TT 17: Superconductivity: Fe-based Superconductors - 122 Part 2 & Theory

Time: Tuesday 9:30–12:30 Location: H 2053

TT 17.1 Tue 9:30 H 2053

Intra-gap absorption in iron-pnictide $Ba(Fe_{1-x}Co_x)_2As_2$ films — •Sina Zapf[1], Boris Gorshunov[1,2,3], Dan Wu[1], Elena Zhukova[1,2,3], Vadim Nozdrin[2], Silvia Haindl[4], and Kazumasa Iida[4] — [1]1. Physikalisches Institut, Universität Stuttgart, Germany — [2]Institute of General Physics, RAS, Russia — [3]Moscow Institute of Physics and Technology, Russia — [4]Institut für Metallische Werkstoffe, IFW Dresden, Germany

Optical measurements on $Ba(Fe_{1-x}Co_x)_2As_2$ thin films [1] indicated strong intra-gap absorption (dynamical conductivity) in the superconducting (SC) state. There, conductivity at lowest frequencies was extracted with rather large uncertainty caused by huge negative dielectric constants, which is a common problem in optical measurements of superconductors. Our aim now was to perform further, more detailed investigation on the THz response of $Ba(Fe_{1-x}Co_x)_2As_2$ films. We measured their complex transmissivity with a coherent-source Terahertz (THz) spectrometer over a wide frequency range and demonstrate a remarkable improvement in resolving the frequency and temperature dependence of the intra-gap optical conductivity. Additionally, in order to enhance the interaction of the radiation with the SC films, we have performed further measurements: Two identical films on dielectric LSAT substrates were positioned face-to-face separated by a spacer, leading to multiple Fabry-Pérot resonances. We present an analysis of such a five layer system that describes the increase in sensitivity to the dynamical conductivity and discuss the experimental challenges and improvements.

[1] B. Gorshunov et al., Phys. Rev. B 81, 060509 (2010)

TT 17.2 Tue 9:45 H 2053

Electronic phase diagram of Co-doped $BaFe_2As_2$ films prepared by PLD — •Fritz Kurth, Kazumasa Iida, Jens Hänisch, Steffen Oswald, Konstantin Nenkov, Jochen Werner, Ludwig Schultz, Bernhard Holzapfel, and Silvia Haindl — IFW Dresden, Helmholtzstrasse. 20, 01069 Dresden; Germany

$Ba(Fe_{1-x}Co_x)_2As_2$ thin films with different Co-concentrations, x, were prepared on Fe-buffered MgO(100) substrates using pulsed laser deposition under ultra high vacuum conditions. All films were grown epitaxially with high phase purity as confirmed by X-ray diffraction. The c-axis lattice parameter was observed to decrease with increasing x, as observed as well in bulk material. The superconducting transition temperature, T_c, shows the typical dome shaped dependence on x where the maximum T_c of over 26 K is found at a doping level of $x = 0.044$, which is different from the results observed on single crystals and bulk pellets. This difference might be due to a change in the Co or As stoichiometry in the films compared to the nominal target compositions. A detailed chemical analysis by Auger electron spectroscopy reveals Co diffusion into the Fe buffer. At high deposition temperatures a large gradient of the Co-content is observed from 18,2 % to 8,7 %. Finally, transport properties of the doping series will be presented in this talk. This work was supported by DFG under Project no. HA5934/3-1.

TT 17.3 Tue 10:00 H 2053

Signatures of non-Fermi liquid behavior in hole-doped and chemically pressurized $EuFe_2As_2$ single crystals — •Jeevan .s Hirale, Jannis Maiwald, and Philipp Gegenwart — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich Hund Platz 1, 37077 Göttingen, Germany

We report a detailed study of the effect of hole-doping and chemical pressure (isovalent doping) in single crystals of $K_xEu_{1-x}Fe_2As_2$ and $EuFe_2(As_{1-y}P_y)_2$, respectively, by measurements of the thermopower, $S(T)$, and electrical resistivity, $\rho(T)$. In this class of FeAs-based superconductivity (SC), it is found that SC appears close to a magnetic instability, suggesting a possible unconventional pairing mechanism. We have synthesized single crystals of both K and P doped samples by the self-flux method. Upon doping Eu with K >30%, T_{SDW} gets suppressed and SC appears with $T_{c,max} \approx 34$ K. Additionally, the Eu^{2+} ordering is suppressed to low temperatures, due to the dilution of magnetic moments. On the other hand, P doping the As site suppresses the SDW transition and results in a SC phase at y >16%. The electrical resistivity data suggest non-Fermi liquid behavior near $x = 0.5$ and $y = 0.2$. This is supported by the observation of a logarithmic divergence in the thermoelectric power coefficient S/T for both systems. We also observe distinct signatures in the thermopower evolution at $x_{cr} = 0.30$ and $y_{cr} = 0.22$, which may hint at Lifshitz transitions of the Fermi surface.

Work supported by DFG through priority program SPP 1458.

TT 17.4 Tue 10:15 H 2053

In-plane anisotropy of electrical resistivity and thermoelectric power in underdoped $EuFe_2(As_{1-x}P_x)_2$ single crystals — •Shuai Jiang[1,2], Hirale S. Jeevan[1], Jannis Maiwald[1], Martin Dressel[2], and Philipp Gegenwart[1] — [1]I. Physikalisches Institut, Universität Göttingen, Germany — [2]1. Physikalisches Institut, Universität Stuttgart, Germany

We have studied the in-plane anisotropy of detwinned isovalent substituted $EuFe_2(As_{1-x}P_x)_2$ single crystals using a uniaxial pressure clamp. In the studied regime $0 < x \leq 0.12$ the structural and magnetic phase transitions are clearly separated. We reveal that the structural transition breaks the C_4 rotational symmetry and induces nematic phase via the in-plane anisotropic measurements of resistivity and thermoelectric power. The observed anisotropy in both properties indicates the existence of nematic phase below the structural phase transition. A reconstruction of the Fermi surface below the magnetic transition is deduced by the thermopower anisotropy. Additionally, the resistivity anisotropy is larger than the orthorhombic distortion, indicating the difference of underlying electronic excitation near Fermi surface. The anisotropy below the Néel transition is caused by the intrinsic electronic structure, whereas the electronic nematicity plays an important role for the larger anisotropy above the Néel transition.

15 min. break.

TT 17.5 Tue 10:45 H 2053

Magnetic Resonance from the Interplay of Frustration and Superconductivity — •Johannes Knolle[1], Ilya Eremin[2], Jorg Schmalian[3], and Roderich Moessner[1] — [1]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]Institut für Theoretische Physik III, Ruhr-Universität Bochum, D-44801 Bochum, Germany — [3]Karlsruhe Institute of Technology, Institute for Theory of Condensed Matter, D-76131 Karlsruhe, Germany

Motivated by iron-based superconductors, we develop a self-consistent electronic theory for the itinerant spin excitations in the regime of coexistence of the antiferromagnetic stripe order with wave vector $Q_1 = (\pi, 0)$ and s± superconductivity. The onset of superconductivity leads to the appearance of a magnetic resonance near the wave vector $Q_2 = (0, \pi)$, where magnetic order is absent. This resonance is isotropic in spin space, unlike the excitations near Q_1, where the magnetic Goldstone mode resides. We discuss several features which can be observed experimentally. In particular, we find that the additional subtle effects of microscopic coexistence of AF and s± SC order, such as damping of the spin waves at Q_1 and the modified dispersing behavior of the spin resonance around Q_2, can be used by INS to distinguish the coexistence phenomenon from phase separation effects.

TT 17.6 Tue 11:00 H 2053

Spectral density in a nematic state of a three-orbital model for iron pnictides — •Maria Daghofer[1], Andrew Nicholson[2], and Adriana Moreo[2] — [1]IFW Dresden, Germany — [2]University of Tennessee and Oak Ridge National Laboratory, TN, USA

We study a nematic phase, i.e., broken rotational symmetry without long-range magnetic order, for a three-orbital model describing the dominant orbitals and bands around the Fermi surface of pnictide superconductors. Using cluster-perturbation theory, we calculate the spectral density $A(\mathbf{k}, \omega)$ for the case of very short-range magnetic order that chooses the ordering vector $(\pi, 0)$ over the equivalent $(0, \pi)$ and thus breaks the fourfold lattice symmetry. The resulting asymmetry between the xz band at $Y = (0, \pi)$ and the yz band $X = (\pi, 0)$ is in very good agreement with angle-resolved photo-emission spectroscopy: The yz bands at X moves to higher energies. We also discuss the impact of onsite Coulomb repulsion and orbital polarization.

TT 17.7 Tue 11:15 H 2053

Eight-band model for the iron arsenides studied by functional RG — •Julian Lichtenstein, Stefan Maier, and Carsten

Honerkamp — Institute for Theoretical Solid State Physics, RWTH Aachen University

We analyze the superconducting instabilities in eight-band models for the iron arsenides by a functional renormalization group approach. This approach allows us to include the arsenic p-states and their non-local interactions directly without having to use descriptions where these states are included via down-folding of the single-particle part and additional screening of the interactions. We compare the results with those found in five-band studies and discuss trends of the superconducting instability as function of various material parameters.

TT 17.8 Tue 11:30 H 2053

Small-q Phonon Mediated Unconventional Superconductivity in the Iron Pnictides — •Alex Aperis[1], Panagiotis Kotetes[1,2], Georgios Varelogiannis[1], and Peter M. Oppeneer[3] — [1]Department of Physics, National Technical University of Athens, GR-15780 Athens, Greece — [2]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [3]Department of Physics and Materials Science, Uppsala University, Box 530, S-751 21 Uppsala, Sweden

We report full momentum-dependent self-consistent calculations of the gap symmetry for the iron-based high-temperature superconductors using a realistic small-q phonon mediated pairing potential within a four-band model. When both electron and hole Fermi surface pockets are present, we obtain the nodeless $s_{\pm}$ state that was first encountered in a spin-fluctuations mechanism picture. Nodal gap structures such as $d_{x^2-y^2}$, $s_{\pm} + d_{x^2-y^2}$ and even a p-wave *triplet* state, are accessible upon doping within our phononic mechanism [1]. Our results *resolve* the conflict between phase sensitive experiments reporting a gap changing sign attributed previously only to a non-phononic mechanism and isotope effect measurements proving the involvement of phonons in the pairing. Application of our theory to specific members of the pnictide family will also be briefly discussed.

[1] A. Aperis *et al.*, Phys. Rev. B **83**, 092505 (2011).

TT 17.9 Tue 11:45 H 2053

Competing antiferromagnetic states in the pnictides — •Philip M. R. Brydon, Jacob Schmiedt, and Carsten Timm — Technische Universität Dresden, Dresden, Germany

Motivated by the complicated nesting properties of the Fermi surface [1], we present a study of the magnetic order in the pnictides focusing upon the competition of the observed stripe order with other commensurate and incommensurate states. Starting from a phenomenological microscopic model, we derive the mean-field Ginzburg-Landau free energy, and systematically construct the magnetic phase diagram as a function of the doping and key band structure parameters [2]. We show that the number, location, and relative size of the hole pockets crucially controls the magnetic state, which we explain in terms of the competition between different nesting instabilities. We discuss the implications for electronic-only models of the magnetic order.

[1] J. Schmiedt, P. M. R. Brydon, and C. Timm, arXiv:1108.5296 (unpublished).
[2] P. M. R. Brydon, J. Schmiedt, and C. Timm, arXiv:1109.2071 (accepted for publication in Phys. Rev. B).

Invited Talk TT 17.10 Tue 12:00 H 2053

Magnetism and Superconductivity: A new era of convergence in condensed matter physics — •Piers Coleman — Center for Materials Theory, Rutgers University, Piscataway, New Jersey

Three years after the discovery of superfluid He-3 was discovered, Physicists first observed heavy fermion superconductivity, yet the open mind-set required to embrace these results as a discovery, rather than a materials artifact was lacking. It took the efforts of a brave and determined set of heavy electron pioneers, to overcome this resistance and change the mind-set.

Today, we are increasingly conscious of the convergence of magnetism and superconductivity in condensed matter physics, of the central role of spin as a driver for heavy electron metals and superconductors - not just as the glue of pairing - but as the basic fabric of these materials. Many of us suspect that the nexus of these phenomena lies at the quantum critical point that appears to present in heavy electron, cuprate and iron-based superconductors.

I'll talk about how our ideas about spins and their role in correlated electron physics are changing. I want to talk about the severe challenges the physicists face in trying to describe the incompressible spin component of these materials. I'll discuss the all-important links between f- and d-electron materials and some of the new kinds of order we are encountering, including a hidden and topological order.