MAR11-2010-001119

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

Disentangling Cooper-pair formation above T_c from the pseudogap state in the cuprates

TAKESHI KONDO, Ames Laboratory, Iowa State University

The discovery of the pseudogap in the cuprates created significant excitement amongst physicists as it was believed to be a signature of pairing, in some cases well above room temperature. This was supported by a number of experiments detecting phase-fluctuating superconductivity above T_c. However, several recent experiments reported that the pseudogap and superconducting state are characterized by different energy scales, and likely compete with each other, leaving open the question of whether the pseudogap is caused by pair formation. To address this issue, we investigate the spectral weights, which are easier to quantify and in many cases interpret than the spectral feature, which is traditionally used. A key such measure is the density of states at the Fermi energy $D(E_F)$. In conventional, clean superconductors this weight is zero below T_c, but can be finite if there are strong impurity scattering effects. In such cases $D(E_F)$ reflects the pair breaking states. A separate scenario is a generic "density wave state" in the absence of pairing, which leads to a decrease of the $D(E_F)$ due to the opening of the density wave gap. In addition there is also the possibility of the coexistence of superconductivity and the density wave state - inhomogeneous superconductors such as the cuprates, where superconducting and non-superconducting patches coexist in the sample. One can then expect that the temperature dependence of $D(E_F)$ can be used to distinguish between these scenarios and disentangle the electronic ground states of the cuprates. Since the spectral gap in the cuprates displays significant momentum dependence, in our study we use the intensity of the spectral function at E_F, $I(E_F, k)$, which when integrated over all momenta equals $D(E_F)$. This allows us to isolate the behavior at a specific k-point and avoid smearing due to averaging. In this talk, we report the discovery of a spectroscopic signature of pair formation and demonstrate that in a region commonly referred to as the "pseudogap", two distinct states coexist: one that persists to an intermediate temperature T_{pair} and a second that extends up to T^*. The first state is characterized by doping independent scaling behavior and is due to pairing above T_c, but significantly below T^*. The second state is the "proper" pseudogap - characterized by the loss of low energy spectral weight, anomalies in transport properties and the absence of pair formation. T_{pair} has a universal value around 120-150K even for materials with very different T_c and it likely sets limit on the highest attainable T_c in the cuprates.