TT 52: Superconductivity: Fe-based Superconductors – FeSe and others

Time: Wednesday 9:30–12:30 Location: H 2053

TT 52.1 Wed 9:30 H 2053

Electric transport and magnetic properties of high quality FeSe crystals grown by flux method — •Antonio Leo[1,2], Anita Guarino[1,2], Gaia Grimaldi[2], Massimiliano Polichetti[1,2], Davide Mancusi[1], Armando Galluzzi[1], Krastyo Buchkov[3], Elena Nazarova[3], Angela Nigro[1,2], and Sandro Pace[1,2] — [1]Physics Department, University of Salerno, Salerno, Italy — [2]CNR-SPIN Institute, Salerno Unit, Salerno, Italy — [3]Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria

Among the families of iron-based superconductors, the 11-family is one of the most attractive for high field applications at low temperatures. The optimization of the fabrication processes for thin films and bulks is the first step for producing tapes and cables for practical high power conductors. An essential part of this processes is the characterization of electric transport and magnetic properties. In this work, we present the results of such characterization on high quality FeSe crystals grown following the NaCl/KCl flux technique developed by Mok et al. [B. Mok et al., Crystal Growth & Design vol. 9(7), May 2009, pp. 3260-3264], with few modifications related to the specifications of the fabrication equipment. By magneto-resistance measurements and Vibrating Sample Magnetometry, we investigate the field vs. temperature phase diagrams of the samples, which show critical temperature values which are among the highest values registered for this compound. The pinning activation energy is thus derived as a function of magnetic field in order to evaluate the potential applications of this high quality FeSe compound.

TT 52.2 Wed 9:45 H 2053

Local probe study of superconductivity and ferromagnetism coexisting in Li-intercalated FeSe — •Sirko Kamusella[1], Ursula Pachmayr[2], Fabian Nitsche[2], Felix Brückner[1], Hubertus Luetkens[3], Rajib Sarkar[1], Hans-Henning Klauss[1], and Dirk Johrendt[2] — [1]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Department Chemie, Ludwig-Maximilians-Universität München, 81377 München, Germany — [3]Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

The intercalated $[(Li_{1-x}Fe_x)OH](Fe_{1-y}Li_y)Se$ exhibits superconductivity with T_c=43 K and ferromagnetic order of iron moments within the Interlayer at $T_{fm} \approx 10$ K. Similar to P-substituted Eu-122 [1] both ordering phenomena are spatially separated and $T_c > T_{fm}$, but in this compound ferromagnetism arises from 3d-electrons and thus offers huge potential to chemically influence the ferromagnetism and further study coexistence in the iron based superconductors.

Our DFT calculation reveals that the hydroxide layers electron-dope the FeSe layer, but do not disturb its typical Fermi surface topology. Instead, the interlayer's dipolar field continuously penetrates the superconducting volume below 10 K.

Our ^{57}Fe-Mössbauer spectroscopy, ^{7}Li-NMR and μSR data show the interplay of both ordering phenomena and distinguish their origin. Our combined results [2] show, that $[(Li_{1-x}Fe_x)OH](Fe_{1-y}Li_y)Se$ is a rare sample of the formation of a spontaneous vortex phase.

[1] T. Goltz, arXiv:1406.7715.
[2] U. Pachmayr *et al.*, Angewandte Chemie (2014).

TT 52.3 Wed 10:00 H 2053

Magnetoresistance and pressure effects on FeSe single crystals — •Stephan Knöner[1], David Zielke[1], Thomas Wolf[2], Christoph Meingast[2], and Michael Lang[1] — [1]Physikalisches Institut, J.W. Goethe-Universität Frankfurt(M), SPP1458, D-60438 Frankfurt(M), Germany — [2]Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany

Among the various iron-based superconductors, FeSe is of special interest, because of its simple structure without spacing layers. In addition, the system exhibits a structural phase transition at ambient pressure and lacks long-range magnetic order. We present resistivity measurements on the newly synthesized FeSe single crystals under truly hydrostatic He-gas pressure up to 800 MPa and magnetic fields up to 10 T. With this technique we were able to precisely determine the pressure dependence of the superconducting (T_c) and structural transition (T_S) in this pressure region, revealing linear pressure dependences with coefficients of dT_S/dP = -31 K/GPa, higher than previously published results, and dT_c/dP = +5.8 K/GPa, which fits very well to literature data. The resistivity just above the superconducting transition has a linear T-dependence and does not change under pressure. A positive magnetoresistance shows up for magnetic fields applied parallel to the c-axis of the crystal, whereas no effect can be observed with the field parallel to the ab-plane. This magnetoresistance grows significantly in size upon cooling through T_S for all pressures. At low temperatures the size of the magnetoresistance decreases with increasing pressure.

TT 52.4 Wed 10:15 H 2053

Orbital-driven nematicity in FeSe — •Seung-Ho Baek[1], Dmitry Efremov[1], Jong Mok Ok[2], Junsung Kim[2], Jeroen van den Brink[1,3], and Bernd Büchner[1,3] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Department of Physics, Pohang University of Science and Technology, Pohang, Korea — [3]Technische Universität Dresden, 01062 Dresden, Germany

An important feature in Fe-based superconductors is that superconductivity occurs in the vicinity of nematic ordering - a lowering of the rotational symmetry preserving time-reversal invariance - as well as of magnetic order. The origin of the nematic symmetry breaking has been heavily debated, because lattice, orbital, and spin degrees of freedom are all directly linked one another from a symmetry point of view, and thus it is challenging to establish which ordering is primary. In this talk, I will present nuclear magnetic resonance (NMR) studies of the high-quality FeSe single crystals, demonstrating that orbital degrees of freedom drives the nematic order.

TT 52.5 Wed 10:30 H 2053

Evidence for a pseudogap and charge density wave in FeSe — •Sahana Roessler[1], Cevriye Koz[1], Ulrich Schwarz[1], Ulrich K. Roessler[2], Frank Steglich[1], Liu Hao Tjeng[1], Peter Thalmeier[1], and Steffen Wirth[1] — [1]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187 Dresden, Germany — [2]IFW Dresden, Postfach 270016, 01171 Dresden, Germany

We present scanning tunneling microscopy/spectroscopy (STM/S) and electrical transport measurements on the structurally simple Fe-based superconductor FeSe. This compound displays a structural transition at T_s = 90 K [1,2] and a superconducting transition at T_c = 8.5 K [3]. We show that there is a crossover energy scale at temperature $T^* \approx 70$ K, below which the anisotropic scatterings of the quasiparticles dominate the transport. The magnetization measurements indicate that T^* is also an energy scale of spin fluctuations. A pseudogap associated with a one-dimensional charge density wave (CDW) was observed below 35 K in the STM/S. The CDW is found to coexist with superconductivity. The pseudogap as well as the CDW observed here are reminiscent of behaviors found also in several high-T_c cuprates, strongly suggesting that the spin and charge fluctuations are intimately connected with high-temperature superconductivity.

[1] T. M. McQueen *et al.*,Phys. Rev. Lett. **103**, 057002 (2009).
[2] C. Koz *et al.*, Z. Anorg. Allg. Chem. **640**, 1600-1606 (2014).
[3] F. C. Hsu *et al.*, Proc. Natl. Acad. Sci. U. S. A. **105**, 14262-14264 (2008).

TT 52.6 Wed 10:45 H 2053

Correlation-driven topological Fermi surface transition in FeSe — I. Leonov[1], •S. L. Skornyakov[2,3], V. I. Anisimov[2,3], and D. Vollhardt[1] — [1]TP III, Center for Electronic Correlations and Magnetism, Univ. Augsburg, Germany — [2]Institute of Metal Physics, Yekaterinburg, Russia — [3]Ural Federal Univ., Yekaterinburg, Russia

We present results of a theoretical investigation of the electronic structure and phase stability of paramagnetic FeSe obtained within a combination of *ab initio* methods for calculating band structure and dynamical mean-field theory [1]. Our results reveal an entire reconstruction of the Fermi surface topology upon a moderate expansion of the lattice (Lifshitz transition), with a change of magnetic correlations from the in-plane magnetic wave vector (π, π) to $(\pi, 0)$. We attribute this behavior to a correlation-induced shift of the Van Hove singularity originating from the d_{xy} and d_{xz}/d_{yz} bands at the M-point across the Fermi level. Our results predict a structural transition of FeSe upon a ca. 10% expansion of the lattice volume as well as a topological change of the Fermi surface of FeSe upon partial substitution Se by Te, which is accompanied with a sharp increase of the local moments. We expect that these changes are responsible for the experimentally observed increase of T_c in FeSe upon doping with Te. The microscopic origin for superconductivity in this system is then due to a Van Hove singularity close to the Fermi level. This identification may open a new route to increase T_c even further.

[1] I. Leonov, S. L. Skornyakov, V. I. Anisimov, D. Vollhardt, arXiv:1411.0604 (2014).

15 min. break.

TT 52.7 Wed 11:15 H 2053

FeSe nano-crystals on Bi_2Se_3(0001) — Sujit Manna[1], Roozbeh Shokri[1], Holger L. Meyerheim[1], Sumalay Roy[1], Katayoon Mohseni[1], •Alberto Cavallin[1], Vasilii Sevriuk[1], Dirk Sander[1], and Jürgen Kirschner[1,2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany.

Iron selenide (FeSe) is a prominent and intensely investigated bulk superconductor owing to its simple tetragonal structure and high transition temperature T_C of 8.5 K [1]. Tremendous activity has aimed to increase T_C by applying pressure, chemical doping, and by a reduction of the structural symmetry [2–4]. Here, we present our LEED, XRD, STM, and STS results on the epitaxial growth of few unit cells thick FeSe nano-crystals on the (0001) surface of the topological insulator Bi_2Se_3. In this case, the substrate induces a uniaxial in-plane strain and lowers the FeSe symmetry from tetragonal to orthorhombic with a b/a ratio of 1.02. STS at 10 K shows a differential conductivity gap at the Fermi energy. Our results open new perspectives for the study of Fe-based superconductivity and of superconductor/topological insulator interfaces in general, by identifying the role of epitaxial strain to modify the atomic structure of FeSe.

[1] F. C. Hsu, et al. Proc. Natl. Acad. Sci. USA 105, 14262 (2008).
[2] Y. Mizuguchi, et al. Applied Phys. Lett. 93, 152505 (2008).
[3] S. Medvedev, et al. Nature Materials 8, 630 (2009).
[4] Q.-Y. Wang, et al. Chin. Phys. Lett. 29, 037402 (2012).

TT 52.8 Wed 11:30 H 2053

Mutual independence of T_c and superfluid density under pressure in optimally-doped $LaFeAsO_{1-x}F_x$ — •Giacomo Prando[1], Ilya Eremin[2], Wolf Schottenhamel[1], Zurab Guguchia[3], Felix Ahn[2], Thomas Hartmann[2], Igor Nekrasov[4], Rustem Khasanov[3], Samuele Sanna[5], Christian Blum[1], Sabine Wurmehl[1,6], and Bernd Büchner[1,6] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW) Dresden, D-01171 Dresden, Germany — [2]Institut für Theoretische Physik III, Ruhr-Universität Bochum, D-44801 Bochum, Germany — [3]Laboratory for Muon Spin Spectroscopy, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [4]Institute for Electrophysics, RAS, Ekaterinburg, 620016, Russia — [5]Dipartimento di Fisica e Unitá CNISM di Pavia, Universitá di Pavia, I-27100 Pavia, Italia — [6]Institut für Festkörperphysik, Technische Universität Dresden, D-01062 Dresden, Germany

We report on the effect of nearly-hydrostatic pressure $P \leq 23$ kbar in an optimally-doped $LaFeAsO_{1-x}F_x$ sample. Our results of muon spin rotation show no dependence of T_c on P and, at the same time, a remarkable enhancement of the superfluid density (n_s). This is a dramatic effect, the saturation value of n_s being increased by ~ 30 % at the maximum P value. We provide evidence from density-functional theory (DFT) calculations that this increase should not be associated to an induced change in the fermiology of $LaFeAsO_{1-x}F_x$. Accordingly, we suggest that the experimental data can be explained by assuming a modification of the ratio between intra- and inter-band impurity scattering, only possible in multi-band SC.

TT 52.9 Wed 11:45 H 2053

Superconductivity in the layered iron-germanide YFe_2Ge_2 — Jiasheng Chen[1], Zhuo Feng[2], Yang Zou[1], Peter Logg[1], Giulio Lampronti[3], and •Malte Grosche[1] — [1]Cavendish Laboratory, Cambridge UK — [2]London Centre of Nanotechnology, University College, London UK — [3]Dept. of Earth Sciences, Cambridge UK

In the d-electron system YFe_2Ge_2, an unusually high Sommerfeld ratio of the specific heat capacity $C/T \sim 100$ mJ/(molK^2) and a non Fermi-liquid temperature dependence of the electrical resistivity $\rho \simeq \rho_0 + AT^{3/2}$ signal strong electronic correlations in an anomalous metallic state. Full resistive transitions, DC diamagnetic screening fractions of up to 80% and clear heat capacity anomalies observed at the transition suggest that pure samples of YFe_2Ge_2 superconduct below 1.8 K [1]. Although the nominal Fe valence in YFe_2Ge_2 is the same as in the isostructural iron-arsenides $(K/Rb/Cs)Fe_2As_2$, which have similar superconducting transition temperatures and a similarly enhanced heat capacity as YFe_2Ge_2, DFT studies suggest that the electronic structure of YFe_2Ge_2 differs substantially from that of the iron-arsenide superconductors, motivating alternative scenarios [2].

[1] Y. Zou *et al*, Physica Status Solidi (RRL) **8,** 928 (2014).
[2] A. Subedi, PRB **89** 024504 (2014);
D. J. Singh, *ibid.* 024505 (2014).

TT 52.10 Wed 12:00 H 2053

Pseudogap from preformed Cooper pairs in a platinum-iron-arsenide superconductor — M. A. Surmach[1], F. Brückner[1], S. Kamusella[1], R. Sarkar[1], P. Y. Portnichenko[1], J. T. Park[2], H. Luetkens[3], P. Biswas[3], W. J. Choi[4], Y. I. Seo[4], Y. S. Kwon[4], H.-H. Klauss[1], and •D. S. Inosov[1] — [1]TU Dresden, Germany — [2]MLZ, Garching, Germany — [3]PSI, Villigen, Switzerland — [4]DGIST, Daegu, Republic of Korea

Using a combination of μSR, INS and NMR, we investigated the novel iron-based superconductor with a triclinic crystal structure $(CaFe_{1-x}Pt_xAs)_{10}Pt_3As_8$ ($T_c = 13$ K). The T-dependence of the superfluid density from our μSR relaxation-rate measurements indicates the presence of two superconducting gaps. According to our INS measurements, commensurate spin fluctuations are centered at the $(\pi, 0)$ wave vector. Their intensity is unchanged across T_c, indicating the absence of a spin resonance typical for many Fe-based superconductors. Instead, we observed a peak in the spin-excitation spectrum around $\hbar\omega_0 = 7$ meV at the same wave vector, which persists above T_c. The temperature dependence of magnetic intensity at 7 meV revealed an anomaly around $T^* = 45$ K related to the disappearance of this new mode. A suppression of the spin-lattice relaxation rate, $1/T_1T$, observed by NMR immediately below T^* without any notable subsequent anomaly at T_c, indicates that T^* could mark the onset of a pseudogap in $(CaFe_{1-x}Pt_xAs)_{10}Pt_3As_8$, which is likely associated with the emergence of preformed Cooper pairs.

TT 52.11 Wed 12:15 H 2053

Superconductivity in 112 type bismuthides and antimonides — Reiner Retzlaff, Alexander Buckow, Jose Kurian, •Soumya Ray, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Germany

We report the epitaxial growth of As free and phase pure thin films of the 112-pnictide compounds $LaPd_xPn_2$ (Pn = Sb, Bi) grown onto (100) MgO substrates by molecular beam epitaxy [1,2]. X-ray diffraction, reflection high-energy electron diffraction, and X-ray photoelectron spectroscopy confirm the $HfCuSi_2$ structure of the material with a peculiar pnictogen square net layer. The superconducting transition temperature, T_c, varies little with Pd concentration. $LaPd_xSb_2$ has a higher T_c (3.2 K) by about 20% as compared to $LaPd_xBi_2$ (2.7 K). Fe substitution of Pd leads to a rapid decay of superconductivity. Our results suggest that these superconductors are conventional type II, and that superconductivity occurs in the metal-pnictogen layer as in all iron-pnictide superconductors rather than in the pnictogen square net layer.

[1] A. Buckow, K. Kupka, R. Retzlaff, J. Kurian, and L. Alff, Appl. Phys. Lett. **101**, 162602 (2012).
[2] A. Buckow, R. Retzlaff, J. Kurian, and L. Alff, Supercond. Sci. Technol. **26**, 015014 (2013).