CMP Seminar
Michigan State University

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Comparison of the pseudogap physics in incommensurate CDW materials and High Temperature Superconductors

Charge density waves (CDWs) and superconductivity are canonical examples of symmetry breaking in materials. Both are characterized by a complex order parameter—namely an amplitude and a phase. In the limit of weak coupling and in the absence of disorder, the formation of pairs (electron electron for superconductivity, electron-hole for CDWs) and the establishment of macroscopic phase coherence both occur at the transition temperature T_c that marks the onset of long-range order. But, the situation may be quite different at strong coupling or in the presence of disorder. We have studied pristine and intercalated samples of 2H-$NbSe_2$, a transition metal dichalcogenide incommensurate CDW material with strong electron-phonon coupling, using a combination of structural (X-ray), spectroscopic (photoemission and tunneling) and transport probes. We find that $T_c(\delta)$ is suppressed as a function of the intercalation-concentration δ and eventually vanishes at a critical value of $\delta=\delta_c$ leading to quantum phase transition (QPT). Our integrated approach provides clear signatures that the phase of the order parameter becomes incoherent at the quantum/ thermal phase transition, although the amplitude remains finite over an extensive region above T_c or beyond δ_c. This leads to the persistence of a gap in the electronic spectra in the absence of a long-range order, a phenomenon strikingly similar to the so-called pseudogap in high temperature superconductors (HTSCs). However, certain features of the pseudogap phase in the HTSCs are strikingly different from the those in the CDW systems. One such feature is the particle-hole symmetry aspect of the energy gap. In the pseudogap state of HTSCs, the energy gap at the antinode, where the value of the gap is maximum, is always particle-hole symmetric just like the superconducting state. However, the energy gap in the CDW systems, where the instability is not driven by Fermi surface nesting, is not particle-hole symmetric.

Monday, October 9, 2017
4:10 p.m.
BPS 1400
Prof. S.D. Mahanti - Host