The spectral weight of hole doped cuprates across the pseudogap critical point

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The mysterious phase diagram of hole doped cuprates is a big puzzle for researchers in condensed matter physics. This phase complexity in cuprates encloses the highest T_c at ambient pressure ($T_c \sim 100$ K). Recent experiments have highlighted the interplay of the pseudogap phase and superconductivity: the pseudogap vanishes at a critical carrier concentration p^*, constituting a quantum critical point around which the superconducting T_c forms a dome. At this critical doping p^*, two important breakthroughs were exhibited: (i) A drop in carrier density n from $1+p$ to p as the system enters the pseudogap phase observed by Hall effect [1, 2] indicating a sudden Fermi surface reconstruction. (ii) A dramatic effective mass enhancement at p^* observed by specific heat [3], believed to result from enhanced fluctuations of the pseudogap at the quantum critical point.

In our study, we used infrared optics to measure the free carrier spectral weight. This quantity, expressed in appropriate units represents the kinetic energy of the charge carriers per primitive cell. The spectra exhibit a narrow coherent zero energy mode and a broad incoherent mid-infrared band. The total (coherent + incoherent) spectral weight represents the unrenormalized kinetic energy K of the charge carriers per primitive cell, and the spectral weight of the narrow zero energy mode is the renormalized kinetic energy K^* [4].

We demonstrate that in the normal state of LSCO and Eu-LSCO cuprates K and K^* are significantly influenced by the behavior of n and m^*, as their values remain extremely small (3 to 4 times smaller) compared to the band calculation. If we compare K^* with the superconducting penetration depth $1/\lambda^2$, we show that superconductivity could be a BEC (Bose-Einstein condensate) in the underdoped region. In addition, the spectral weight enclosed inside the MIR band $K_{MIR} = K - K^*$ tracks the superconducting critical temperature T_c, suggesting a candidate for the pairing mechanism.

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