TT 46: Superconductivity: Fe-based Superconductors - FeSe

Time: Wednesday 10:00–12:45 Location: H19

TT 46.1 Wed 10:00 H19

Superconductivity and electronic structure in single-layer FeSe on $SrTiO_3$ probed by scanning tunneling microscopy — •Jasmin Jandke[1], Jonas Dressner[1], Fang Yang[2], Chunlei Gao[2], and Wulf Wulfhekel[1] — [1]Physikalisches Institut, Karlsruhe Institut of Technology, Germany — [2]Fudan Universität, Shanghai , China

We use high-resoluion scanning tunneling spectroscopy (STS) to study single-layer FeSe on Nb-doped $SrTiO_3$ (001). Features of bosonic excitations were observed in the measured quasiparticle density of states. Furthermore, using STS, quasiparticle interference (QPI) imaging was performed in order to map the multiband electronic structure of FeSe. Compared to previous measurements [1,2], an additional feature is visible in our measured QPI maps on a single-layer FeSe/$SrTiO_3$. The origin of this feature will be discussed.

[1] D. Huang et al. PRL **115**, 017002 (2015)
[2] Q. Fan et al. arXiv:1504.02185 [cond-mat.supr-con] (2015)

TT 46.2 Wed 10:15 H19

High-T_c superconductivity in monolayer FeSe on $SrTiO_3$ via interface-induced small-q electron-phonon coupling — •Alexandros Aperis and Peter M. Oppeneer — Uppsala University, Sweden

A monolayer of FeSe deposited on $SrTiO_3$ becomes superconducting at temperatures that exceed T_c=100 K, as compared to a bulk T_c of 8 K. Recent ARPES measurements have provided strong evidence that an interfaced-induced electron-phonon interaction between FeSe electrons and $SrTiO_3$ phonons plays a decisive role in this phenomenon. However, the mechanism that drives this tantalizing high-T_c boost is still unclear.

Here, we examine the recent experimental findings using fully anisotropic, full bandwidth multiband Eliashberg calculations focusing on the superconducting state of FeSe/STO. We use a realistic ten band tight-binding band structure for the electrons of monolayer FeSe and study how the suggested interface-induced small-q electron-phonon interaction mediates superconductivity. Our calculations produce a high-T_c s-wave superconducting state with the experimentally resolved momentum dependence. Further, we calculate the normal metal/insulator/superconductor tunneling spectrum and identify fingerprints of the interface-induced phonon mechanism.

TT 46.3 Wed 10:30 H19

Tuning orbital-selective correlation effects in the superconducting iron chalcogenides $Rb_{1-x}Fe_{1.6}Se_{2-z}S_z$ — •Zhe Wang[1], Vladimir Tsurkan[1,2], Michael Schmidt[1], Alois Loidl[1], and Joachim Deisenhofer[1] — [1]Experimetal Physics V, University of Augsburg, Augsburg, Germany — [2]Institute of Applied Physics, Academy of Sciences of Moldova, Chisinau, Republic of Moldova

We report a terahertz time-domain spectroscopy study on superconducting and metallic iron chalcogenides $Rb_{1-x}Fe_{1.6}Se_{2-z}S_z$ [1,2]. With increasing sulfur doping the superconducting transition is reduced from T_c = 32 K for z = 0 and finally suppressed at z = 1.4 [1]. The dielectric constant and the optical conductivity exhibit a metal-to-insulator-type transition associated to an orbital-selective Mott phase [2]. This orbital-selective Mott transition appears at T_{met} = 90 K for z = 0 and shifts to higher temperatures for higher doping levels [1], identifying sulfur substitution as an efficient parameter to tune orbital-dependent correlation effects in the iron-chalcogenide superconductors. The reduced correlation strength of the dxy charge carriers may also account for the suppression of the pseudogap-like feature between T_c and T_{met} that was observed for z = 0 [2].

[1] Zhe Wang, V. Tsurkan, A. Loidl, and J. Deisenhofer, arXiv:1506.04614
[2] Zhe Wang, M. Schmidt, J. Fischer, V. Tsurkan, M. Greger, D. Vollhardt, A. Loidl, and J. Deisenhofer, Nature Comm. **5**, 3202 (2014)

TT 46.4 Wed 10:45 H19

Influence of substrate type on transport properties of superconducting $FeSe_{0.5}Te_{0.5}$ thin films — •Feifei Yuan[1,2], Kazumasa Iida[1,3], Marco Langer[1,4], Jens Hänisch[1,4], Ruben Hühne[1], and Ludwig Schultz[1] — [1]IFW, Dresden, Germany — [2]Southeast University, Nanjing, China — [3]Nagoya University, Nagoya, Japan — [4]KIT, Eggenstein-Leopoldshafen, Germany

$FeSe_{0.5}Te_{0.5}$ thin films were grown by pulsed laser deposition on CaF_2, AlO_3 and MgO substrates and structurally and electro-magnetically characterized in order to study the influence of the substrate on their transport properties. The in-plane lattice mismatch between $FeSe_{0.5}Te_{0.5}$ bulk and the substrate shows no influence on the lattice parameters of the films, whereas the type of substrate affects the crystalline quality of the films and, therefore, the superconducting properties. The film on MgO showed an extra peak in the angular dependence of critical current density J_c at $\theta = 180°$ (H//c), which arises from c-axis defects as confirmed by transmission electron microscopy. In contrast, no J_c peaks for H//c were observed in films on CaF_2 and $LaAlO_3$. $J_c(\theta)$ can be scaled successfully for both films without c-axis correlated defects by the anisotropy Ginzburg-Landau approach with appropriate anisotropy ratio γ. The scaling parameter γ is decreasing with decreasing temperature, which is different from what we observed in $FeSe_{0.5}Te_{0.5}$ films on Fe-buffered MgO substrates.

TT 46.5 Wed 11:00 H19

Investigation of the electronic and magnetic structure of thin layer FeTe on Bi_2Te_3 — •Lasse Cornils[1], Sujit Manna[1], Anand Kamlapure[1], Torben Hänke[1], Jin Hu[2], Zhiqiang Mao[2], Bo Brummerstedt Iversen[3], Philip Hofmann[3], Jens Wiebe[1], and Roland Wiesendanger[1] — [1]Department of Physics, University of Hamburg, Hamburg, Germany — [2]Department of Physics, Tulane University, New Orleans, United States — [3]Interdisciplinary Nanoscience Center iNANO, Aarhus University, Denmark

The surprising discovery of Fe based superconductors in 2008 lead to a big effort in finding new materials with very high critical temperatures. One good example are Fe-chalcogenides. Although the parent compound FeTe is not superconducting, the situation changes drastically on interfacing the material with other substrates. Recently He and coworkers [1] found zero resistance at the interface of Bi_2Te_3 films grown on bulk FeTe, which showed a transition temperature of 12K. In this talk we present our latest results on our investigation of the electronic and magnetic nature of epitaxially grown FeTe thin films on the topological insulator Bi_2Te_3 using spin-polarized scanning tunneling microscopy and spectroscopy. Up to several monolayers of FeTe, an antiferromagnetic structure similar to the one observed on its bulk compound FeTe was clearly visible. Surprisingly we found a gap around the Fermi level indicating proximity to superconductivity in coexistence with magnetism on the nanoscale.

[1] Q.-L. He et al., Nature Comm. **5**, 4247 (2014)

15 min. break

Invited Talk TT 46.6 Wed 11:30 H19

On Nematicity, Magnetism and Superconductivity in FeSe — •A. E. Böhmer[1], K. Kothapalli[1], W. T. Jayasekara[1], A. Sapkota[1], U. Kaluarachchi[1], E. I. Timmons[1], P. Das[1], B. G. Ueland[1], G. Drachuck[1], M. Schütt[2], V. Taufour[1], M. A. Tanatar[1], S. L. Bud'ko[1], Y. Xiao[3], R. M. Fernandes[2], R. Prozorov[1], A. I. Goldman[1], and P. C. Canfield[1] — [1]Ames Lab. / Iowa State University, Ames, IA, USA — [2]University of Minnesota, Minneapolis, MN, USA — [3]Argonne National Lab., Argonne, IL, USA

FeSe provides a new perspective on the intensively studied phase interplay in iron-based materials. At ambient pressure, FeSe exhibits the typical (nematic) structural phase transition, but, unusually, no long-range magnetic order and no competition between nematicity and superconductivity. Under pressure, the structural transition is gradually suppressed and a new, likely magnetic phase emerges.

I will present our recent results on the nematic phase and the pressure-temperature phase diagram of vapor-grown single crystals of FeSe. The origin of the nematic resistivity anisotropy at ambient pressure and the pressure evolution of the orthorhombic distortion, the superconducting upper critical field and magnetic ordering are investigated using resistivity, elastoresistivity, diffraction and synchrotron Mössbauer spectroscopy. The relation of magnetism, structure and superconductivity in FeSe will be discussed and compared to other iron-based systems.

Work at Ames Lab. was supported by US DOE, DE-AC02-07CH11358. This research used resources at Argonne National Lab.

TT 46.7 Wed 12:00 H19

Superconductivity and spin excitations in orbitally ordered FeSe — •Andreas Kreisel[1], Shantanu Mukherjee[1,3], Peter J. Hirschfeld[2], and Brian M. Andersen[1] — [1]Niels Bohr Institute, University of Copenhagen, Denmark — [2]University of Florida, Gainesville, FL, USA — [3]Dept. of Physics, State University of New York at Binghamton, Binghamton, NY, USA

We provide a band-structure with low-energy properties consistent with recent photoemission and quantum oscillations measurements on the Fe-based superconductor FeSe[1], including a mean-field like orbital ordering in the d_{xz}/d_{yz} channel, and show that this model also accounts for the temperature dependence of the measured Knight shift and the spin-relaxation rate[2]. An RPA calculation of the dynamical spin susceptibility yields spin excitations which are peaked at wave vector $(\pi, 0)$ in the 1-Fe Brillouin zone, with a broad maximum at energies of order a few meV. Furthermore, the superconducting gap structure obtained from spin fluctuation theory exhibits nodes on the electron pockets, consistent with the 'V'-shaped density of states measured by tunneling spectroscopy on this material. The redistribution of spectral weight in the superconducting state creates a $(\pi, 0)$ "neutron resonance" as seen in recent experiments[3]. Comparing to various experimental results, we give predictions for further studies.

[1] S. Mukherjee *et al.*, PRL **115**, 026402 (2015)
A. Kreisel, *et al.*, arXiv:1506.03593
[2] S.-H. Baek *et al.*, Nat. Mater. **14**, 210 (2015)
A. E. Böhmer *et al.*, PRL **114**, 027001 (2015)
[3] M.C. Rahn *et al.*, PRB **91**, 180501 (2015)
Q. Wang, *et al.*, arXiv:1502.07544

TT 46.8 Wed 12:15 H19

Interplay between iCDW order and electronic excitations in FeSe — •Markus Klug and Joerg Schmalian — Institute for Theory of Condensed Matter, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The origin of the nematic transition at 90K in FeSe and its underlying mechanism including its relevance for superconductivity remain unknown. Recently, the possibility of imaginary charge density wave order (iCDW), which breaks translational and time reversal symmetry, was proposed [1]. In this talk the implications of iCDW order in elastic neutron scattering and electronic Raman scattering are analyzed. We discuss the emergence of a spin and charge gap as well as the possibility of new collective modes.

[1] A. V. Chubukov, R. M. Fernandes and J. Schmalian,
PRB **91**, 201105(R) (2015)

TT 46.9 Wed 12:30 H19

Gap anisotropy in FeSe — •Yevhen Kushnirenko[1], Alexandr Fedorov[1,2], Erik Haubold[1], Bernd Büchner[1], Daniil Evtushinsky[3], Timur Kim[4], Moritz Hoesch[4], Thomas Wolf[5], and Sergey Borisenko[1] — [1]IFW-Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany — [2]Physikalisches Institut, Universit at zu Köln, Zulpicher Strasse 77, 50937 Köln, Germany — [3]Helmholtz-Zentrum Berlin, BESSY, D-12489 Berlin, Germany — [4]Diamond Light Source, Harwell Campus, Didcot, OX11 0DE, United Kingdom — [5]Institut für Festkörperphysik, Karlsruhe Institute for Technology, Karlsruhe 76021, Germany

FeSe is the simplest iron-based superconductor, but details of its electronic structure such as symmetry and structure of the order parameter are still not known. Knowledge of the superconducting gap symmetry can help us to understand mechanism of pairing in this material. We used angle-resolved photoemission spectroscopy (ARPES) for measurements of the superconducting gap. Synchrotron radiation was used as a light source for our experiments. We analyzed a gap behavior in different parts of the three-dimensional Brillouin zone (near Gamma, Z, A and M-point). We have found considerable gap anisotropy on the electron pocket (near A and M-point). The gap anisotropy on the central pocket (near Z-point) is small. Our results put constraints on existing theories of superconductivity in iron-based pnictides and chalcogenides.