TT 34: Fe-based Superconductors

Time: Wednesday 11:30–13:00 Location: HSZ 103

TT 34.1 Wed 11:30 HSZ 103

Efficient tuning of the superconductor $BaNi_2As_2$ by Calcium substitution - Single crystal Growth and Characterization — •Fabian Henssler, Kristin Willa, Mehdi Frachet, Tom Lacmann, Christoph Meingast, Michael Merz, Amir-Abbas Haghighirad, and Matthieu Le Tacon — Institut für Quantenmaterialien und Technologien, KIT Karlsruhe, Deutschland

$BaNi_2As_2$ is a highly tunable superconductor, which is non-magnetic and isostructural to the Fe-based parent compound $BaFe_2As_2$. Beyond superconductivity, recent publications reinforce the strong interplay between nematicity, charge density waves (CDW), and structural distortions [1,2,3]. At about 145 K, an incommensurate CDW forms, which coincides with a small lattice distortion ($\delta\sim10^{-4}$) [4]. At slightly lower temperatures (T_S), the system undergoes a first-order transition, which can be suppressed e.g. by P- or Sr-substitution. Thereby, the superconducting transition temperature T_c can be enhanced by a factor of six [5]. In the case of Sr substitutions, however, a concentration as large as $x_{Sr}\sim0.7$ is required. As an alternative, we report on the growth of Ca-substituted single crystals with Ca content up to $x_{Ca}\sim0.1$. Specific heat and electrical transport measurements indicate that Ca is about eight times more efficient than Sr to suppress T_S.

[1] M. Frachet et al., arXiv:2207.02462 (2022)
[2] C. Meingast et al., Phys. Rev. B 106, 144507 (2022)
[3] S. M. Souliou et al., arXiv:2207.07191 (2022)
[4] M. Merz et al., Phys. Rev. B 104, 184509 (2021)
[5] C. Eckberg et al., Nat. Phys. 16, 346-350 (2020)

TT 34.2 Wed 11:45 HSZ 103

Electronic theory for FFLO state in KFe_2As_2 superconductor — •Luka Jibuti and Ilya Eremin — Ruhr Universität Bochum, Bochum, Germany

Following the experimental observation of the Frude-Ferrel-Larnik-Ovchinnikov (FFLO) state in heavily hole-doped KFe_2As_2, we develop a microscopic theory of multi-orbital FFLO phase in this system, based on the microscopic low-energy model consisting of two Γ-centered hole pockets created by xz and yz orbitals and the sizeable spin-orbit coupling between them. We use the leading angular harmonics approximation (LAHA) to write down the general form of the interaction, that involves both s-wave and d-wave channels. By decomposing the interaction into s- and d-wave channels, employing the mean-field approximation and solving the self-consistent equations for the order parameters, we analyse the creation of the FFLO phase, with the appearance of the non-zero, symmetry preserving q vector for the nodal d-wave state and s-wave with accidental nodes. We also discuss the role of spin-orbit coupling and possible orbital FFLO state, discussed recently in the context of Ising superconductors.

TT 34.3 Wed 12:00 HSZ 103

Superconductivity of $CaKFe_4As_4$ under anisotropic strains — B. Zúñiga Céspedes[1], A. Valadkhani[2], S. Mandloi[1], M. Xu[3,4], J. Schmidt[3,4], S. L. Bud'ko[3,4], P. C. Canfield[3,4], A. P. Mackenzie[1,5], R. Valentí[2], and •E. Gati[1] — [1]MPI CPfS, 01187 Dresden, DE — [2]Inst. for Theor. Physics, Goethe University, 60438 FFM, DE — [3]Ames Lab, US DOE, Ames, IA 50011, USA — [4]Dept. of Physics and Astronomy, Iowa State Uni, Ames, IA 50011, USA — [5]Scottish Universities Physics Alliance, School of Physics and Astronomy, Uni of St Andrews, UK

$CaKFe_4As_4$ is an exceptional member of the family of Fe-based superconductors. First, it is a stochiometric superconductor at ambient pressure with high critical temperature $T_c \sim 35$ K. Second, this superconducting phase can be found in close proximity to a so-called hedgehog vortex magnetic order (SVC), which does preserve tetragonal symmetry. This is in contrast to the ubiquitous stripe-type magnetic order (SSDW) in the Fe-based superconductors that is accompanied by a vestigial nematic phase. Thus, $CaKFe_4As_4$ is an important testbed to investigate the interplay of superconductivity with different magnetic orders and nematicity. Here, we will discuss the impact of anisotropic strains, which couple directly to the nematic order parameter, on superconductivity. To this end, we present measurements of T_c as well as results of DFT calculations of the stability of SVC vs. SSDW order under large strains. Our results support the notion that nematic fluctuations contribute to superconducting pairing in this high-T_c superconductor.*Funded through the SFB/TRR288 (Elasto-Q-mat).*

TT 34.4 Wed 12:15 HSZ 103

The resistive anisotropy of FeSe in the nematic state — •Clifford Hicks[1,2], Jack Bartlett[2], Alexander Steppke[2], Suguru Hosoi[3], Takasada Shibauchi[4], and Andrew Mackenzie[2] — [1]University of Birmingham, U.K. — [2]Max Planck Institute for Chemical Physics of Solids, Dresden — [3]Osaka University, Japan — [4]University of Tokyo, Japan

We employed strain tuning to adjust the degree of twinning of samples of FeSe. By doing so, we were able to measure the resistive anisotropy in the nematic state. The resistive anisotropy of the nematic state, along with the dependence of the resistivity and the superconducting critical temperature on biaxial strain suggest a strong role for the yz orbital in electronic scattering in FeSe.

TT 34.5 Wed 12:30 HSZ 103

The low-temperature specific heat and thermal expansion of YFe_2Ge_2 — •Pavlo Khanenko[1,2], Jiasheng Chen[2], Jacintha Banda[1], Thomas Luehmann[1], F. Malte Grosche[2], and Manuel Brando[1] — [1]Max Planck Institute for Chemical Physics of Solids, Germany — [2]Cavendish Laboratory, University of Cambridge, Cambridge, UK

We present specific heat and thermal expansion coefficient measurements of the layered iron-based superconductor YFe_2Ge_2 down to 40 mK and in magnetic field. A new generation of crystals [1] with residual resistivity ratios larger than 500 and $T_c = 1.2$ K have been investigated. These crystals display a sharp superconducting anomaly in both specific heat and thermal expansion. From the jump magnitudes and using the Ehrenfest relation we derive a small positive pressure dependence of T_c, $dT_c/dp = 24.4$ mK/GPa. Despite the high purity of the crystals, the residual Sommerfeld coefficient is relatively large $\gamma_0 \approx 40\,\mathrm{mJ/K^2mol}$, i.e., less than about half of the value in the normal state ($100\,\mathrm{mJ/K^2mol}$). The field dependences of $\gamma_0(B)$ and its respective coefficient in thermal expansion $\alpha_0(B)$ are analyzed within the frame of two gap scenario.

[1] J. Chen *et al.*, Phys. Rev. Lett. 125, 237002 (2020)

TT 34.6 Wed 12:45 HSZ 103

Spin-density-wave order and evidence for superconductivity in single-crystal $LuFe_2Ge_2$ — •Jiasheng Chen and F. Malte Grosche — Cavendish Laboratory, Cambridge, UK

The discovery of unconventional superconductivity in YFe_2Ge_2 [1, 2] has encouraged the search for more iron-based superconductors in the germanide family. The isostructural and isoelectronic compound, $LuFe_2Ge_2$, exhibits physical properties that closely resemble those of YFe_2Ge_2. Despite the additional spin-density-wave order observed below 9 K in $LuFe_2Ge_2$, the overall shape and magnitude of the resistivity and susceptibility above 10 K, and the similarly enhanced Sommerfeld coefficient $C/T > 70\,\mathrm{mJ/molK^2}$ suggest a similar underlying physics in the two systems [3]. Using the liquid transport flux growth method [2], we investigated the effect of changing growth conditions on the crystal quality and on the spin-density-wave order in $LuFe_2Ge_2$. In the best samples with RRR reaching 170, we observe evidence of superconductivity, making it the second iron-germanide superconductor discovered to date.

[1] J. Chen et al., PRL 116, 127001 (2016)
[2] J. Chen *et al.*, PRL 125, 237002 (2020)
[3] M. Avila *et al.*, J. Magn. Magn. Mater. 270 , 51 (2004)