PC5-1-INV

Orbitals and Nematicity in La-1111 Single Crystals

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While there is broad consensus that superconductivity in Fe based superconductors is due to an unconventional, most likely electronic pairing, many important aspects of the normal and superconducting state are still unexplored. In particular, the role of orbital degrees of freedom for the normal state electronic properties, nematicity, and pairing is discussed very controversial. In my talk I will present results on a series of large La-1111 single crystals which have been grown for the first time using a method based on anomalous solid state reaction. We have reexamined the phase diagram and studied magnetism and nematic order by means of NMR and strain dependent transport measurements. The possible formation of polaron-like structures will be discussed and evidence for an unusual state with suppressed long range order and soft nematic fluctuations will be presented.

PC5-2-INV

Composition - Temperature Phase Diagram of Iron-Based Superconductors Tuned by Disorder

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Two phase transition lines forming composition – temperature phase diagram of iron-based superconductors (IBS): antiferromagnetic Spin Density Wave (SDW) and superconducting (SC) can be tuned in large extend by controlled disorder. I will present measurements of magnetization and electronic transport of $Ba(FeAs_{1-x}P_x)_2$ crystals, modified by point disorder induced by low temperature electron irradiation or by correlated disorder produced by swift heavy ions. Strong depression of SDW transition by both types of disorders is consistent with itinerant magnetism of IBS. SDW transition of Lifshitz type preserves its character even in strongly disordered material. Depression of superconducting transition temperature T_c by point disorder is proportional to the dose and reaches values below 1/3 of initial T_c without saturation. In contrast, increase of normal state resistivity induced by columnar defects has almost no effect on T_c. It is consistent with absence of pair-braking effect of intraband scattering channel prevailing for this type of disorder. The region of particular interest is that of slightly underdoped materials where magnetic and superconducting orders co-exist. The sequence of transitions (in the function of temperature on cooling) from normal, paramagnetic to antiferromagnetic and finally to superconducting state can be modified by disorder to direct transition from paramagnetic metal to superconductor. Extension of the SDW transition line can be traced inside of the superconducting dome by abrupt change of the critical current. This transition line follows the evolution with irradiation dose of SDW phase of the ground state and disappears at sufficiently high disorder. This confirms disorder induced downward shift in composition of putative Quantum Critical Point [1].

[1] Yuta Mizukami, *et al.* Journal of the Physical Society of Japan, 86, 083706 (2017)

Keywords: phase diagram, disorder

PC5-3-INV

Probing the superconducting gap structure of iron-based superconductors by angle-resolved specific heat measurements

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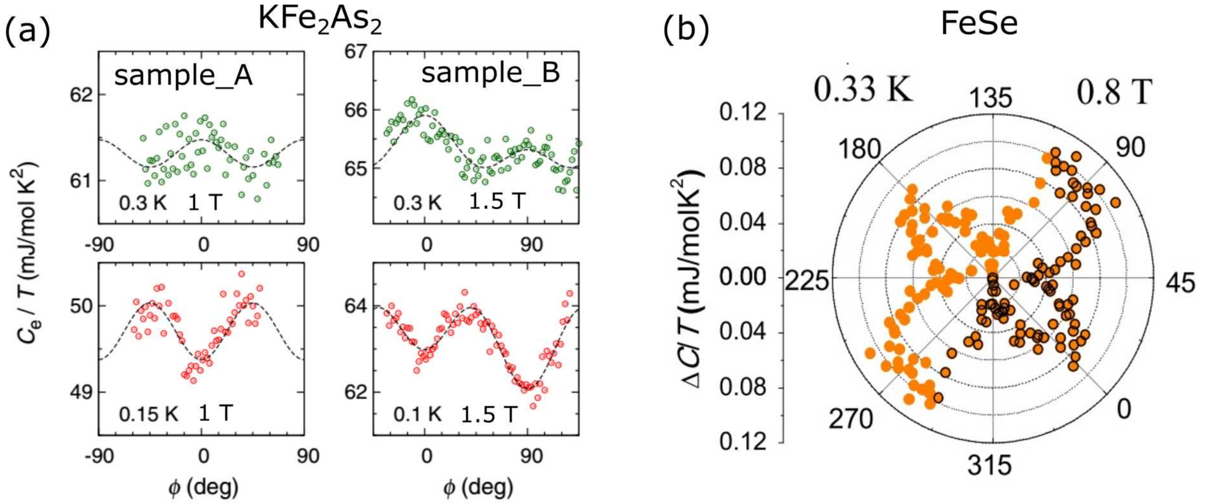
Superconducting (SC) gap structures are intimately related to the pairing mechanism, which is pivotal for high temperature superconductors. This issue is also crucial for the iron-based superconductors (IBSs). SC gap structure of IBSs has already been confirmed not to be a conventional *s*-wave, but some of them may have large anisotropy or nodes. On the other hand, the 3D nature of the band structure of IBSs, with strong warping along the k_z-direction, suggests that a 3D space-resolved technique is required. The field angle-resolved specific heat (ARSH) measurement not only has the space-resolution, but also probes the quasi-particles in bulk, which is ideal for studying the SC gap structure of IBSs.

In this report, we will first introduce the principle and experimental details of the ARSH measurement system. Then, we will use two IBSs (KFe_2As_2 and FeSe) as examples to discuss the SC gap structure probed by ARSH measurements. For KFe_2As_2, a fourfold oscillation with minima in H | | [100] direction is observed in the electronic specific heat C_e as shown in Fig. (a), which indicates the presence of line nodes on the Fermi surface where the Fermi velocity is parallel to the [100] direction. In FeSe, ARSH measurements show a clear fourfold symmetric oscillation with sign change when the field rotates in the *ab*-plane (Fig. (b)), which indicates the existence of node or gap minimum. Such a symmetric oscillation is only observed under small fields and temperatures lower than 2 K, which suggests that it comes from the small gap. When the field is rotated out of the *ab*-plane, the oscillation symmetry gradually changes with increasing field, which confirms the node or minimum in the gap are in vertical line shape along the k_z direction.



PC5-4-INV

Unique defect structure and advantageous vortex pinning properties in $CaKFe_4As_4$

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The enhancement of critical current density (J_c) is one of the key issues towards superconductivity applications. After the discovery of iron-based superconductors (IBSs), which are considered as candidate materials for high-field applications, high J_c values have been achieved by various techniques to introduce artificial pinning centers, while a further improvement of J_c is desired. Among various IBSs, 122 materials such as $Ba_{1-x}K_xFe_2As_2$ have been intensively studied owing to their small anisotropy. Meanwhile, recent studies demonstrated the high application potentiality of $CaKFe_4As_4$ (CaK1144) [1-3]. Here, we report unprecedented vortex pinning properties in the CaK1144 system arising from the inherent defect structure. Scanning transmission electron microscopy (STEM) revealed the existence of nanoscale intergrowths of the $CaFe_2As_2$ phase, which is unique to CaK1144 formed as a line compound. The J_c properties in CaK1144 are found to be distinct from other IBSs characterized by a significant anisotropy with respect to the magnetic field orientation as well as a novel pinning mechanism significantly enhanced with increasing temperature. We propose a comprehensive explanation of the J_c properties based on the unique intergrowths acting as pinning centers.

[1] S. J. Singh, *et al.* Phys. Rev. Mater. 2, 074802 (2018).
[2] S. Pyon, *et al.* Phys. Rev. B 99, 104506 (2019).
[3] S. Ishida, *et al.* npj Quantum Materials, 4, 27 (2019).

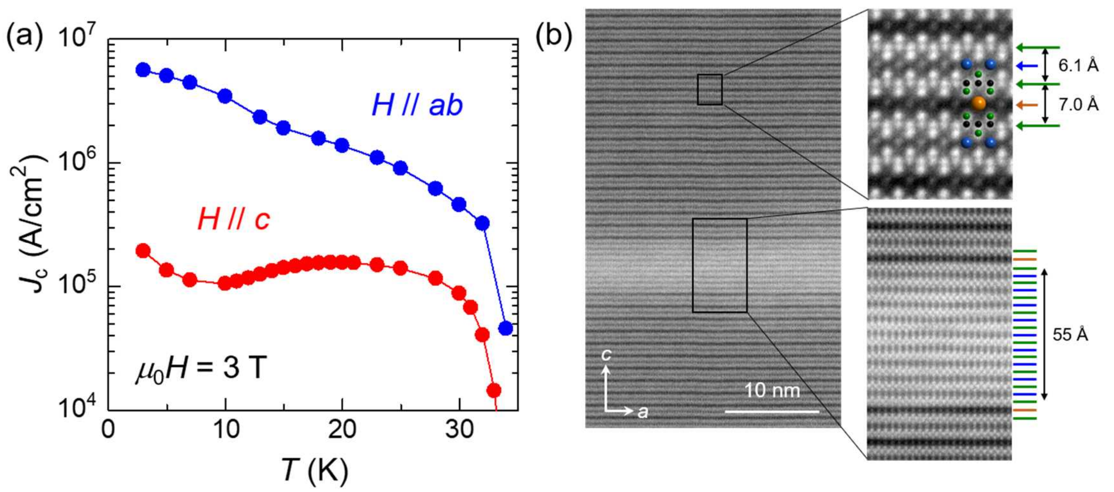

Fig. (a) Temperature dependence of J_c of CaK1144 single crystal under 3 T for *H* // *c* (red) and *ab* (blue), (b) STEM images around CaK1144 matrix and Ca122 intergrowth.

Keywords: Iron-based superconductors, CaKFe4As4, Critical current density, Defect structure

PC5-5

Critical Current Density and Its Enhancement by Particle Irradiation in $KCa_2Fe_4As_4F_2$.

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$KCa_2Fe_4As_4F_2$ is a new iron-based superconductor (IBS) with T_c ~ 33 K having a layered structure, where Fe_2As_2 double layer in KFe_2As_2 is sandwiched by Ca_2F_2 layers. This is another stoichiometric IBS similar to $CaKFe_4As_4$, where we have reported a very large critical current density (J_c) due to the presence of novel layered defects parallel to the *ab*-plane [1]. In the present study, we have grown high-quality single crystals of $KCa_2Fe_4As_4F_2$ and characterized J_c properties including its anisotropy and homogeneity.

Single crystals of $KCa_2Fe_4As_4F_2$ are grown by the flux method. J_c as functions of magnetic field (//*c*-axis) at temperatures between 2 K and 30 K are shown in Fig. 1. The self-field J_c at 2 K reaches ~8 MA/cm^2, which is larger than any other IBSs. However, unlike the case of $CaKFe_4As_4$, no defect structures are found by TEM observations. Magneto-optical imaging shows that shielding currents flow rather homogeneously throughout the crystal. For *H*//*ab*, the average J_c is much smaller than that for *H*//*c*-axis, probably due to the large anisotropy of this material. Effects of particle irradiation on the enhancement of J_c will also be reported.

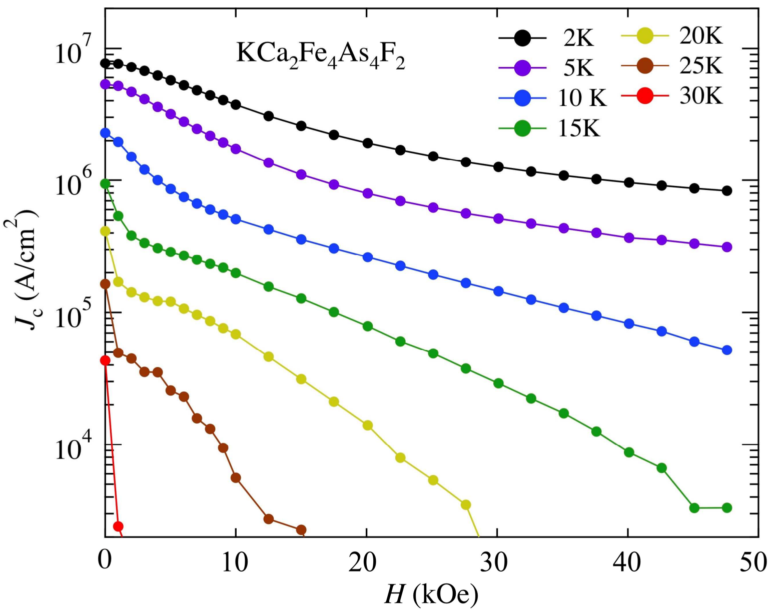

Fig. 1 Magnetic field (*H*//*c*) dependence of J_c in $KCa_2Fe_4As_4F_2$ at various temperatures.

[1] S. Pyon *et al.*, Phys. Rev. B **99**, 104506 (2019).

Keywords: KCa2Fe4As4F2, critical current density, irradiation effect, anisotropy