe_3$ as a function of temperature and magnetic field. We find that these two collective states coexist at all the temperatures below the magnetic transition and that the magnetic order is coupled to the CDW state such that the magnetic wave vector can be described in terms of the CDW wave vector. Furthermore, we find an additional field induced phase where the magnetic wave vector locks-in to the CDW wave vector. Therefore, $TbTe_3$ can be considered as an ideal system to study the competition and coexistence of magnetism and CDW orders.

TT 59.6 Thu 16:15 H22

High-harmonic spectroscopy of the charge-density wave transition in 1T-$TiSe_2$ — •Tobias Heinrich[1], Sergey Zayko[1], Murat Sivis[1], Kai Rossnagel[2], Ofer Kfir[1], and Claus Ropers[1] — [1]4th Physical Institute - Solids and Nanostructures, University of Göttingen, Germany — [2]Institute for Experimental and Applied Physics, University of Kiel, Germany

Correlated materials exhibit a wide variety of intriguing ordering phenomena, such as the charge-density wave (CDW) state in layered transition-metal dichalcogenides. The charge-density at the transition metal site and the CDW-induced band structure changes can be probed by photoemission spectroscopy [1,2]. However, also near-edge optical and x-ray spectroscopy of core-levels should provide valuable time-resolved information.

Here, we employ an extreme-ultraviolet pump-probe setup to study the CDW-to-normal phase transition in 1T-$TiSe_2$. Our setup features femtosecond infrared pump and high-harmonic ($25-50$eV) probe pulses, suitable to access CDW-features near the Ti M-edge. In our experiments, we find characteristic spectral changes upon thermally inducing the phase transition near 202 K, which are indicative of a

splitting of the Ti-M edge into nonequivalent Ti sites. In ongoing experiments, we investigate the temporal evolution of the spectral signatures with a temporal resolution below 40 fs, complementing ultrafast photoemission spectroscopy studies.
[1] Timm Rohwer *et al.*, Nature **471**, 490-493 (2011)
[2] S. Hellmann *et al.*, PRL **105**, 187401 (2010)

15 min. break.

TT 59.7 Thu 16:45 H22

Photo-induced rearrangement of orbitally ordered layers in thin 1T-TaS_2 — •Quirin Stahl[1], Tobias Ritschel[1,2], Maximilian Kusch[1], Florian Heinsch[1,3], Gaston Garbarino[4], Norman Kretzschmar[4], and Jochen Geck[1] — [1]TU Dresden, Germany — [2]UBC, Vancouver, Canada — [3]HZDR, Germany — [4]ESRF, Grenoble, France

The ultra-fast semiconductor-to-metal transition in nano-thick 1T-TaS_2 crystals induced by femtosecond laser pulses currently attracts a lot of interest [1,2]. In particular, since it is believed that such laser pulses stabilize so-called hidden states, which cannot be reached from thermal equilibrium and which exhibit unique electronic properties. We present a detailed XRD study of nano-thick 1T-TaS_2 single crystals. In a first experiment we studied the charge density wave order in the supercooled state, which has been observed earlier in resistivity measurements [3]. This phase is then compared to the charge density wave order created by a femtosecond laser pulse. Our measurements reveal the existence of commensurate domains separated by discommensurations in both phases, implying that the hidden state of 1T-TaS_2 stands in close relation to the nearly commensurate state. The electronic characteristics are discussed in terms of switching between orbital configurations, caused by the rearrangement of orbitally ordered layers.
[1] L. Stojchevska et al., Science 334, 177 (2014)
[2] I. Vaskivskyi et al., Science Advances 1, 6 (2015)
[3] M. Yoshida et al., Scientific Reports 4, 7302 (2014)

TT 59.8 Thu 17:00 H22

Scanning tunneling microscopy on an excitonic insulator Ta_2NiSe_5 — Qingyu He[1], Xinglu Que[1], Alexander Yaresko[1], •Andreas Rost[1], Masahiko Isobe[1], Tomohiro Takayama[1], Lihui Zhou[1], and Hidenori Takagi[1,2] — [1]Max Planck Institute for solid state research, Stuttgart, Germany — [2]University of Tokyo, Tokyo, Japan

Ta_2NiSe_5 is the strongest candidate for the long conjectured excitonic insulator state. It is a direct zero gap semiconductor at high temperature, and undergoes at T_c = 326 K a semiconductor-insulator transition simultaneous with an orthorhombic-monoclinic q = 0 structure transition. Our low temperature STM evidences its layered structure with rippling atomic chains. The local spectroscopy reveals the opening of the excitonic insulator gap and the spectral weight shift with decreasing temperature. High resolution STM topography shows a local distortion associated with the structure transition. This distortion may play an important role in the formation of the excitonic state, as also supported by our band structure calculations.

TT 59.9 Thu 17:15 H22

LDA+U and LDA+DMFT study on structurally-triggered metal insulator transition in $CaCu_3Fe_4O_{12}$ — •Atsushi Hariki, Mathias Winder, and Jan Kuneš — Institute of Solid State Physics, TU Wien, 1040 Vienna, Austria

We study structurally-triggered metal-insulator transition of $CaCu_3Fe_4O_{12}$ by means of local density approximation (LDA) +U and LDA+dynamical mean-field theory (DMFT). We show from the LDA+U calculations that the metal-insulator transition is induced by the breathing distortion of Fe-O bonds, that is structurally triggered by rotation of FeO_6 octahedra. Based on the LDA+DMFT calculations, taking all Cu 3d, Fe 3d and O 2p bands into account explicitly, we discuss electronic coupling of Fe (formally tetravalent) 3d and O 2p states under the breathing distortion as well as origin of the experimental ferrimagnetic ordering.

TT 59.10 Thu 17:30 H22

Correlation between charge- and oxygen-ordering in 214-type hole-doped $Pr_{2-x}Sr_xNiO_{4+d}$ systems — •Avishek Maity[1,2], Rajesh Dutta[2], Laura Guasco[3], Alexie Bossak[4], Monica Ceretti[3], and Werner Paulus[3] — [1]Georg-August-Universität-Goettingen, Göttingen, 37077 Germany — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Garching, 85747 Germany — [3]Université de Montpellier, Montpellier, 34095 France — [4]The European Synchrotron-ESRF, Grenoble, 38000 France

The research on charge-ordered (CO) stripes in 214-type cobaltates/nickelates has become a fertile territory of research in the last two decades after they were experimentally evidenced in homologous superconducting cuprates $La_{2-x}Sr_xCuO_{4+d}$[1]. Although contentious, fluctuation of such organized quantum mater e.g. stripe is believed to be responsible for high-Tc superconductivity [2]. What still remains poorly discussed, is the influence of nonstoichiometric interstitial oxygen (Oint) on the organization of holes in a line shape. We have investigated CO state in $Pr_{2-x}Sr_xNiO_{4+d}$ by several synchrotron and neutron diffraction measurements. $Pr_{2-x}Sr_xNiO_{4+d}$ being a potential O-ion conductor, the high mobility of Oint gives rise to a complex long-range O-ordering even at RT. Investigating different doping level, we have found that the spacing in between the stripes is defined by the Oint-ordered supercell. I will present the relation between O-order and CO and the effect on CO correlation.
[1] J. M.Tranquada et al., Nature 375, 561-563 (1995)
[2] J. Zaanen, Nature 471, 314-316 (2011)

TT 59.11 Thu 17:45 H22

Spin, charge and orbital order in $Pr_{1-x}Ca_xMnO_3$ — •Michael ten Brink[1,2], Sangeeta Rajpurohit[2], Mohsen Sotoudeh[2], Christian Jooss[3], and Peter E. Blöchl[1,2] — [1]Institut für Theoretische Physik, Georg-August-Universität Göttingen — [2]Institut für Theoretische Physik, Technische Universität Clausthal — [3]Institut für Materialphysik, Georg-August-Universität Göttingen

The strong coupling of electron, phonon and spin degrees of freedom in manganites leads to a rich phase diagram with several competing ordering principles. We investigate the ground state phases for the whole doping range of $Pr_{1-x}Ca_xMnO_3$ using two theoretical methods: 1. density functional calculations (DFT) with local hybrid functionals, which allows us to compare to experimental spectra (EELS, XPS and optical absorption), 2. from the DFT calculations we determine the parameters of a tight-binding model, which captures the interactions between the relevant electron, spin and phonon degrees of freedom. This model allows us to study a variety of defect structures in larger systems and the spin, charge and orbital order in a unified framework.