TT 36: Focussed Session: Superconductivity and Magnetism in Ferropnictides and Related Materials

Time: Thursday 9:30–13:00 Location: HSZ 03

Topical Talk TT 36.1 Thu 9:30 HSZ 03

Superconductivity and Magnetism in $LaO_{1-x}F_xFeAs$ — •Bernd Buechner[1], Hans-Joachim Grafe[1], Christian Hess[1], Ruediger Klingeler[1], Guenter Behr[1], Agnieszka Kondrat[1], Norman Leps[1], Guillaume Lang[1], Hans-Henning Klauss[2], and Hubertus Luetkens[3] — [1]IFW Dresden — [2]TU Dresden — [3]PSI Villigen

Measuring NMR as well as muSR, transport and thermodynamic properties we have determined the phase diagram of $LaO_{1-x}F_xFeAs$ superconductors. In my talk, I will show experimental studies of the magnetic ordering, properties of the superconducting state and the normal state properties in the superconducting regions of the phase diagram. While the temperature dependence of the London penetration as determined from *SR points to an isotropic s wave state, our early NMR data suggest singlet pairing and nodes of the order parameter. In the paramagnetic normal state, NMR on all three nuclei shows that the local electronic susceptibility rises with increasing temperature. This had led to suggest the presence of a pseudogap, which I will discuss in detail. The scaling of all NMR shifts with respect to the macroscopic susceptibility indicates that there is no apparent multiband effect through preferential hyperfine couplings. Relaxation measurements indicate a similar temperature-dependence for $(T_1T)^{-1}$, and suggest that the dynamical susceptibility changes uniformly in q space with varying temperature. The transport properties show some striking similarities to the findings in cuprates and, finally, susceptibility as well as NMR studies point to the antiferromagnetic fluctuations.

Invited Talk TT 36.2 Thu 10:00 HSZ 03

Magnetism, superconductivity, and pairing symmetry in Fe-based superconductors — •Andrey Chubukov — Dept . of Physics, University of Wisconsin, 1150 University ave., Madison WI 53706

I discuss the interplay between antiferromagnetism and superconductivity in novel Fe-based superconductors within the itinerant model of small electron and hole pockets. I argue that the effective interactions in both magnetic and pairing channels logarithmically flow towards the same values at low energies, i.e., antiferromagnetism and superconductivity are competing orders. The magnetic instability comes first for equal sizes of hole and electron pockets, but looses to superconductivity upon doping. I discuss the transition between the two ordered states and argue that it must be first order. The superconducting gap has no nodes, but changes sign between the two Fermi surfaces (extended s-wave symmetry). I discuss properties of such superconductors and the effects of non-magnetic impurities. I argue that the temperature dependencies of the spin susceptibility, the NMR relaxation rate and the superfluid density are exponential for the clean case, but become power-laws in the dirty limit. I discuss potential smoking-gun experiments to probe extended s-wave symmetry.

Topical Talk TT 36.3 Thu 10:30 HSZ 03

Structural and magnetic transitions of underdoped $(Ba_{1-x}K_x)Fe_2As_2$ — •Dirk Johrendt[1], Marianne Rotter[1], Marcus Tegel[1], Inga Schellenberg[2], Falko M. Schappacher[2], and Rainer Poettgen[2] — [1]LMU München, Department Chemie, Butenandtstr. 5-13 (Haus D), 81377 München, Germany — [2]WWU Münster, Institut für Anorganische und Analytische Chemie, Corrensstr. 30, 48149 Münster. Germany

$BaFe_2As_2$ is the parent compound of the 122-type family of iron arsenide superconductors. Superconductivity up to $T_c = 38$ K is induced by doping the barium site by potassium or the iron site by cobalt or even without chemical doping under high pressure. The structural and magnetic phase transition of the parent compound is completely suppressed at the optimal doping level in $(Ba_{1-x}K_x)Fe_2As_2$ around x = 0.4. But In the underdoped regime, superconductivity co-exists with the orthorhombically distorted lattice and it is debatable at the moment, to what extent the superconducting state may also co-exist with the antiferromagnetic order.

The talk will first briefly review the properties of $BaFe_2As_2$ and the doped Ba122-superconductors. Then recent results of studies in the underdoped regime will be reported. $(Ba_{1-x}K_x)Fe_2As_2$ ($x < 0.4$) has been studied in detail by low-temperature x-ray powder diffraction and ^{57}Fe-Mössbauer spectroscopy. Relationships between the evolution of magnetic ordering and the onset of the orthorhombic lattice distortion are discussed in connection with possible inhomogeneities of the potassium distribution in underdoped superconducting Ba122-materials.

15 min. break

Topical Talk TT 36.4 Thu 11:15 HSZ 03

Relation of structure, magnetism, doping and pressure in AFe_2As_2 — •Helge Rosner, Deepa Kasinathan, Alim Ormeci, Katrin Koch, Miriam Schmitt, Walter Schnelle, Corneliu Miclea, Michael Nicklas, Manoj Kumar, Christoph Geibel, Ulrich Schwarz, and Andreas Leithe-Jasper — MPI CPfS Dresden, Nöthnitzer Str. 40, 01187 Dresden

We present an overview of our recent experimental and theoretical studies on the AFe_2As_2 (A = Sr, Eu, K) compounds. Starting with thermodynamic measurements and band structure results for the undoped $SrFe_2As_2$ under ambient conditions, we report the influence of hydrostatic pressure and substitution on the A site as well as the Fe site on the magneto-structural and superconducting transitions: (i) $SrFe_2As_2$ orders antiferromagnetically at 205 K, intrinsically tied to a tetragonal-orthorhombic distortion. (ii) The magnetism is weakened upon application of pressure as indicated by resistivity, X-ray data and calculations. (iii) Similar to substitution on the A site, substitutions on the Fe-site quenches the magnetic transition and induces bulk superconductivity with T_c up to 20 K. (iv) For underdoped $SrFe_{2-x}Co_xAs_2$, superconductivity with T_c up to 27 K is observed for pressures of 2.6 GPa. The first observation of bulk superconductivity induced by electron doping in AFe_2As_2 compounds – despite strong disorder in the Fe-As layer – favors an *itinerant* electronic theory in contrast to the strongly correlated cuprates. Although discrepancies between experiment and calculated electronic structure remain, DFT band structure calculations provide a consistent overall picture of AFe_2As_2 compound.

TT 36.5 Thu 11:45 HSZ 03

DFT studies of Iron-based Superconductors — •Lilia Boeri[1], Oleg V. Dolgov[1], Alexander A. Golubov[2], and Ole Krogh Andersen[1] — [1]MPI-FKF, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Faculty of Science and Technology and MESA+ Institute for Nanotechnology, University of Twente,7500 AE Enschede, The Netherlands

The discovery of superconductivity in iron pnicticides has generated considerable interest. So far, however, not only the pairing mechanism, but even the basic electronic structure of these materials is not well understood.

We use Density Functional Theory to understand the electronic and vibrational properties of LaOFeAs, which can be considered a prototype for iron pnictides.

First, we calculate the phonon dispersions and electron-phonon coupling using linear response and show that standard Migdal-Eliashberg theory cannot explain the experimental T_c. Then we derive ab-initio an accurate tight-binding Hamiltonian, using downfolding + N-ization (NMTO), which allows us to elucidate the origin of the complicated band structure of iron pnicticides. As a first application of our model, we study itinerant magnetism.

Topical Talk TT 36.6 Thu 12:00 HSZ 03

Quasiparticle renormalization effects in the normal-state optical properties of iron pnictides — •Alexander Boris[1], N.N. Kovaleva[1,2], P. Popovich[1], Y. Matiks[1], C.T. Lin[1], R.K. Kremer[1], L. Boeri[1], O.V. Dolgov[1], I.I. Mazin[3], and B. Keimer[1] — [1]Max-Planck-Institut für Festkörperforschung, 70569 Stuttgart — [2]Department of Physics, Loughborough University, Loughborough, United Kingdom — [3]CCMS, Naval Research Laboratory, Washington, D.C. 20375, USA

We report a comprehensive spectroscopic ellipsometry study on iron pnictides, $LaFeAsO_{1-x}F_x$ and $Sr_{1-x}K_xFe_2As_2$, over a wide range of temperatures (10 - 350 K) and photon energies extending from the far infrared (IR) into the deep ultraviolet (UV), 0.01 - 6.5 eV. The optical

conductivity spectra are dominated by a sequence of interband transitions which agree very well with those predicted by LDA calculations. The free charge carrier response is, however, heavily damped. This implies that the electronic states near the Fermi surface are strongly renormalized. From our optical measurements we address

i) electron-electron correlation effects [1],

ii) electron-phonon coupling, and

iii) dynamic charge and spin ordering [2]

as possible renormalization factors.

[1] A.V.Boris et al., preprint at arXiv:0806.1732;

[2] I.I. Mazin and M.D. Johannes, Nature Physics (in press), preprint at arXiv:0807.3737.

Topical Talk TT 36.7 Thu 12:30 HSZ 03

C-axis transport of pnictide single crystals — •Paul Müller[1], Yuri Koval[1], Günter Behr[2], and Bernd Büchner[2] — [1]Department of Physics, Universität Erlangen-Nürnberg — [2]IFW Dresden

Mesa structures were fabricated on the (ab) plane of small $LaO_{0.9}F_{0.1}FeAs$ single crystals. Resistance vs. temperature measurements showed metallic behavior with a residual resistance ratio higher than 10. Both magnetic susceptibility and c-axis transport measurements showed the same value for the critical temperature, i.e. ∼20K. Current-voltage characteristics are typical for overdamped Josephson junctions with a critical current density of $\sim 10^5$ A/cm^2. Moreover, the critical current vs. temperature dependence follows the Ambegaokar-Baratoff relation for the maximum dc Josephson current. One possible explanation could be that we have observed an intrinsic Josephson effect in <c>-direction. This is supported by recent measurements of radiation emission between 11 and 12 GHz. Finally, we discuss current injection effects on Josephson critical current and T_c.