TT 25: FS: Iron-Based Superconductors

Time: Wednesday 14:00–18:00 Location: H20

Invited Talk TT 25.1 Wed 14:00 H20

Fermiology of Fe-Pnictide Superconductors Revealed by Quantum Oscillations — •James Analytis — Stanford Linear Accelerator Center

The iron-pnictide superconductors are a new class of materials with unique superconducting and magnetic properties. Many theoretical frameworks describing these materials rely heavily on the nature of the size and topology of the Fermi surface. The classic method of determining the Fermi surface is by looking at oscillations in the magnetization as a function of field. These oscillations, known as the de Haas-van Alphen effect, are extremely powerful in determining the full three-dimensional topology of the FS, in addition to the quasiparticle renormalization to the effective mass. In the present study we measure the Fermi surface of the superconducting P-doped BaFe2As2 using this technique and describe the consequences for theories of pnictide superconductivity.

Topical Talk TT 25.2 Wed 14:30 H20

Magnetic degeneracy and hidden metallicity of the spin density wave state in Fe-based superconductors — •Ilya Eremin — MPI fuer Physik komplexer Systeme, 01187 Dresden, Germany

In my talk, I will analyze spin density wave (SDW) order in iron-based superconductors and electronic structure in the SDW phase. We consider an itinerant model for $Fe-$pnictides with two hole bands centered at $(0,0)$ and two electron bands centered at $(0,\pi)$ and $(\pi,0)$ in the unfolded BZ. A SDW order in such a model is generally a combination of two components with momenta $(0,\pi)$ and $(\pi,0)$, both yield (π,π) order in the folded zone. Neutron experiments, however, indicate that only one component is present. We show that $(0,\pi)$ or $(\pi,0)$ order is selected if we assume that only one hole band is involved in the SDW mixing with electron bands. A SDW order in such 3-band model is highly degenerate for a perfect nesting and hole-electron interaction only, but we show that ellipticity of electron pockets and interactions between electron bands break the degeneracy and favor the desired $(0,\pi)$ or $(\pi,0)$ order. We further show that stripe-ordered system remains a metal for arbitrary coupling. We analyze electronic structure for parameters relevant to the pnictides and argue that the resulting electronic structure is in good agreement with ARPES experiments. We discuss the differences between our model and J_1-J_2 model of localized spins.

Topical Talk TT 25.3 Wed 15:00 H20

Muon spin relaxation and Moessbauer studies of iron pnictide superconductors — •Hans-Henning Klauss[1], H. Maeter[1], T. Dellmann[1], H. Luetkens[2], R. Khasanov[2], A. Amato[2], Y. Pashkevich[3], C. Hess[4], R. Klingeler[4], B. Büchner[4], A. Leithe-Jasper[5], H. Rosner[5], C. Geibel[5], W. Schnelle[5], M. Braden[6], and J. Litterst[7] — [1]Technische Universität Dresden, Germany — [2]PSI Villigen, Switzerland — [3]Donetsk Phystech NASU, Ukraine — [4]IFW Dresden, Germany — [5]MPI-CPfS, Dresden, Germany — [6]Universität Köln, Germany — [7]Technische Universität Braunschweig, Germany

We have determined the electronic phase diagrams and order parameters of $ReO_{1-x}F_xFeAs$ and $(Sr,Eu)Fe_{2-x}Co_xAs_2$ superconductors. The results prove an important role of the structural distortion for the SDW magnetism [1-3] and reveal two gap multiband superconductivity. We examined the interplay of iron and rare earth magnetic order in $ReO_{1-x}F_xFeAs$. The undoped compounds show different magnetic coupling strength of the rare earth ion to the antiferromagnetic iron layers ranging from independent order to strong polarization of the rare earth moments by the ordered iron [4]. Finally, we present recent studies on $(Ca,Sr,Ba,Eu)Fe_2As_2$ [5] and $(Fe_2As_2)(Sr_4T_2O_6)$based pnictide superconductors.

[1] H. Luetkens, et al., Phys. Rev. Lett.,101, 2008
[2] H.-H. Klauss, et al., Phys. Rev. Lett., 101, 2008
[3] H. Luetkens, et al., Nature Materials, 8, 2009
[4] H. Maeter et al., Phys. Rev. B., 80, 2009
[5] R. Khasanov et al., Phys. Rev. Lett., 102, 2009

15 min. break

Topical Talk TT 25.4 Wed 15:45 H20

Interplay among lattice, orbital and spin degrees of freedom in iron pnictides — •Roser Valenti — Institute of Theoretical Physics, Goethe University, Frankfurt am Main, Germany

By means of ab initio molecular dynamics calculations as well as dynamical mean field theory considerations, we investigate the role of lattice, orbital and spin degrees of freedom in iron pnictides. We analyze the nature of magnetism as well as the origin of structural and magnetic phase transitions under pressure in the 1111 and 122 families and discuss their implications on the superconductor behavior of these materials.

Topical Talk TT 25.5 Wed 16:15 H20

Lattice dynamics and magnetism in layered iron based superconductors — •Thomas Brückel[1,2], Yixi Su[2], Yinguo Xiao[1], and Ranjan Mittal[2] — [1]Forschungszentrum Jülich, Institut für Festkörperforschung IFF, 52425 Jülich, Germany — [2]Forschungszentrum Jülich, Jülich Centre for Neutron Science JCNS, Outstation at FRM II, 85747 Garching, Germany

The discovery of superconductivity in layered iron based compounds at critical temperatures of up to some 56 K has attracted much attention by the solid state physics community. Scattering methods, in particular neutron scattering and resonant x-ray scattering, prove crucial to access microscopic information about these new classes of compounds. We have employed inelastic neutron scattering to study the phonon density of states as well as full phonon dispersion relations [1]. The proximity to magnetism suggests that magnetic order and spin fluctuations play an important role in these compounds [2]. We will review our experimental findings on ordering phenomena and spin- and lattice excitations and discuss their possible relevance for superconductivity.

[1] R. Mittal et al., Phys. Rev. B 78 (2008), 104514; R. Mittal et al., Phys. Rev. B 78 (2008), 224518 (R); R. Mittal et al., PRL 102 (2009), 217001; R. Mittal et al., Phys. Rev. B 79 (2009), 144516; R. Mittal et al., Phys. Rev. B 79 (2009), 214514

[2] Y. Su et al., Phys. Rev. B 79 (2009), 064504; Y. Xiao et al., Phys. Rev. B79, 060504 (R)

15 min. break

TT 25.6 Wed 17:00 H20

ARPES studies on FeAs-based superconductors and their parent compounds — •Jörg Fink[1,2], S. Thirupathaiah[1], R. Ovsyannikov[1], H.A. Dürr[1], S. de Jong[3], Y. Huang[3], R. Huisman[3], M.S. Golden[3], A. Gloskovskii[4], Y.Z. Zhang[5], H.O. Jeschke[5], R. Valenti[5], H.S. Jeevan[6], P. Gegenwart[6], and A. Erb[7] — [1]HZ Berlin — [2]IFW Dresden — [3]U Amsterdam — [4]U Mainz — [5]U Frankfurt — [6]U Göttingen — [7]WMI Garching

We report high-resolution ARPES studies of the electronic structure of $BaFe_{2-x}Co_xAs_2$, $Ba_{1-x}K_xFe_2As_2$, FeTe(Se), and $EuFe_2As_2$. The results are compared with DFT band structure calculations. From photon energy dependent measurements, information on the band dispersion perpendicular to the Fe layers could be derived. with increasing Co doping in $BaFe_{2-x}Co_xAs_2$, the dimensionality increases and, due to the filling of the hole pockets, the nesting condition decreases. In the AFM phase of $EuFe_2As_2$ back-folded bands strongly hybridize with the non-folded bands leading to the opening of gaps around both high-symmetry points. This transforms the large Fermi surface of the PM phase into droplet Fermi surfaces in the AFM low-T phase.

TT 25.7 Wed 17:15 H20

Energy and temperature dependence of spin fluctuations in electron-doped iron arsenide superconductors — •Dmytro Inosov[1], Jitae Park[1], Philippe Bourges[2], Dunlu Sun[1], Yvan Sidis[2], Astrid Schneidewind[3,4], Klaudia Hradil[4,5], Daniel Haug[1], Chengtian Lin[1], Bernhard Keimer[1], and Vladimir Hinkov[1] — [1]MPI für Festkörperforschung, Stuttgart, Germany — [2]LLB, CEA-CNRS, CEA Saclay, France — [3]Inst. für Festkörperphysik, TU Dresden, Germany — [4]FRM-II, TU München, Garching, Germany — [5]Institut für Physikalische Chemie, Univ. Göttingen, Germany

Using inelastic neutron scattering we have studied the spin excitations in optimally doped $BaFe_{1.85}Co_{0.15}As_2$ ($T_c = 25\,K$) over a wide range of temperatures and energies. We present the results in absolute units

and find that the normal state spectrum carries a weight comparable to underdoped cuprates. In contrast to cuprates, however, the spectrum agrees well with predictions of the theory of nearly antiferromagnetic metals, without complications arising from a pseudogap or competing incommensurate spin-modulated phases. We also show that the temperature evolution of the resonance energy follows the superconducting energy gap, as expected from conventional Fermi-liquid approaches. Our observations point to a surprisingly simple theoretical description of the spin dynamics in the iron arsenides and provide a solid foundation for models of magnetically mediated superconductivity.

TT 25.8 Wed 17:30 H20

Doping evolution of the electronic density of states and the gap symmetry in Co-doped 122 iron pnictides — •Frédéric Hardy[1], Thomas Wolf[1], Peter Schweiss[1], Peter Adelmann[1], Robert A. Fisher[2], Rolf Heid[1], Robert Eder[1], Hilbert v. Löhneysen[1], and Christoph Meingast[1] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, 76021 Karlsruhe, Germany — [2]Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA

Iron pnictides represent a new class of multiband superconductors which offer new possibilities for studying the interplay between magnetism and superconductivity. In these materials, solid experimental evidence for any particular pairing state remains elusive because several probes point to different conclusions. Some of these apparent contradictions may arise from the influence of the magnetic instability, which is expected to strongly alter the gap topology, from impurity effects, or from experimental difficulties like sample inhomogeneities. Here, we present a critical analysis of our own specific-heat and thermal expansion-data, realized on high-quality flux-grown Co-doped 122 single crystals, for doping levels that cover the entire phase diagram.

TT 25.9 Wed 17:45 H20

Mössbauer high pressure and magnetic field studies of the superconductor FeSe — Vadim Ksenofontov[1], Gerhard Wortmann[2], Ivan Trojan[3], Taras Palasyuk[3], Sergey Medvedev[3], Michail Eremets[3], Tyrel M. McQueen[4], Richard J. Cava[4], and •Claudia Felser[1] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, Mainz, Germany — [2]Department of Physics,University of Paderborn, Paderborn, Germany — [3]Max-Planck-Institute for Chemistry, Mainz, Germany — [4]Department of Chemistry, Princeton University, Princeton, USA

Superconducting FeSe has been investigated by Mössbauer spectroscopy applying high pressure and strong external magnetic fields. It was found that pressure-induced structural phase transition between tetragonal and hexagonal modifications is accompanied by increased distortion of local surrounding of Fe atoms. Appearance of the hexagonal phase above 7.2 GPa is accompanied by degradation of superconducting properties of FeSe. Low-temperature measurements demonstrated that the ground states in both orthorhombic and hexagonal phases of FeSe are nonmagnetic. Mössbauer measurements in the external magnetic field below transition to the superconducting state revealed zero electron spin density on Fe atoms. Interpretation of Mössbauer spectra of FeSe in the Shubnikov phase is discussed.