TT 2: Superconductivity: Fe-based Superconductors - 1111, LiFeAs & As-free Pnictides

Time: Monday 9:30–13:00 Location: H 2053

TT 2.1 Mon 9:30 H 2053

NMR evidence for spin fluctuations in underdoped $LaO_{1-x}F_xFeAs$ — •Franziska Hammerath[1], Hans-Joachim Grafe[1], Guillaume Lang[1], Dalibor Paar[2], Günter Behr[1], Jochen Werner[1], and Bernd Büchner[1] — [1]Leibniz-Institut für Festkörper- & Werkstoffforschung, Dresden, Germany — [2]Department of Physics, Faculty of Science, University of Zagreb

We present ^{75}As Nuclear Magnetic Resonance (NMR) measurements on the iron-based superconductor $LaO_{1-x}F_xFeAs$ with $0 \leq x \leq 0.1$, covering a broad range of the phase diagram from magnetically-ordered to optimally-doped superconducting samples [1]. For underdoped samples ($x = 0.05$, $x = 0.075$) the ^{75}As NMR spin-lattice relaxation rate $(T_1T)^{-1}$ shows a Curie-Weiss-like increase at intermediate temperatures, indicating the slowing down of spin fluctuations. However, a simple Curie-Weiss fit fails to describe $(T_1T)^{-1}(T)$ above 250 K and the occurrence of a peak in $(T_1T)^{-1}$ slightly above T_c. Instead, the data can be well described by considering a BPP-model for fluctuating magnetic fields in combination with a doping-independent linear temperature dependence at high temperature. At optimal doping ($x = 0.1$) spin fluctuations are suppressed and only the linear contribution to $(T_1T)^{-1}$ is left. This stands in contrast to other pnictides, such as $Ba(Fe_{1-x}Co_xAs)_2$ and $Ba(FeAs_{1-x}P_x)_2$. Our analysis is consistent with charge carrier localization in underdoped $LaO_{1-x}F_xFeAs$ as seen by means of resistivity measurements [2].

[1] H. Luetkens et al. Nature Materials **8**, 306 (2009).
[2] C. Hess et al., Eur. Phys. Lett. **87**, 17005 (2009).

TT 2.2 Mon 9:45 H 2053

^{75}As NQR investigations of charge inhomogeneities in $CeFe_{1-x}Co_xAsO$ — •Eva Maria Brüning, Guillaume Lang, Hans-Joachim Grafe, Louis Veyrat, Sabine Wurmehl, and Bernd Büchner — Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

In the iron pnictides superconductors, carrier doping plays a crucial role in the appearance of superconductivity, whereas the magnetic and the structural phase transitions are suppressed. This is for example the case in $LaFeAsO_{1-x}F_x$ [1]. NQR measurements on $LnFeAsO_{1-x}F_x$ (Ln = La, Sm) showed in the underdoped region the coexistence of two charge environments at the nanoscale; they point to local electronic order in the iron layers [2]. Surprisingly, in LaFeAsO and SmFeAsO, superconductivity could be successfully induced by cobalt substitution in place of iron which shows that in-plane disorder is highly tolerated in these compounds [3], as in 122 pnictides. This is in high contrast to the cuprate high-Tc superconductors where replacing Cu by other transition metals (Zn, Ni) leads to a suppression of superconductivity. We report on ^{75}As NQR investigations of $CeFe_{1-x}Co_xAsO$ (x=0.03, 0.05, 0.07) and the comparison of in-plane Co-doping and out-of-plane F-doping.

[1] Y. Kamihara. al., Chem. Soc. **130**, 3296 (2008)
[2] G. Lang et. al., Phys Rev. Lett. **104**, 097001 (2010)
[3] C. Wang et. al., Phys Rev. B **79**, 054521 (2009)

TT 2.3 Mon 10:00 H 2053

Physics of defect induced local moments in pnictide superconductors — •Vadim Grinenko[1], Stefan-Ludwig Drechsler[1], Konstatin Kikoin[2], Mahmoud Abdel-Hafiez[1], Saicharan Aswartham[1], Anja Wolter-Giraud[1], Christian Hess[1], Manoj Kumar[1], Sabine Wurmehl[1], Guenter Fuchs[1], Konstantin Nenkov[1], Franziska Hammerath[1], Guillaume Lang[1], Hans-Joachim Grafe[1], Bernhard Holzapfel[1], Jeroen van den Brink[1], Bernd Buechner[1], and Ludwig Schultz[1] — [1]IFW-Dresden, D-01171 Dresden, Germany — [2]School of Physics and Astronomy, Tel-Aviv University , Tel-Aviv, Israel

Many unusual physical properties of Fe-pnictide superconductors are related to the presence of local magnetic moments induced by point-defects, e.g. As-vacancies. In the La-1111 system they improve the superconducting properties as compared with As-stoichiometric samples enhancing T_c and the $-dH_{c2}/dT$ at T_c. But they also enhance strongly the spin susceptibility, which governs the Pauli limiting behavior of the As-deficient La-1111. In heavily hole doped K-122 superconducting single crystals the local moments leads to a complex phase diagram with a Griffith and a spin glass phase. The local moments picture explains also the observed non-Fermi-liquid behavior and the large effective mass enhancement of the quasi-particles in K-122. In Co-doped Ba-122 superconducting single crystals the local moments form also a spin glass state and lead to a strong Pauli limiting behavior.

TT 2.4 Mon 10:15 H 2053

Critical current scaling and anisotropy in oxypnictide superconductors — Martin Kidszun[1], Jens Hänisch[1], Bernhard Holzapfel[1], Tom Thersleff[1,2], and •Silvia Haindl[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O.Box 270116, 01171 Dresden, Germany — [2]Department of Engineering Sciences, University of Uppsala, Box 534, 751 21 Uppsala, Sweden

Having succeeded in the fabrication of epitaxial superconducting La-1111 thin films we performed an extensive study of electrical transport properties [1]. We found that the anisotropic Ginzburg-Landau scaling approach can be applied to the angular dependent critical current densities and results in temperature dependent γ-values between 3 and 5. Originally, the anisotropic Ginzburg-Landau scaling approach was developed for a single band superconductor where γ denotes the mass anisotropy. In multiband superconductors the scaling parameter, γ, varies with temperature, however its interpretation as an effective mass anisotropy remains subtle. According to the temperature dependence of the upper critical field we present an explanation using two dominating electronic bands.

[1] M. Kidszun et al., Phys. Rev. Lett. 106 (2011) 137001

TT 2.5 Mon 10:30 H 2053

Effects of correlation in LiFeAs — •Johannes Ferber, Kateryna Foyevtsova, Roser Valenti, and Harald 0. Jeschke — Institut für theoretische Physik, Universität Frankfurt, Germany

We discuss the role of correlations in the iron pnictide LiFeAs by studying the effects on band structure, mass enhancements, and Fermi surfaces in LDA+DMFT. For LiFeAs, seemingly contradictory results from angle-resolved photoemission spectroscopy (ARPES) and de Haas-van Alphen (dHvA) measurements have been reported. Whereas dHvA observes good agreement with LDA results, ARPES reports strongly altered Fermi surfaces, possibly as a result of electronic correlations. In our calculations we find the hole pockets of the Fermi surface to be affected more strongly by correlations. Based on this observation, we give a suggestion for how to reconcile the experimental findings and assess the importance of correlations in this compound.

TT 2.6 Mon 10:45 H 2053

Spin fluctuations in the FeAs-based superconductors — •N. Qureshi[1], Y. Sidis[2], S. Wurmehl[3], I. Morozov[3], S. Aswartham[3], L. Harnagea[3], C. Nacke[3], B. Büchner[3], P. Steffens[4], and M. Braden[1] — [1]University of Cologne — [2]LLB, Saclay (France) — [3]IFW Dresden — [4]ILL, Grenoble (France)

We have performed inelastic neutron scattering (INS) studies on two undoped compounds: superconducting paramagnetic LiFeAs and non-superconducting antiferromagnetic (AF) $BaFe_2As_2$. INS using LiFeAs single crystals revealed clear evidence for AF fluctuations at an incommensurate Q-vector, which vanish at low energies. The excitations clearly responds to the opening of the superconducting gap by a redistribution of spectral weight. Applying more sophisticated methods like polarized neutron scattering with longitudinal polarization analysis to $BaFe_2As_2$ single crystals revealed anisotropic fluctuations, where the out-of-plane mode lies lower than the in-plane mode. This finding is astonishing as the static moment aligns along the FeAs layers. The fit of a J_1-J_2 model [1] using the coupling constants of $SrFe_2As_2$ [2] and taking into account the instrumental resolution yielded the single-ion anisotropies responsible for both gaps. In comparison to theoretical values [3] we find that the order of the gaps is reversed and that the spin-orbit coupling is underestimated in the calculations.

[1] D.-X. Yao and E. W. Carlson, Front. Phys. China 5, 166 (2010)
[2] R. Ewings et al., Phys. Rev. B 83 214519 (2011)
[3] A. N. Yaresko et al. Phys. Rev. B 79, 144421 (2009)

TT 2.7 Mon 11:00 H 2053

Anisotropic Energy-Gaps of Iron-Based Superconductivity from Intra-Band Quasiparticle Interference in LiFeAs —

•A.W. Rost[1,2], M.P. Allan[1,2,3], A.P. Mackenzie[2], Y. Xie[3], J.C. Davis[1,2,3,4], K. Kihou[5], C.-H. Lee[5], A. Iyo[5], H. Eisaki[5], and T.-M. Chuang[1,3,6] — [1]LASSP, Department of Physics, Cornell, Ithaca, NY 14853, USA — [2]SUPA, School of Physics and Astronomy, Univ. of St Andrews, St Andrews, Fife KY16 9SS, UK — [3]CMPMS Department, Brookhaven National Laboratory, Upton, NY 11973, USA — [4]Kavli Institute at Cornell for Nanoscale Science, Cornell, Ithaca , NY 14853, USA — [5]AIST, Tsukuba, Ibaraki 305-8568, Japan — [6]Inst. of Physics, Academica Sinica, Nankang, Taipei 11529, Taiwan

Cooper pairing in the Fe-based superconductors is thought to occur due to the projection of the antiferromagnetic interactions between iron atoms onto the complex momentum-space electronic structure. A key consequence is that distinct anisotropic energy gaps $\Delta_i(k)$ with specific relative orientations should occur on the different electronic bands i. To determine this previously unresolved gap structure high-precision spectroscopy is required. Here we introduce the STM technique of intra-band Bogoliubov quasiparticle scattering interference (QPI) to iron-based superconductor studies, focusing on LiFeAs. We identify the QPI signatures of three hole-like dispersions and, by introducing a new QPI technique, determine the magnitude and relative orientations of corresponding anisotropic $\Delta_i(k)$. Intra-band Bogoliubov QPI therefore yields the spectroscopic information required to identify the mechanism of superconductivity in Fe-based superconductors.

15 min. break.

TT 2.8 Mon 11:30 H 2053

Defect dependent influence on the superconducting gap of LiFeAs — •Danny Baumann, Torben Hänke, Ronny Schlegel, Sabine Wurmehl, Rico Pohle, Martha Scheffler, Luminita Harnagea, Christian Hess, and Bernd Büchner — IFW Dresden, Institute for Solid State Research, P.O. Box 270116, D-01171 Dresden, Germany

We have performed scanning tunneling spectroscopy measurements on the stoichiometric iron pnictide superconductor LiFeAs. After cleaving single crystalline samples, we observe a flat sample surface which can be imaged with atomic resolution by scanning tunneling microscopy. In addition, the surface contains a small amount of defects.

Here we will report on the dependence of the spectroscopic signature of LiFeAs on the occurring defects. Furthermore, we will present an analysis of the structure and symmetry of the observed defects and the influence on the density of the state of LiFeAs.

TT 2.9 Mon 11:45 H 2053

Temperature dependency of the superconducting gap in LiFeAs probed by STM — •Martha Scheffler, Rico Pohle, Torben Hänke, Ronny Schlegel, Danny Baumann, Steffen Sykora, Luminita Harnagea, Sabine Wurmehl, Christian Hess, Jeroen van den Brink, and Bernd Büchner — IFW Dresden, Institute for Solid State Research, P.O. Box 270116, D-01171 Dresden, Germany

We present temperature depending scanning tunneling spectroscopy measurements on the iron pnictide superconductor LiFeAs. At temperatures T $\sim$ 15K we see that the superconducting gap vanishes. Independent on the temperature we observe an asymmetry in the spectra with additional features near the Fermi energy and 50mV above E_F.

The good agreement of our results with model calculations for the tunneling conductance allows us to draw conclusions about the low energy properties of the superconducting system.

TT 2.10 Mon 12:00 H 2053

Electronic Transport Properties of LiFeAs in comparision to Ni-doped and Li-deficient LiFeAs — •Dirk Bombor, Anne Bachmann, Luminita Harnagea, Claudia Nacke, Saicharan Aswaratham, Sabine Wurmehl, Christian Hess, and Bernd Büchner — Leibnitz Institute for Solid State and Materials Research, IFW Dresden, Germany

Electronic transport properties of the unconventional 111-superconductor LiFeAs in comparison with Ni-doped and Li-deficient LiFeAs have been studied. Unlike in other iron arsenide superconductors the stoichiometric LiFeAs doesn't show any nesting of the Fermi surface and therefore exhibits no spin density wave but even the undoped compound becomes superconducting below 18 K. In contrast to other iron arsenide superconductors we find that doping by substitution of iron with Ni as well as Li-deficiency suppresses superconductivity. Beside this Li-deficient samples show ferromagnetic ordering below 160 K which leads to an enhancement of the unusual negative magnetoresistance. All compounds show a non-monotonic temperature dependence of the Hall coefficient which is discussed.

TT 2.11 Mon 12:15 H 2053

Ferromagnetic resonance in $Li_{1-\delta}Fe_{1-x}Ni_xAs$ single crystals — •A. Alfonsov, V. Kataev, C. Nacke, S. Aswartham, L. Harnagea, S. Wurmehl, A. U. B. Wolter, and B. Büchner — IFW Dresden, D-01169 Dresden, Germany

The magnetization measurements on $Li_{1-\delta}Fe_{1-x}Ni_xAs$ samples reveal a spontaneous magnetization below a critical temperature $T_c \sim 140 - 160$ K. In the electron spin resonance spectra measured at the X-band (9.5 GHz) frequency a strong ferromagnetic resonance (FMR) signal appears below T_c. Its behavior is similar in all samples. The temperature dependence of the resonance position of this signal corresponds to that of the spontaneous magnetization. The angular dependence of the position and of the linewidth of the signal, measured at low temperatures, suggests that the ferromagnetic magnetization is aligned in the FeAs plane. We discuss the properties of FMR signals in $Li_{1-\delta}Fe_{1-x}Ni_xAs$ samples.

TT 2.12 Mon 12:30 H 2053

As-free pnictide $LaNi_{1-x}Sb_2$ thin films grown by Reactive Molecular Beam Epitaxy — •Reiner Retzlaff, Alexander Buckow, Jose Kurian, and Lambert Alff — Institute of Materials Science, Technische Universität Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany

We use reactive molecular beam epitaxy (RMBE) as synthesis technique for the search of arsenic free pnictide superconductors. Epitaxial thin films of $LaNi_{1-x}Sb_2$ were grown on (100) MgO substrates from elemental sources by simultaneous evaporation of high purity La, Ni and Sb metals by e-gun. The $LaNi_{1-x}Sb_2$ thin films grow epitaxially and are (00l) oriented with high crystalline quality, as evident from RHEED and X-Ray diffraction studies. The Ni deficient $LaNi_{1-x}Sb_2$ thin films show metallic behavior with a room temperature resistivity of 110 $\mu\Omega$cm, while the stoichiometric compound is a semiconductor/insulator [1]. The isostructural compound with Bi as pnictide shows a superconducting transition with a $T_C(0)$ of 3.1 K.

[1] R. Retzlaff *et al.* Submitted.

TT 2.13 Mon 12:45 H 2053

Synthesis of As-free pnictide superconductors $RENi_{1-x}Bi_2$ (RE = La, Ce) using Molecular Beam Epitaxy — •Alexander Buckow, Reiner Retzlaff, Jose Kurian, and Lambert Alff — FB Materialwissenschaft, TU Darmstadt, Deutschland

We have used reactive molecular beam epitaxy (RMBE) as synthesis technique for the search for arsenic free pnictide superconductors. High quality epitaxial thin films of $LaNiBi_2$, which was reported recently [1], were successfully grown on (100) MgO substrates by RMBE. The films were (00l) oriented and the epitaxial nature of the films was confirmed by RHEED and X-ray diffraction measurements. The a-axis of $LaNiBi_2$ is 45° rotated with respect to the MgO lattice. The c-axis lattice constant was determined to be 9.79 Å and the in-plane lattice constant is 4.565 Å. Ni deficient films show a $T_C(0)$ of 3.1 K, while the stoichiometric compound is semiconducting [2]. Furthermore, we report on the substitution of La by Ce demonstrating the capability of MBE as material screening tool.

[1] H. Mizoguchi *et al.*, Phys. Rev. Lett. **106**, 057002 (2011)
[2] A. Buckow *et al.* (to be published)