TT 27: Superconductivity: Fe-based Superconductors - 122

Time: Tuesday 9:30–13:15 Location: H18

Topical Talk TT 27.1 Tue 9:30 H18

Hydrostatic-Pressure Tuning of Magnetic, Nonmagnetic and Superconducting States in Annealed $Ca(Fe_{1-x}Co_x)_2As_2$ — •Elena Gati[1], Sebastian Köhler[1], Daniel Guterding[1], Bernd Wolf[1], Stephan Knöner[1], Sheng Ran[2], Sergey L. Bud'ko[2], Paul C. Canfield[2], and Michael Lang[1] — [1]Physikalisches Institut, J.W. Goethe-Universität, SPP 1458, D-60438 Frankfurt (Main), Germany — [2]Ames Laboratory, Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011, USA

Iron-based superconductors manifest rich phase diagrams where antiferromagnetic (afm), tetragonal (t), orthorhombic (o) and superconducting (sc) phases are observed in close proximity. We report on measurements of the magnetic susceptibility and electrical resistance under ^{4}He-gas pressure on single crystals of $Ca(Fe_{1-x}Co_x)_2As_2$. We demonstrate that for accurately heat-treated crystals with modest Co-concentration the salient ground states associated with iron-arsenide superconductors, i.e., o/afm, sc, and nonmagnetic collapsed-t states can be accessed all in one sample with reasonably small and truly hydrostatic pressure. Systematic investigations of the various phase transitions and ground states through pressure tuning revealed no coexistence of bulk superconductivity with the o/afm phase which we relate to the strongly first-order character of the o/afm transition in the present compound. Our results [1], together with literature results, indicate that preserving fluctuations associated with the o/afm transition to low enough temperatures is essential for superconductivity to form.

[1] E. Gati et al., arXiv:1210.5398 (2012)

TT 27.2 Tue 10:00 H18

Electronic structure, magnetic and superconducting properties of co-doped iron-arsenide superconductors — •Helge Rosner[1], Walter Schnelle[1], Franziska Weikert[2,3], Michael Nicklas[1], Jochen Wosnitza[3], and Andreas Leithe-Jasper[1] — [1]MPI CPfS Dresden — [2]Los Alamos National Laboratory, New Mexico, US — [3]HLD Dresden Rossendorf

We present a joint experimental and theoretical study of co-doped iron-arsenide superconductors of the 122 family $A_{1-x}K_xFe_{2-y}T_yAs_2$ (A=Ba,Sr,Eu; T=Co,Ru,Rh). In these systems, the co-doping enables the separation of different parameters - like electron count, disorder or the specific geometry of the FeAs layer - with respect to the position of the respective compounds in the general 122 phase diagram. For a series of compounds, we investigate the relevance of the different parameters for the magnetic, thermodynamic and superconducting properties. Our experimental investigations are supported by density functional electronic structure calculations applying different approximations for doping and disorder.

TT 27.3 Tue 10:15 H18

Crystal growth and physical properties of Na-doped $BaFe_2As_2$ superconducting single crystals — •S. Aswartham[1], M. Abdel-Hafiez[1], D. Bombor[1], A. U. B. Wolter[1], M. Kumar[1], C. Hess[1], D. V. Evtushinsky[1], V. B. Zabolotnyy[1], A. A. Kordyuk[1], T. K. Kim[1,2], S. V. Borisenko[1], S. Wurmehl[1], and B. Büchner[1] — [1]Leibniz Institute for Solid State and Materials Research, D 01069 Dresden, Germany — [2]Diamond Light Source Ltd., Didcot OX11 0DE, United Kingdom

Single crystals of $Ba_{1-x}Na_xFe_2As_2$ with x = 0, 0.25, 0.35, 0.4 were grown using a self-flux high temperature solution growth technique. The superconducting and normal state properties were studied by temperature dependent magnetic susceptibility, electrical resistivity and specific heat revealing that the magnetic and structural transition is rapidly suppressed upon Na-substitution at the Ba-site in $BaFe_2As_2$, giving rise to superconductivity. A superconducting transition as high as 34 K is reached for a Na-content of x=0.4. The positive Hall coefficient confirms that the substitution of Ba by Na results in hole-doping similarly to the substitution of Ba by K. Angle resolved photoemission spectroscopy was performed on all $Ba_{1-x}Na_xFe_2As_2$ crystals. The Fermi surface of hole-doped $Ba_{1-x}Na_xFe_2As_2$ is to high extent the same as the Fermi surface found for the K-doped sister compounds, suggesting a similar impact of the substitution of Ba by either K or Na on the electronic band dispersion at the Fermi level.

TT 27.4 Tue 10:30 H18

Raman active phonons in twin-free $BaFe_2As_2$ — •Andreas Baum[1], Bernhard Muschler[1], Florian Kretzschmar[1], Jiun-Haw Chu[2,3], James G. Analytis[2,3], Ian R. Fisher[2,3], and Rudi Hackl[1] — [1]Walther-Meissner-Institut, 85748 Garching, Germany — [2]SIMES, SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA — [3]GLAM and Department of Applied Physics, Stanford University, Stanford, CA 94305, USA

The magneto-structural phase transition of $BaFe_2As_2$ is studied by Raman spectroscopy. The main focus is placed on the anomalies of the lattice dynamics upon entering the spin density wave (SDW) phase. Since the related lattice distortion is very small the crystals are twinned, and in the existing experiments the properties of the phonons could only partially be clarified. To overcome the problem of twinning uniaxial stress was applied before cool down. In the twin-free crystals the symmetry properties of the phonons could be pinned down. The E_g vibration of the Fe and As atoms at 135 cm^{-1} splits into a B_{2g} and a B_{3g} mode at 138 and 128 cm^{-1}, respectively, below the SDW transition. The unexpected leakage of the As A_{1g} phonon observed in the tetragonal B_{2g} symmetry can be traced back to a resonance effect occuring only when the incoming and outgoing photon polarizations are oriented parallel to the new orthorhombic b axis along which the Fe spins order ferromagnetically.

TT 27.5 Tue 10:45 H18

Thermopower as sensitive probe of electronic nematicity in iron pnictides — Shuai Jiang[1,2], H.S. Jeevan[1], Jinkui Dong[1], and •Philipp Gegenwart[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]1.Physikalisches Institut, Universität Stuttgart, Germany

We study the in-plane anisotropy of the thermoelectric power and electrical resistivity on detwinned single crystals of isovalent substituted $EuFe_2(As_{1-x}P_x)_2$. Compared to the resistivity anisotropy the thermopower anisotropy is more pronounced and clearly visible already at temperatures much above the structural and magnetic phase transitions. Most remarkably, the thermopower anisotropy changes sign below the structural transition. This is associated with the interplay of two contributions due to anisotropic scattering and orbital polarization, which dominate at high- and low-temperatures, respectively.

[1] S. Jiang, H. S. Jeevan, J. Dong, P. Gegenwart, arXiv:1210.2634

15 min. break

TT 27.6 Tue 11:15 H18

Softening of the elastic shear mode C_{66} in iron-based superconductors — •Anna Böhmer[1,2], Philipp Burger[1,2], Frédéric Hardy[1], Peter Schweiss[1], Rainer Fromknecht[1], Thomas Wolf[1], Christoph Meingast[1], Marius Reinecker[3], and Wilfried Schranz[3] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, D-76021 Karlsruhe — [2]Karlsruher Institut für Technologie, Fakultät für Physik, D-76128 Karlsruhe — [3]Universität Wien, Fakultät für Physik, A-1090 Wien

The structural phase transition of underdoped iron-based superconductors is accompanied by a large softening of the elastic shear mode C_{66}, which has attracted considerable attention. This softening has been discussed both in terms of orbital and spin-nematic fluctuations which would be responsible for the structural phase transition and, possibly, superconductivity. However, sample requirements have so far restricted experimental investigations of C_{66} (via measurements of the ultrasound velocity) to the $Ba(Fe,Co)_2As_2$ system.

Here, we report on a new technique, based on a three-point bending setup, to probe the Young's modulus of a sample with a capacitance dilatometer. For certain orientations, the Young's modulus is related to the elastic constant C_{66} whose effective temperature dependence can be obtained. Platelet-like samples, as frequently encountered for iron-based systems, are easily studied with our setup. Data on several systems will be presented and discussed.

TT 27.7 Tue 11:30 H18

Paramagnetic limiting of the upper critical field of KFe_2As_2 studied by low temperature thermal expansion and magnetostriction — •Diego A. Zocco[1], Kai Grube[1], Sebastian

Zaum[1], Felix Eilers[1], Roland Schäfer[1], Thomas Wolf[1], Philipp Burger[1], Frédéric Hardy[1], Anna Böhmer[1], Christoph Meingast[1], and Hilbert von Löhneysen[1,2] — [1]Institut für Festkörperphysik, Karlsruhe Institute of Technology, D-76021 Karlsruhe, Germany — [2]Physikalisches Institut, Karlsruhe Institute of Technology, D-76031 Karlsruhe, Germany.

We present low-temperature thermal expansion and magnetostriction measurements of single crystals of KFe_2As_2 ($T_c \sim 3.4$ K) in magnetic fields up to 14 T applied parallel and perpendicular to the c-axis of the samples ($B^c_{c2} \sim 1.5$ T and $B^{ab}_{c2} \sim 4.8$ T). In the normal state, quantum oscillations of the sample length were observed for $B \parallel c$ and $B \perp c$, giving estimated mean-free-path values of 177 and 52 nm, respectively, indicating that the superconducting state can be described as being in the clean limit ($\xi^{ab}_0 \sim 10$ nm). While the superconducting state is limited by orbital pair-breaking effects when magnetic fields are applied parallel to the c-axis, our measurements confirm strong paramagnetic effects on $B_{c2}(T)$ along the ab direction, as it was similarly found in other Fe-based materials such as LiFeAs and $FeSe_{1-x}Te_x$.

TT 27.8 Tue 11:45 H18

Pressure dependencies and first-order transition in KFe_2As_2 — •Philipp Burger[1,2], Anna Böhmer[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, 76021 Karlsruhe, Germany — [2]Fakultät für Physik, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany

Here we present a thermodynamic study on KFe_2As_2 single crystals (T_c=3.4 K) using high-resolution thermal-expansion, specific heat, magnetostriction and magnetization measurements. From these measurements we extract the uniaxial pressure dependencies of the Sommerfeld coefficient γ, the critical temperature T_c, the upper critical field H_{c2}, the magnetic susceptibility χ and the thermodynamical critical field H_c. Interestingly, the normalized pressure derivatives of T_c and H_c are about a factor of 10 larger than the pressure dependence of gamma, clearly showing that T_c is not closely correlated with γ. In particular the pressure dependencies of T_c show a very anisotropic behavior for the two different directions. Similar anisotropic behavior is also observed for H_{c2} and H_c indicating that they are strongly coupled to each other.

In addition, magnetostriction and magnetization data for H parallel a-axis show that the superconducting transition is changing from second-order to first-order around 2 K. These results support that the upper critical field H_{c2} is strongly suppressed via Pauli paramagnetism.

TT 27.9 Tue 12:00 H18

Effect of uniaxial stress and doping on structural and electronic properties of $BaFe_2As_2$ and $CaFe_2As_2$ — •Milan Tomic, Roser Valenti, and Harald O. Jeschke — Institut für Theoretische Physik, Goethe-Unversität Frankfurt, Max-von-Laue-Str. 1, 60438 Frankfurt, Germany

We investigate the effects of the uniaxial tensile and compressive stresses applied along **a**, **b** and **a**+**b** directions in $BaFe_2As_2$ and $CaFe_2As_2$ in the framework of ab initio density functional theory calculations. While the systems remain in the orthorhombic phase at moderate pressures, we observe an inversion of magnetism at a critical strain happening when the **a** and **b** axes approach the tetragonal condition. Furthermore, the doping-temperature-pressure phase diagrams of the 122 family of superconductors have been discussed intensively due to electronic nematicity above the structural and superconducting transition and the complex coupling between electronic and lattice degrees of freedom. We employ density functional theory to predict the structure of supercells of $Ca_{1-x}Sr_xFe_2As_2$ and $CaFe_2(As_{1-x}P_x)_2$. We then predict structural transitions of the doped compounds under pressure and compare to the parent compound. We carefully analyze the changes in the electronic structure caused by doping and stress.

TT 27.10 Tue 12:15 H18

Coherent phonon oscillations in 122 FeAs compounds — •L. Rettig[1], R. Cortes[2], T. Rohwer[3], P. Gegenwart[4], H.S. Jevaan[4], T. Wolf[5], B. Kamble[6], I. Eremin[6], L. Kipp[3], K. Rossnagel[3], M. Bauer[3], J. Fink[7], M. Wolf[2], and U. Bovensiepen[1] — [1]Universität Duisburg-Essen, D-47048 Duisburg — [2]Fritz-Haber-Institut d. MPG, D-14195 Berlin — [3]Christian-Albrechts-Universität Kiel, D-24118 Kiel — [4]Georg-August-Universität Göttingen, D-37077 Göttingen — [5]Karlsruhe Institute of Technology, D-76021 Karlsruhe — [6]Ruhr-Universität Bochum, D-44801 Bochum — [7]Leibniz-Institute for Solid State and Materials Research Dresden, D-01171 Dresden

We present time- and angle-resolved photoemission spectroscopy results on various 122 FeAs compounds employing fs UV and XUV pulses. We observe coherent oscillations of the spectral weight near E_F and identify three coherent modes - the most prominent Raman active A_{1g} mode and two weaker modes. The analysis of the transient electron distribution allow us to separate the oscillating chemical potential from the relaxation dynamics of the excited electronic distribution.

Similar experiments using a high-harmonics light source enable the analysis of the electron dynamics at the Γ-point and at the X-point, which shows an in-phase oscillation of the chemical potential at the two Fermi surface sheets. This indicates a substantial modification of the electronic density of states by the coherent oscillations, which is corroborated by theoretical investigations of the influence of the A_{1g} mode on the electronic structure in 122 FeAs compounds.

TT 27.11 Tue 12:30 H18

Strain induced bulk superconductivity in $BaFe_2As_2$ thin films — •Jan Engelmann[1,2], Paul Chekhonin[2], Werner Skrotzki[2], Ruben Hühne[1], Fritz Kurth[1,2], Silvia Haindl[1], Kazumasa Iida[1], Ludwig Schultz[1,2], Holzapfel Bernhard[1,3], and Grinenko Vadim[1] — [1]IFW Dresden, P. O. Box 270116, 01171 Dresden, Germany — [2]Dresden University of Technology, Department of Physics, 01062 Dresden, Germany — [3]TU Bergakademie Freiberg, 09596 Freiberg, Germany

We report superconductivity in non-doped $BaFe_2As_2$ (Ba122) thin films grown on Fe buffered Spinel single crystalline substrates. Superconductivity was achieved in our thin films by varying the thickness of the Ba122. Increasing the thickness to a critical value of approximately 10 nm results in an increase of the superconducting critical temperature to T_c=28 K whereas films with a thickness of >100 nm do not show any superconductivity. We connect this appearance of superconductivity with the inclusion of strain in our samples. Very thin samples are fixed to the Fe buffer layer and substrate lattice constant (increased a-axis lattice constant and shortened c-axis lattice constant) whereas with increasing thickness the Ba122 layer relaxes to its bulk values. We will present via X-ray analysis the relaxation of the c-axis lattice constant coming along with structural changes showed via transmission electron microscopy (TEM) and atomic force microscopy (AFM). The bulk nature of superconductivity was determined by measurements of the critical current density and via magnetic measurements using a SQUID.

TT 27.12 Tue 12:45 H18

Intrinsic ab-Plane Pinning in Epitaxial Pnictide Thin Films — •Jens Haenisch[1], Kazumasa Iida[1], Fritz Kurth[1], Michael Schulze[1], Sabine Wurmehl[1], Shinya Ueda[2], Michio Naito[2], Chiara Tarantini[3], Jan Jaroszynski[3], Ludwig Schultz[1], and Bernhard Holzapfel[1] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Tokyo University A & T, Koganei, Tokyo 184-8588, Japan — [3]NHMFL, 1800 E. Paul Dirac Drive, Tallahassee, FL 32310, USA

In type II superconductors with short coherence lengths ξ and large uniaxial crystallographic anisotropy, the order parameter may be modulated along the c-axis or even be restricted to superconducting planes. In such a case, flux lines may be pinned intrinsically by this modulation. This is well known for the high-T_c cuprates. The pnictides as well full-fill the conditions for intrinsic pinning. However, up to now it has not been reported. $FeSe_{0.5}Te_{0.5}$ thin films have been grown by PLD in a temperature series between 350 °C and 550 °C. For the film deposited at 450 °C we found clear signature of intrinsic pinning for $B > 7$ T and $T < 4$ K. $J_c(B)$ is constant in this region and the $V(I)$ exponent n shows a strong dip in its angular dependence for field orientations near ab. For the lowest T, n is rising again. This behavior is explained by trapping and lock-in of flux lines and the presence of double-kink excitations. An MBE-grown SmFeAs(O,F) thin film with very clean microstructure and a T_c of 55.7 K has been investigated in high static magnetic fields. This compound shows the same intrinsic-pinning behaviour for $B > 35$ T: constant J_c and a change of $n(B, \theta)$.

TT 27.13 Tue 13:00 H18

Investigations of pnictide superconductors - three Josephson junction aproaches — •Stefan Schmidt[1], Sebastian Döring[1], Martin Feltz[1], Noor Ali Hasan[1], Sandra Gottwals[1], Frank Schmidl[1], Silvia Haindl[2], Kazumasa Iida[3], Fritz Kurth[3], Bern-

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The investigation of fundamental electrical properties in iron pnictide superconductors has to be pursued in order to realize devices and applications in the future. Particularly, Josephson junctions are a very important tool to examine device-oriented interface effects in hybrid and all-pnictide contacts. We present results on different junction geometries based on thin film technology using Co-doped Ba-122 as base electrode. Planar SNS' junctions that favor transport along the c-axis are compared to edge-type (hybrid) and grain boundary junctions (all-pnictide) where charge carriers are transported within the ab-plane of the superconductor.

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S. Schmidt et al., IEEE-TAS (accepted, 2012), arXiv.org: 1211.3879