TT 8: Superconductivity: Fe-based Superconductors - 122 Part 1

Time: Monday 15:00–18:30 Location: H 2053

TT 8.1 Mon 15:00 H 2053

Elastic anomalies in $Ba(Fe_{1-x}Co_x)_2As_2$ — •Christoph Meingast[1], Anna Böhmer[1,2], Frederic Hardy[1], Philipp Burger[1,2], Peter Adelmann[1], Doris Ernst[1], Rainer Fromknecht[1], Peter Schweiss[1], Rolf Heid[1], and Thomas Wolf[1] — [1]Karlsruhe Institute of Technology, Institute for Solid State Physics, 76021 Karlsruhe, Germany — [2]Karlsruhe Institute of Technology, Fakultät für Physik, 76128 Karlsruhe, Germany

The elastic properties of $Ba(Fe_{1-x}Co_x)_2As_2$ single crystals are studied using a three-point-bending arrangement in a capacitance dilatometer. In this novel setup, a constant pressure is applied and the elastic response is determined as a function of temperature. In the undoped compound we find a very large softening of the elastic response at the structural/magnetic transitions near 140 K. The high resolution of this setup allows us to distinguish the behavior at both transitions. The large softening for undoped crystals weakens with doping and in the overdoped crystals only the very small softening as usually seen in superconductors at T_c is observed. We discuss our results in light of recent ultrasound measurements [1,2].

[1] R. M. Fernandes et al., Phys. Rev. Lett. 105, 157003 (2010).
[2] Y. Yoshizawa et al., arXiv: 1111.0366

TT 8.2 Mon 15:15 H 2053

Pair-breaking in overdoped $Ba(Fe_{1-x}Co_x)_2As_2$: Evidence for s± superconductivity — •Frédéric Hardy, Robert Eder, Thomas Wolf, Rolf Heid, Philipp Burger, Anna Böhmer, Peter Schweiss, and Christoph Meingast — Institut für Festkörperphysik KIT, Karlsruhe, Germany

Using specific-heat measurements, we study the effect of disorder induced by Co substitution on the thermodynamic properties of overdoped $Ba(Fe_{1-x}Co_x)_2As_2$ ($x > 0.06$) superconductors. We find that scattering of electrons by these non-magnetic impurities is rather strong (beyond Born limit) explaining the rapid suppression of T_c for $x = 0.12$. The variation of the specific-heat discontinuity, the thermodynamic critical field, and the gapless contributions, with Co content can be accurately reproduced only if the superconducting ground state exhibits s± symmetry. Comparisons with other systems including K and P doped single crystals are given.

TT 8.3 Mon 15:30 H 2053

Spectroscopic study of transition metal impurities in iron pnictides — •Roberto Kraus, Valentina Bisogni, Luminita Harnagea, Saicharan Aswartham, Sabine Wuhrmehl, Bernd Büchner, and Jochen Geck — IFW Dresden, PF 270116, D-01171 Dresden, Germany

In $Ba(Fe,TM)_2As_2$, superconductivity emerges upon replacing Fe with heavier TM=Co or Ni. The prevalent interpretation of this effect is that the TM-impurities add electrons to the Fe-band and thereby induce superconductivity. However, this interpretation has been questioned recently based on theoretical grounds [1].

To clarify this we have performed valence band photoemission and Auger spectroscopy studies of single crystalline $Ca(Fe,Co)_2As_2$ and $Ba(Fe,TM)_2As_2$ with TM=Ni or Cu. The valence band photoemission data together with model calculations show that the Co and Ni impurity states largely overlap in energy with the Fe-bands, whereas the Cu impurity states do not. The LVV Auger lines measured at the L_3-absorption edge of the impurities unambiguously reveal a $3d^8$ final state for Ni and Cu.

This experimental result is incompatible with the naive assumption that Ni and Cu dope, respectively, 2 and 3 electrons into delocalized Fe-states. Rather our results reveal a much more complex situation and support the isovalent substitution of Fe by Ni and Cu.

[1] Wadati et al., PRL **105**, 157004 (2010)

TT 8.4 Mon 15:45 H 2053

Scanning tunneling spectroscopy in Co-doped $BaFe_2As_2$: What density functional theory can tell us. — •Klaus Koepernik[1], Steven Johnston[1], Jeroen van den Brink[1], Erik van Heumen[2], and Mark S. Golden[2] — [1]IFW Dresden, Germany — [2]van der Waals-Zeeman institute, University of Amsterdam, the Netherlands

We us density functional theory to simulate the scanning tunneling spectra and topographic images of Co-doped $BaFe_2As_2$. The matrix element effects are evaluated and the specific contributions of the different surface atoms to the spectra are considered. The results give a better understanding of the measured spectra and assess the resolution of STS measurements in these systems.

TT 8.5 Mon 16:00 H 2053

Universal microscopic description of the infrared conductivity of 122 iron arsenides — •Aliaksei Charnukha[1], Oleg V. Dolgov[1], Alexander A. Golubov[2], Yulia Matiks[1], Dun Lu Sun[1], Cheng Tian Lin[1], Bernhard Keimer[1], and Alexander V. Boris[1] — [1]Max-Planck-Institut für Festköorperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Faculty of Science and Technology and MESA+ Institute of Nanotechnology, NL-7500 AE Enschede, The Netherlands

We report the full complex dielectric function of high-purity $Ba_{0.68}K_{0.32}Fe_2As_2$ single crystals with T_c=38.5 K determined by wide-band spectroscopic ellipsometry at temperatures 10 K≤T≤300 K. We discuss the microscopic origin of superconductivity-induced infrared optical anomalies in the framework of a multiband Eliashberg theory with two distinct superconducting gap energies $2\Delta_A = 6k_BT_c$ and $2\Delta_B = 2.2k_BT_c$. The observed unusual suppression of the optical conductivity in the superconducting state at energies up to 14 k_BT_c can be ascribed to spin-fluctuation–assisted processes in the clean limit of the strong-coupling regime. We further demonstrate that the same model provides a good description of the infrared conductivity of electron-doped compounds in this class of superconductors.

TT 8.6 Mon 16:15 H 2053

Multigap superconductivity in $(Ba,K)Fe_2As_2$ probed by thermal expansion — •Anna Böhmer[1,2], Philipp Burger[1,2], Frédéric Hardy[1], Thomas Wolf[1], Peter Schweiss[1], Rainer Fromknecht[1], and Christoph Meingast[1] — [1]Institut für Festkörperphysik, Karlsruher Institut für Technologie, Postfach 3640, 76021 Karlsruhe — [2]Fakultät für Physik, Karlsruher Institut für Technologie, Postfach 6980, 76049 Karlsruhe

Hole doped $(Ba,K)Fe_2As_2$ is one of the most widely studied iron-based superconductors. Here, we report on an investigation of its thermal expansion using capacitive dilatometry. Overdoped samples, which do not undergo the magneto-structural transition, exhibit clear signatures of two-gap superconductivity in the thermal expansion coefficients. The data are analyzed with an extension of the two-gap alpha model, which is widely used to describe the specific heat of multi-band superconductors. By combining specific-heat and thermal-expansion data we are able to extract the uniaxial pressure dependence of T_c, of the gap magnitudes and of the electronic density of states. The influence of uniaxial pressure on the phase diagram is discussed.

TT 8.7 Mon 16:30 H 2053

A light scattering study of the superconducting gap in $Ba_{0.6}K_{0.4}Fe_2As_2$ — •Florian Kretzschmar[1], Bernhard Muschler[1], Rudi Hackl[1], Tom Devereaux[2,3], and Hai-Hu Wen[4] — [1]Walther Meissner Institut, Bayerische Akademie der Wissenschaften, 85748 Garching — [2]Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025, USA — [3]Geballe Laboratory for Advanced Materials & Dept. of Applied Physics, Stanford University, CA 94305, USA — [4]Nanjing University, Nanjing, P.R. China

We present results of electronic Raman scattering experiments on optimally doped $Ba_{0.6}K_{0.4}Fe_2As_2$ in the superconducting state. In contrast to $Ba(Fe_{1-x}Co_x)_2As_2$ we find superconductivity features in all symmetries. The observed gaps depend strongly on the band index but are only weakly momentum-dependent on the individual bands. We find a small gap 2Δ in the range 10 meV on one hole-like band and two large and rather isotropic gaps of 23 meV on the other hole-like band and 25 meV on the electron-like bands, respectively. Below a symmetry independent threshold of approximately 25 cm^{-1} the Raman response is very small and nearly energy independent. Although the intensity is not exactly zero it is safe to conclude that there is a full gap on all bands having a magnitude of at least 1 k_BT_c. This work is supported by the DFG via the SPP 1458.

15 min. break.

TT 8.8 Mon 17:00 H 2053

Calorimetric evidence of multiband superconductivity in $A_{1-x}Na_xFe_2As_2$ (A = Ba and Ca) single crystals — •Mahmoud Abdel-Hafiez, Saicharan Aswartham, Dirk Bombor, Luminita Harnagea, Manoj Kumar, Ashim Pramanik, Volodymr Zabolotnny, Vladislav Kataev, Christian Hess, Sabine Wurmehl, Anja U. B. Wolter, and Bernd Büchner — Leibniz Institute for Solid State and Materials Research IFW Dresden, 01069 Dresden, Germany

We report on the electronic properties and the superconducting gap characteristics of superconducting single crystals of $A_{1-x}Na_xFe_2As_2$ (A = Ba and Ca) studied by low temperature specific heat measurements. The zero-field specific heat data manifests a high electronic specific heat in the normal state, which is comparable to other hole-doped 122 compounds. We demonstrate that the measured zero field temperature dependence of the specific heat can be well described by two s-wave gaps. This is further confirmed by the scaling based on the s-wave and d-wave scenario of the low temperature data at various magnetic fields. Our results are qualitatively similar to other hole-doped 122 compounds, but nevertheless the magnitude of the gaps and their ratio are quite different.

TT 8.9 Mon 17:15 H 2053

Microscopic interplay of superconducting and magnetic order parameters in ferropnictides — •H. Maeter[1], T. Goltz[1], J. Spehling[1], H.-H. Klauss[1], M. Bendele[2], H. Luetkens[2], R. Khasanov[2], G. Pascua[2], Z. Shermadini[2], A. Amato[2], S. Aswartham[3], J. E. Hamann-Borrero[3], A. Kondrat[3], C. Hess[3], A. Wolter[3], S. Wurmehl[3], G. Behr[3], B. Büchner[3], E. Wiesenmayer[4], D. Johrendt[4], H. Potts[5], and B. Banusch[5] — [1]Institut für Festkörperphysik, TU Dresden, Germany — [2]Laboratory for Muon-Spin Spectroscopy, Paul Scherrer Institut, Villigen, Switzerland — [3]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden,Germany — [4]Department Chemie, Ludwig-Maximilians-Universität München, Germany — [5]Swiss Nanoscience Institute, Universität Basel, Switzerland

We present results of μSR experiments of $Ba_{1-x}Na_xFe_2As_2$ that show a large coupling of the superconducting and magnetic order parameters. This is unexpected in light of the phase separation in $Ba_{1-x}K_xFe_2As_2$. However, in a μSR study of $Ba_{1-x}K_xFe_2As_2$ we unambiguously showed microscopic coexistence, even though there are many reports of phase separation in this system [1]. In $FeSe_{1-x}$ the interplay of phase separation and microscopic coexistence is also evident, here pressure can induce a change from microscopic coexistence to a combination of both [2]. In light of the μSR results it seems likely that phase separation and microscopic coexistence depend on the microscopic properties much more than on disorder.

[1] Wiesenmayer et al., Phys. Rev. Lett. 107, 237001 (2011);
[2] Bendele et al., Phys. Rev. Lett. 104, 087003 (2010).

TT 8.10 Mon 17:30 H 2053

Influence of doping in KFe_2As_2 superconducting single crystals — •S. Aswartham[1], M. Roslova[1,2], I. V. Morozov[1,2], A. U.B Wolter[1], M. Kumar[1], C. Hess[1], S. Wurmehl[1], and B. Büchner[1] — [1]Leibniz Institute for Solid State and Materials Research, D-01069 Dresden, Germany — [2]Department of Chemistry, Moscow State University, Moscow 119991, Russia

Single crystals of the new unconventional superconductor KFe_2As_2 were grown using two different fluxes, i.e KAs and FeAs flux. The superconducting transition temperature and the superconducting volume fraction were found to be same in all crystals independent of the flux. However, the normal state susceptibility is changed significantly. On the other hand we investigated, the influence of various types of doping in KFe_2As_2. Specifically, we investigate the substitution of K by Na (yielding $K_{1-x}Na_xFe_2As_2$) and the substitution of Fe by other transition metals like Co, Cr, Rh (yielding $K(Fe_{1-x}TM_x)_2As_2$). We will present a systematic study of the crystal growth, characterization and superconducting properties of these newly synthesized superconductors.

TT 8.11 Mon 17:45 H 2053

Enhancement of the upper critical field in codoped iron-arsenic high-temperature superconductors — •H. Rosner[1], M. Nicklas[1], W. Schnelle[1], A. Leithe-Jasper[1], J. Wosnitza[2], and F. Weickert[1,3] — [1]MPI CPfS Dresden — [2]HLD Dresden-Rossendorf — [3]LANL Los Alamos

We present the first study of codoped iron-arsenide superconductors of the 122 family $(Sr/Ba)_{1-x}K_xFe_{2-y}Co_yAs_2$ with the purpose to increase the upper critical field H_{c2} compared to single doped $Sr/BaFe_2As_2$ materials. H_{c2} was investigated by measuring the magnetoresistance in high pulsed magnetic fields up to 64 T. We find, that H_{c2} extrapolated to T = 0 is indeed enhanced significantly to 90 T for polycrystalline samples of $Ba_{0.55}K_{0.45}Fe_{1.95}Co_{0.05}As_2$ compared to 75 T for $Ba_{0.55}K_{0.45}Fe_2As_2$ and $BaFe_{1.8}Co_{0.2}As_2$ single crystals. Codoping thus is a promising way for the systematic optimization of iron-arsenic based superconductors for magnetic-field and high-current applications.

TT 8.12 Mon 18:00 H 2053

Electronic properties of $BaFe_2As_2$ and $CaFe_2As_2$ under hydrostatic and non-hydrostatic pressure conditions — •Milan Tomić, Roser Valentí, and Harald Jeschke — Institut für Theoretische Physik, Goethe-Universität, Frankfurt am Main, Germany

We have examined the effects of different external pressure conditions on the structural and electronic properties of the 122 family of iron pnictides by considering ab initio constant pressure structural relaxations. We find magneto-structural phase transitions in both $CaFe_2As_2$ and $BaFe_2As_2$ and observe a high sensitivity of the electronic structure and Fermi surface topology on the nature of the pressure conditions. In this talk, we will present these results, compare them with the effects of phosphorus doping and will discuss possible implications for superconductivity.

TT 8.13 Mon 18:15 H 2053

Dispersive High-Energy Spin Excitations in Iron Pnictide Superconductors Investigated with RIXS — •Thorsten Schmitt[1], Kejin Zhou[1], Y. B. Huang[1,2], C. Monney[1], V. N. Strocov[1], J. van den Brink[3], and H. Ding[2] — [1]Paul Scherrer Institut, Villigen PSI, Switzerland — [2]IOP, CAS, Beijing, China — [3]IFW Dresden, Germany

The discovery of iron-based high temperature superconductivity has triggered tremendous research efforts in searching for novel high-T_c superconductors. Unlike cuprates, which have long-range ordered antiferromagnetic Mott insulators as parent compounds, the parent compounds of iron-based superconductors are spin-density wave metals with delocalized electronic structure and more itinerant magnetism.

Recent developments of the high-resolution resonant inelastic X-ray scattering (RIXS) technique [1] have enabled investigations of magnetic excitations in cuprates [2], which show excellent agreement with results from Inelastic Neutron Scattering. In this presentation we demonstrate that RIXS can be used to measure collective magnetic excitations in iron-based superconductors despite their much stronger itinerancy compared to cuprates. The persistence of high-energy spin excitations even in optimally doped pnictide superconductors in a wide range of temperatures strongly suggests a spin-mediated Cooper pairing mechanism as proposed in cuprate superconductors.

[1] G. Ghiringhelli et al., Rev. Sci. Inst. 77, 113108 (2006); V. N. Strocov et al., J. Synch. Rad. 17, 631 (2010).
[2] J. Schlappa et al., Phys. Rev. Lett. 103, 047401 (2009); L. Braicovich et al., Phys. Rev. Lett. 104, 077002 (2010).