

Comment on “Spin Dynamics of the Electron-Doped High- T_c Superconducting Cuprates”

In a recent Letter, Onufrieva and Pfeuty [1] have argued that the basic difference between electron-doped and hole-doped cuprates is their proximity to two different magnetic quantum critical points (QCP). Here, we dispute that the asymmetry of the electron- and hole-doped cuprates can be characterized by these two points.

Onufrieva and Pfeuty have presented calculations of the noninteracting spin susceptibility for a two-dimensional electronic system on a square lattice for various tight-binding parameters of the energy dispersion, $\varepsilon_{\mathbf{k}}$. In Fig. 1 of Ref. [1] they have shown the real part of the noninteracting spin susceptibility at the antiferromagnetic wave vector $\mathbf{Q}_{AF} = (\pi, \pi)$, $\chi_0(\mathbf{Q}_{AF}, 0)$ as a function of the doping concentration. The curve shows two specific points arising from particular points of the Brillouin zone at which the analyticity is broken. These points the authors regard as quantum critical points (QCP1 and QCP2) they hold responsible for the asymmetry of the spin dynamics of electron- and hole-doped cuprates.

The problem we would like to stress here is a sensitivity of the quantum critical behavior arising from these specific points of the Fermi surface with respect to the interaction (scattering) between the quasiparticles. In Fig. 1 we show calculations of the real part of the spin susceptibility $\chi_0(\mathbf{Q}_{AF}, 0)$ including particle-hole scattering processes within the fluctuation-exchange approximation (FLEX) for the Hubbard model [2,3]. The figure shows the doping dependence of $\chi_0(\mathbf{Q}_{AF}, 0)$ for $t'/t = -0.3$ and different values of the effective on-site Coulomb interaction U . The result of Onufrieva and Pfeuty is obtained in the noninteracting limit $U \rightarrow 0$. Already at modest values of the interaction, $U = 2t$, the spin susceptibility $\chi_0(\mathbf{Q}_{AF}, 0)$ does not show two singular points arising from QCP1 and QCP2, respectively, but just a single maximum. With increasing interaction strength U this maximum moves towards half filling. This behavior arises because the scattering processes renormalize the energy dispersion $\omega_{\mathbf{k}} = \varepsilon_{\mathbf{k}} - \text{Re}\Sigma(\mathbf{k}, \omega)$ and lead to a finite lifetime of the quasiparticles, neglected by Onufrieva and Pfeuty. Here, $\Sigma(\mathbf{k}, \omega)$ is the self-energy. In particular, the lifetime is strongly reduced around the specific regions of the Brillouin zone responsible for the critical behavior in the noninteracting system. The overall behavior of the spin susceptibility is consistent with the one in the cuprates [4] in the sense that $\chi_0(\mathbf{Q}_{AF}, 0)$ increases towards half-filling. Although there is some asymmetry between electron and hole doping in both cases, we do not find the tremendous difference as found by Onufrieva and Pfeuty. Thus, we challenge the conclusion of the authors of Ref. [1] that the main difference between

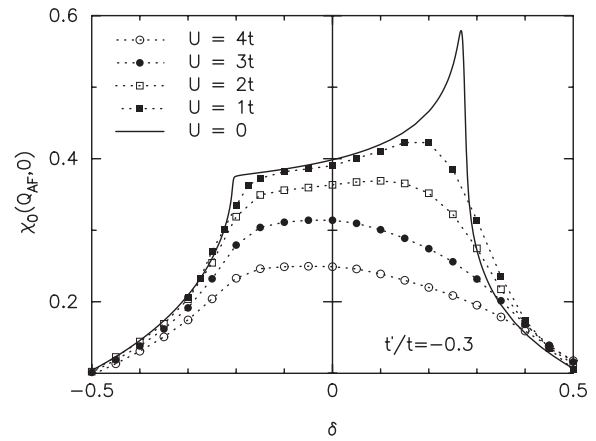


FIG. 1. Calculated real part of the spin susceptibility, $\chi_0(\mathbf{Q}_{AF}, 0)$, as a function of hole doping concentration for $t'/t = -0.3$ and $U/t = 0, 1, 2, 3,$ and 4 within the FLEX approximation.

electron- and hole-doped cuprates is their proximity to two different quantum critical points. Although we do not doubt the existence of such topological points in the weak-coupling limit, our result shows that in a strongly interacting system these points become irrelevant and specifically do not lead to a nonanalyticity of physical observables, such as spin susceptibility in the presence of scattering.

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