TCSUH SPECIAL SEMINAR

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Thursday, March 2, 2023

In Person: Houston Science Center (HSC), 102
11:00 a.m. – 12:00 p.m.

Cracking the Essential Coordination Structure of the Iron-based Superconductor

ABSTRACT: High-temperature superconductors often contain transition-metal lattice planes coordinated by anions, where novel quantum states of paired electrons emerge. In iron-based high-temperature superconductors, the Fe atoms in the square-lattice are tetrahedrally coordinated by pnictogen or chalcogen anions[3,4], forming strong Fe-anion tetrahedral structures that are hard to break. Therefore, usual cleaving techniques only expose the plane of complete anion coverage. We found, utilizing scanning tunneling microspectroscopy, breaking a local tetrahedral Fe-anion coordination structure by a vacancy in this complete anion coverage locally destroys the superconductivity, manifested with the suppressed superconducting coherence peaks and a pair of in-gap states in the tunneling spectrum. This dramatic spectral behavior clearly indicates the integrity of the anion coordination structure in the iron-based superconductivity. More significantly, we demonstrate here the hard-to-break coordination structure can be cracked open by using our cryogenic cleaving method, resulting in the exposure of a pristine Fe-plane, allowing us to directly probe this mysterious lattice. We find that the tunneling spectrum on this Fe-lattice exhibits a striking pseudogap feature without superconducting coherence peaks. More surprisingly, by locally decorating this pristine Fe-plane with atomic anions to restore a local tetrahedral structure, the superconducting coherence peaks emerge in the local gap spectrum. All these results emphasize the essential role of the coordination structure in the emergence of the iron-based superconductivity. We also notice that the exposed pristine Fe square-lattice is actually a checkerboard composed of corner-sharing squares. The electronic nature of this checkerboard and the homogeneous pseudogap states formed on this checkerboard both deserve deep theoretical investigations. The anion-decoration enabled local superconducting spectral behavior presents an atomic perspective of the paired quantum states emerged in the essential coordination structures of the iron-based superconductors, which may also provide a significant reference for understanding the cuprate high-Tc superconductivity.

BIO: Shuheng H. Pan is a distinguished professor and National Expert in the Institute of Physics, Chinese Academy of Sciences and Beijing National Laboratory for Condensed Matter Physics. He received his B.S. from Soochow University in China (1982) and Ph.D. from the University of Texas, Austin, USA (1990). After two years of postdoctoral research at the University of Basel in Switzerland, he accepted the offer, became a national research staff member of the applied physics department at the University of Hamburg in Germany, and participated in establishing the National Laboratory for Microstructure Research in Hamburg. In 1995, he returned to the United States and joined the ultra-low temperature physics group in the physics department of the University of California, Berkeley. In 1999, he became an associate professor of the physics department at Boston University. In 2001, he moved to the University of Houston and became a tenured full professor of the Physics department and the Texas Center for Superconductivity. In 2001, he joined the Institute of Physics CAS for research in superconductivity and strongly correlated electron systems and development of advanced scanning tunneling microspectroscopic instruments.

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