MAR15-2014-000409

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Experimental Signatures of Orbital Fluctuations in Iron Based Superconductors

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Understanding the high temperature superconductivity has been one of main subjects in the condensed matter physics. The discovery of new classes of high-temperature superconductors, iron pnictides in 2008, launched an international wave of research in the past few years. While the magnetic interactions are certainly important in these materials, there have been significant evidences suggesting that the orbital degrees of freedom could play an important role as well. In this talk, I will demonstrate that the orbital degrees of freedom do play a significant role in physical properties of iron-based superconductors. At the level of single particle properties, while the orbital order in the quasi-1D dxz and dyz bands has been proposed to be a possible driving mechanism for the structural phase transition, our study shows that the fluctuations associated with the orbital order could further drive a non-Fermi liquid behavior in the critical region of the orbital ordering phase transition. I will show that this non-Fermi liquid behavior could induce a zero-bias anomaly in the point contact spectroscopy, which has been observed in a variety of iron based superconductors. As for the magnetic properties, we also find that the orbital order and fluctuations can qualitatively change the nature of the spin excitation spectrum, giving rise to the novel incommensurate-to-commensurate transformation observed in a recent neutron scattering measurement. In the superconducting state, we predict that a new collective excitation, termed as orbital resonance mode, could exist generally in the iron-based superconductors, which in principle can be measured by Raman spectroscopy. Our findings offer a new perspective on the pairing mechanism of iron based superconductors, and suggest that orbital degrees of freedom could provide a new route to high temperature superconductivity.