Doctoral Dissertation Defense

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Committee Chair: Dirk Morr
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Electronic Structure and Transport in Correlated and Complex Materials

Talk Abstract: Condensed matter systems show complex characteristics due to the electron-electron interaction effects. One of the central problems in condensed matter physics is to describe the phenomenology of the complex materials arising from these interactions. Superconductors are class of condensed matter systems which exhibit interesting properties such as zero resistivity, magnetic flux quantization etc. Moreover there are classes of superconducting materials such as cuprates, heavy fermions and more recently discovered iron-based materials where the electron-electron correlations play crucial role in the emergence of superconductivity. As a result of electron-electron correlations these materials exhibit exotic phases, for example, the cuprate superconductors possess a pseudogap phase and iron based superconductors possess an electronic nematic phase. The origins of these phases are still highly debated issue. More interestingly the superconducting phase in these materials lies in either close proximity or exists simultaneously with other phases. This suggests that the interplay of the various degrees of freedom of electrons play important role in superconductivity in these materials. Although there have been extensive studies to understand the microscopic origin of superconductivity in these materials, there is no consensus so far. An important approach to understanding the nature of superconductivity in these materials, facilitated by significant advances in scanning tunneling spectroscopy (STS) has been to study the response of these complex systems to defects and impurities. Modifications of the local electronic structure arising from defects can be readily probed via STS, and provides unprecedented insight into strong correlation effects, and the nature of the superconductivity.

In this talk I will demonstrate that the differential conductance,(dI⁄dV, measured via spectroscopic imaging scanning tunneling microscopy in the doped iron chalcogenide FeSe0.45Te0.55 , possesses a series of characteristic features that allow one to extract the orbital structure of the superconducting gaps. This yields nearly isotropic superconducting gaps on the two hole-like Fermi surfaces, and a strongly anisotropic gap on the electron-like Fermi surface. I will show that the pinning of nematic fluctuations by defects can give rise to a dumbbell-like spatial structure of the induced impurity bound states, and explains the related C2 symmetry in the Fourier transformed differential conductance. I will also briefly show how STS with a superconducting tip, which is known as Josephson scanning tunneling spectroscopy (JSTS) maps the variation of superconducting order parameter in presence of defects and vortex in a superconducting system which can give crucial information about the nature of superconductivity in a system.