北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Weekly Seminar

Doped Mott insulator perspective of high T_c cuprate

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Time: 3:00pm, April. 6, 2022 (Wednesday)

时间: 2022年4月6日 （周三）下午3:00

Venue: Room W563, Physics building, Peking University

地点: 北京大学物理楼, 西563会议室

Abstract

The mechanism of high temperature superconductivity in the cuprates remains an outstanding puzzle despite more than 30 years of intense research. One of the few consensuses is that the parent compound is a Mott insulator with strong onsite Coulomb repulsion, and superconductivity emerges when the doped charge carriers become mobile. A key task is thus to understand the electronic structure evolution of the doped Mott insulator.

In this talk, we report scanning tunneling microscopy studies of the atomic scale electronic structure of cuprates with increasing doping levels. We first show how the low energy electronic states emerge within the charge transfer gap when one hole and two holes are introduced into the parent compound. They can be regarded as hydrogen atom and molecule in a Mott insulator background, and exhibit characteristic spatial distributions reminiscent of molecular orbitals. When a few percent of holes are dispersed into the Mott insulator, they self-assemble into small islands of checkerboard consisting of puddles with size around 4 a_0. Even in the insulating sample, we observe the existence of superconducting-like gap with size around 10 meV when approaching the checkerboard island from the Mott insulator phase. Across the insulator to superconductor transition, the local spectra remain qualitatively similar, and the main difference is the emergence of quasiparticle interferences characteristic of phase coherence. We find that each checkerboard puddle contains approximately two holes, thus may host a local Cooper pair that constitutes the phase coherent condensate when its spatial occupation exceeds a threshold. These results shed new lights on the emergence of local Cooper pairing and global phase coherence, two critical steps for the superconductivity in cuprates. In the end, we will discuss how superconductivity is suppressed in the overdoped regime when the hole density is too large.

About the speaker

Yayu Wang received his B.S. degree in physics from the University of Science and Technology of China in 1998 and Ph.D. from Princeton University in 2004. From 2004 and 2007 he was a Miller Research Fellow at UC Berkeley. After a brief visit to MIT, he joined the physics department of Tsinghua University in December 2007. His recent research interests include transport studies of topological quantum materials and STM studies of high temperature superconductors.