PC4-1-INV

Non-magnetic Pair-breaking Scattering in Iron-based Superconductors

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After more than ten years of intense research, it is commonly accepted that iron-based superconductors have sign-changing order parameter that is usually nodeless but can also be nodal [1-3]. Details of the superconducting gap structure and relative strengths of inter-band and intra-band potentials of the pairing matrix can be probed experimentally by studying the response to controlled non-magnetic disorder [1,3-5]. Point-like scattering is induced by MeV electron irradiation at 22 K to avoid fast recombination. Measurements of the superconducting transition, T_c, alone are insufficient and other quantities are needed to arrive to the objective conclusions. We use anisotropic resistivity to examine nematic response as well as Matthiessen's rule in the normal state [4,5] and precision measurements of London penetration depth in the superconducting state [1-3,6]. Knowing the response to a controlled disorder, we can also analyze other properties in materials where natural "as-grown" disorder often determines the thermodynamic behavior and explains the large differences between clean (and nodal) stoichiometric compounds, such as AsP122 [2] and charge-doped (and nodeless) BaCo122 and BaK122 [3-6]. Finally, it is important to understand the role of scattering in the behavior of quantum phase transitions beneath the dome of superconductivity. The quantum critical point is found near optimal doping in AsP122 [2] and, surprisingly, in BaCo122 [6] where quantum phase transition not only exists but seems to be protected from scattering by the superconducting state revealing a novel aspect of the interplay of superconductivity and magnetism [6].
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Keywords: iron-based superconductor, pair-breaking scattering, quantum phase transition, electron irradiation

PC4-2-INV

Zero-Energy Vortex Bound State in the Topological Superconductor Fe(Se,Te)

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A vortex core of a topological superconductor is an ideal platform of Majorana fermions. Although several experimental efforts have been made to detect Majorana fermions in the vortex cores as a zero-energy vortex bound state (ZVBS) [1,2], existence of the Majorana fermions is still controversial. Using a dilution-refrigerator scanning tunneling microscope [3], we have systematically examined a large number of vortices in the superconducting topological surface state of $FeTe_{0.6}Se_{0.4}$. We found that a certain number of vortices possess the ZVBS below 20 μeV suggesting its Majorana bound-state origin, but others do not. Interestingly, emergence of the ZVBS is not related to the preexisting quenched disorders, and the fraction of vortices with the ZVBS decreases with increasing magnetic field [4]. Moreover, our time dependent measurements of tunneling spectra on a creeping vortex indicate that the ZVBS disappears after the creep (Fig. 1). These findings suggest that inter-vortex interaction plays an important role in the ZVBS formation [5].

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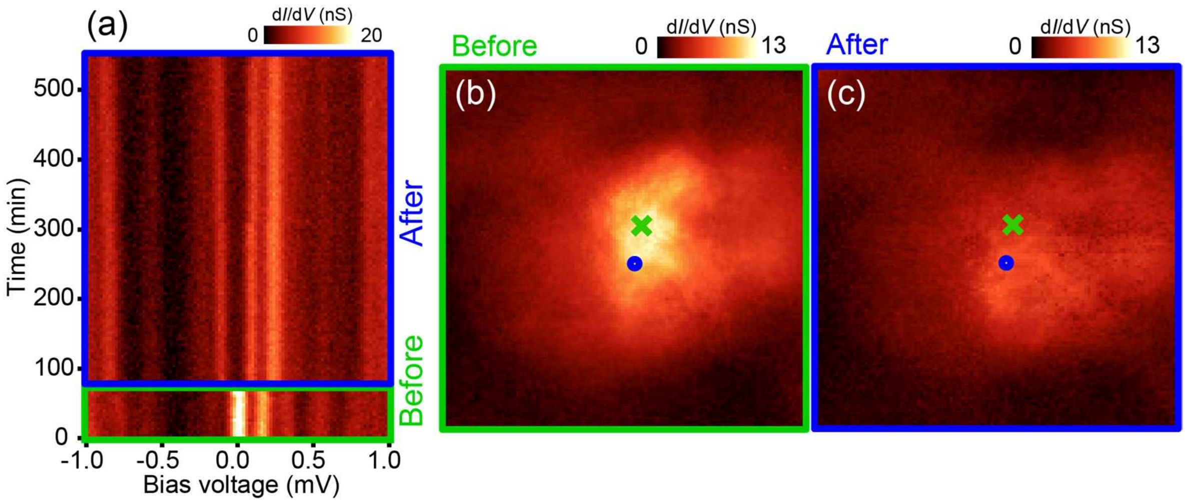

Fig. 1: (a) Time dependence of the tunneling spectra taken at a vortex core. (b) and (c) The zero bias conductance maps on 16 nm x 16 nm FOV before (b) and after (c) the vortex jump. Green cross and blue circle indicate the highest intensity points before and after the jump, respectively.

Keywords: Topological superconductor, Majorana fermion, Scanning tunneling microscope, Vortex

PC4-3-INV

Quantum critical transport phenomena in the nematic $FeSe_{1-x}S_x$

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Many high-temperature superconductors in their normal state show marked deviations from Fermi liquid (FL) theory, the standard model of metals. The most prominent is the linear temperature dependence of resistivity believed to be related to the maximum (Planckian) dissipation allowed by quantum mechanics. Such behavior is often ascribed to the existence of a quantum critical point (QCP) located inside the superconducting dome in vicinity of which a coupling between critical fluctuations of an order parameter and low-energy quasi-particle excitations gives rise to novel non-FL physics. In a host of metallic systems that exhibit this so-called quantum critical behavior, evidence for electronic nematicity, a correlated electronic state with broken rotational symmetry, has been reported. In all cases, however, the nematicity is found to be intertwined with other forms of order, such as antiferromagnetism or charge density wave, that might themselves be responsible for the existence of the QCP. The iron-chalcogenide family $FeSe_{1-x}S_x$ is unique in this respect since the superconductivity emerges from an electronic nematic state which exists in isolation and therefore provides a unique opportunity to study the influence of nematic fluctuations on high-temperature superconductivity. Substitution of Se with S effectively suppresses the nematic transition which is believed to terminate inside the superconducting dome at the QCP $x = 0.16$. In this talk, we report the results of our dc transport experiments – at both ambient and applied pressures – in magnetic field strengths strong enough to suppress the superconductivity and access the field-induced normal state and reveal classic signatures of quantum criticality: an enhancement in the coefficient of the T^2 resistivity on approaching the QCP and, at the QCP itself, a strictly T-linear resistivity that extends over a decade in temperature. We also report a detailed study of the normal state transverse magnetoresistance in $FeSe_{1-x}S_x$ across the nematic QCP that reveals unambiguously and for the first time, the coexistence of two charge sectors in a quantum critical system: one associated with the fermionic quasiparticles and possibly associated with the quantum critical excitations. Finally, we present our most recent Hall effect measurements performed on the same series of single-crystalline $FeSe_{1-x}S_x$ samples which indicate that a conventional, multi-band model fails to capture the longitudinal and Hall resistivities self-consistently, suggesting that there exists a component in the Hall resistivity associated with the quantum critical sector.

Keywords: High temperature superconductivity, Quantum criticality, Electronic nematicity, Electrical transport

PC4-4-INV

Spin-orbit coupling and its influence on superconductivity in iron-based superconductors

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In this talk, I will present our inelastic neutron scattering efforts to determine low-energy spin excitations in a variety of iron-based superconductors, in which spin-orbit coupling leads to anisotropic response in spin space. To prepare the scientific context I will first introduce our earlier works on $BaFe_2As_2$ and $FeSe_{1-x}S_x$, where regardless of whether long-range magnetic order is present, we show that the magnetic excitations at low temperatures are preferentially polarized along the *c*-axis [1,2]. In our most recent work on the tetragonal and *c*-axis oriented magnetic phase of $Sr_{1-x}Na_xFe_2As_2$, we find the first spectroscopic evidence that the itinerant charge carriers actually "prefer" to be assisted by *c*-axis polarized magnetic excitations in their formation of superconducting Cooper pairs [3], namely, only the weak *c*-axis response exhibits a spin resonant mode in the superconducting state. Our results naturally explains why the superconductivity competes strongly with the tetragonal magnetic phase in $Sr_{1-x}Na_xFe_2As_2$, and provide a fresh view on how to make a good superconductor out of a magnetic "Hund's metal".

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Keywords: iron-based superconductors, neutron scattering, spin anisotropy, strongly correlated electron systems

PC4-5

Infrared Spectroscopic Studies of the Phonon Dynamics in Iron-based Superconductors

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The temperature dependence optical reflectivity has been measurement on iron-based superconductors of different families. The optical conductivity has been obtained by using the two-Drude component model. It has been found that the phonons show red- or blue-shift in different samples. Interestingly, the phonon conductivity exhibits a Fano lineshape, suggesting possible coupling between phonon and electrons or spin. Based on the temperature evolution of the lineshape and peak shift, we discuss the possible role played by electron-phonon and spin fluctuation in the occurrence of superconductivity in iron-based superconductors.

Keywords: Infrared spectroscopy, iron-based superconductor, electron-phonon coupling