TT 54: Focused Session: Magnetism & Superconductivity in Fe-based Pnictides and Chalcogenides (jointly with MA)

Iron-based superconductors and their relation to magnetism is an exciting research field involving condensed matter physics, materials science, and solid state chemistry. In this Focus Session recent advances and results will be presented by leading experts in the field.

Organizers: Joachim Deisenhofer (University of Augsburg), Carsten Honerkamp (RWTH Aachen)

Time: Thursday 9:30–12:45 Location: H20

Invited Talk TT 54.1 Thu 9:30 H20

Fermiology and Order Parameter of Iron-based Superconductors from ARPES — •Sergey Borisenko — IFW Dresden

We use angle-resolved photoemission at ultra-low temperatures (1K-ARPES) to study iron-based superconductors. A number of materials from the 11, 111, 1111, 122, 245 and 1048 families have been studied. In some of them precise measurements of the superconducting gap as a function of momentum allow us to draw conclusions as for the structure and symmetry of the order parameter. In addition, we single out those details of the low-energy electronic structure which are necessary for the superconductivity itself.

[1] S. V. Borisenko et al., arXiv:1204.1316 (2012)
[2] S. V. Borisenko, Synchrotron Radiation News **25**(5), 6 (2012)
[3] S. V. Borisenko et al., J. Vis. Exp. **68**, e50129, DOI: 10.3791/50129 (2012)

Invited Talk TT 54.2 Thu 10:00 H20

Electron Correlations in Solids from the Dynamical Mean Field Perspective and the Origin Anomalous State of Matter in Iron Chalchogenides — •Kristjan Haule — Rutgers The State University of New Jersey, Piscataway, NJ, USA

The Dynamical Mean Field Theory in combination with the Density Functional Theory has recently enabled detailed modeling of the electronic structure of complex materials such as heavy fermions, transition metal oxides, chalchogenides and arsenides. Simulations based on this method has recently uncovered the origin of unusual properties of iron based high temperature superconductors and the physics behind the poor metallic conductivity in these systems. Here the Coulomb interaction among the electrons is not strong enough to localize electrons, but it significantly slows them down, such that low-energy emerging quasiparticles have a substantially enhanced mass, and at intermediate temperature and intermediate energy scale show strong deviations from the Fermi liquid theory. This enhanced mass emerges not because of the Hubbard interaction U, but because of the Hund's rule interactions J that tends to align electrons with the same spin but different orbital quantum numbers when they find themselves on the same atom. The ab-initio simulations with the Dynamical Mean Field Theory not only uncover the origin of anomalous properties, but also successfully explains the key properties of these material: such as the mass renormalizations and anisotropy of quasiparticles, the crossover into an incoherent regime above a low temperature scale, the magnetic moments in iron compunds, and dispersion of magnetic excitations.

Topical Talk TT 54.3 Thu 10:30 H20

A Light Scattering Study of the Evolution of Pairing in Fe-based Superconductors — •Rudi Hackl[1], Florian Kretzschmar[1], Bernhard Muschler[1], Thomas Böhm[1], Hai-Hu Wen[2], Vladimir Tsurkan[3,4], Joachim Deisenhofer[3], and Alois Loidl[3] — [1]Walther-Meissner-Institut, DE-85748 Garching — [2]Nanjing University, Nanjing 210093, China — [3]University of Augsburg, DE-86159 Augsburg — [4]Academy of Sciences of Moldova, MD-2028 Chisinau

The iron-based superconductors are a laboratory for exploring the relevance of electron-electron interactions beyond electron-phonon coupling, being at work in conventional superconductors, since the Fermi surfaces can be varied systematically by atomic substitution. This enables one to systematically study magnetism and superconductivity as a function of the Fermi surface topology. Inelastic light scattering affords a window into the electronic properties of the ordered states. In particular, the evolution of the superconducting pairing upon doping can be probed since light scattering allows access to the anisotropy of the energy gap and, in some cases, of the pairing potential. $Ba_{1-x}K_xFe_2As_2$ is one of those cases since the competition between s- and d-wave pairing leads to the appearance of exciton-like modes below the gap edges of the various bands. Along with the results from other materials having different Fermi surface cross-sections the data in $Ba_{1-x}K_xFe_2As_2$ support the spin fluctuation scenario driven by interband coupling. The experiments show that there exist alternative routes for the analysis of the pairing interaction in superconductors with unconventional coupling and anisotropic gaps.

15 min. break

Topical Talk TT 54.4 Thu 11:15 H20

Theory of Magnetism and Superconductivity for Iron-Chalcogenides — •Jiangping Hu — Dept. of Physics, Purdue University, West Lafayette, IN, USA — Institute of Physics, Chinese Academy of Sciences, Beijing, China

We discuss the difference on both magnetic and superconducting properties between iron-pnictides and iron-chalcogenides high temperature superconductors and construct a microscopic model based on S_4 symmetry that faithfully represents the intrinsic unit cell doubling of the materials. Within this model, we can show that there are two different types of extended S-wave pairing states. One is in the A representation of S_4 and the other is in the B representation of S_4. The A-phase is well studied $S_\pm$ phase when there are both electron pockets at M points and hole pockets at Γ point. However, the B phase is the new phase which has been ignored by models with one-iron per unit cell. The B phase is characterized by the sign reverse of the superconducting order parameter in real space between top and bottom layers in the building block of the trilayer Fe-As(Se) structure. We show that the B-phase is most likely realized in the electron-doped 122' or strained single layer iron-chalcogenides.

Topical Talk TT 54.5 Thu 11:45 H20

Charge Dynamics in 122 Iron Pnictides — •Aliaksei Charnukha, Oleg V. Dolgov, Paul Popovich, Dunlu Sun, Chengtian Lin, Alexander Yaresko, Bernhard Keimer, and Alexander V. Boris — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany

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 broadband spectroscopic ellipsometry at temperatures $10 \le T \le 300$ 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, $2\Delta_A \approx 6\ k_BT_c$ and $2\Delta_B \approx 2.2\ k_BT_c$. 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 observe a superconductivity-induced suppression of an absorption band at an energy of 2.5 eV, two orders of magnitude above the superconducting gap energy $2\Delta \approx 20$ meV, which challenges one of the central notions of conventional theories of superconductivity. We argue that the observed superconductivity-induced suppression involves a redistribution of electronic population between bands with different orbital character. Our results emphasize the importance of orbital physics for the mechanism of superconductivity in the iron-based superconductors.

TT 54.6 Thu 12:15 H20

Disentangling Magnetism and Superconductivity in $EuFe_2(As_{1-x}P_x)_2$ — •Sina Zapf[1], Tomislav Ivek[1], Felix Klingert[1], Fabian Pfister[1], Shuai Jiang[1], Dan Wu[1], Hirale S. Jeevan[2], Philipp Gegenwart[2], Reinhard K. Kremer[3], and Martin Dressel[1] — [1]1. Physikalisches Institut, Universität Stuttgart — [2]I. Physikalisches Institut, Universität Göttingen — [3]Chemical Service Group, MPI-FKF Stuttgart

Due to local magnetic ordering of Eu^{2+}, $EuFe_2(As_{1-x}P_x)_2$ is a per-

fect system to study the interplay between superconductivity (SC) and magnetism in iron pnictides. However, there is still an ongoing debate about the extent of the superconducting dome and the development of the local Eu magnetic ordering with chemical pressure [1,2]. Especially the question whether SC coexists with ferro- (FM) or antiferromagnetic (AFM) Eu^{2+} ordering has drawn tremendous interest.
We have performed a systematic study on a set of high-quality single crystals (x = 0, 0.12, 0.145, 0.15, 0.165, 0.17, 0.26, 0.35 and 1) using DC resistivity, as well as DC and AC magnetic susceptibility measurements along the principal crystallographic directions. By combining these techniques we identify the different phases, prove that AFM interlayer coupling coexists with SC and discuss the complex magnetization behaviour of these compounds. Our investigations reveal the delicate interplay between SC and magnetism.

[1] Jeevan et al., PRB 83, 054511 (2011)
[2] Cao et al., Condens. Matter 23, 464204 (2011)

TT 54.7 Thu 12:30 H20

Growth and characterization of $Rb_{1-x}Fe_{2-y}Se_2$ single crystals — •Vladimir Tsurkan[1,2], Joachim Deisenhofer[1], Axel Günther[1], Hans-Albrecht Krug von Nidda[1], Sebastian Widmann[1], and Alois Loidl[1] — [1]Experimental Physics 5, Center for Electronic Correlations and Magnetism, University of Augsburg, D 86159, Augsburg, Germany — [2]Institute of Applied Physics, Academy of Sciences of Moldova, MD-2028, Chisinau, R. Moldova

Growth of single crystals of Rb-Fe-Se system and their characterization by X-ray powder diffraction, Squid magnetometry, conductivity, and specific heat are presented [1]. The single crystals exhibit an anisotropic antiferromagnetism below 400 K. For 1.53 $<$ Fe $<$ 1.6 the superconducting (SC) behavior is found. The sharp transition into the SC state at 32.4 K is observed for $Rb_{0.8}Fe_{1.6}Se_2$. For the Fe concentrations below 1.5 and above 1.6, respectively, samples show insulating and semiconducting behavior. Magnetic behavior of SC and non-SC samples provides an evidence for the coexistence of superconductivity and static antiferromagnetic order. The evolution of the SC and AFM correlations in the Rb-Fe-Se system is discussed within the constructed phase diagram which includes several structural phases with different magnetic behavior. The coexistence of the superconductivity and antiferromagnetism in $Rb_{0.8}Fe_{1.6}Se_2$ is considered within a scenario of phase separation based on the results of neutron scattering, Mössbauer spectroscopy, optical, μSR, and nuclear magnetic resonance investigations.

[1] V. Tsurkan, J. Deisenhofer, A. Günther, H.-A. Krug von Nidda, S. Widmann, and A. Loidl, Phys. Rev. B **84**, 144520 (2011)