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Erratum: Superconductivity in inhomogeneous Hubbard models [Phys. Rev. B 73, 214510 (2006)]

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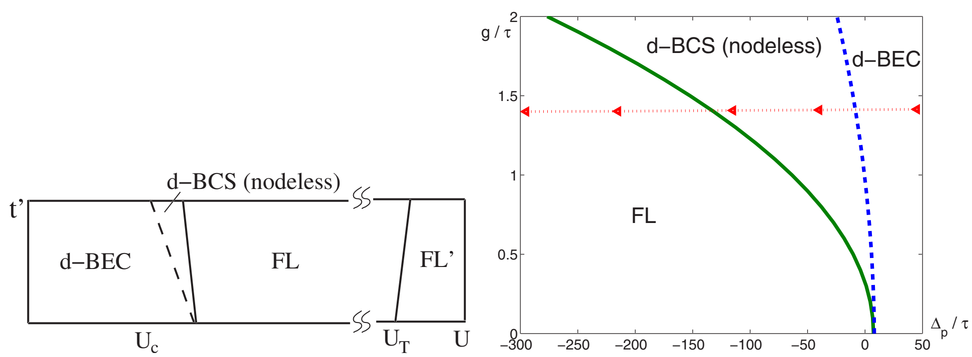
In a recent paper[1] we reported a study of certain inhomogeneous Hubbard models and derived their zero-temperature phase diagrams as functions of the on-site repulsion U and the inter-cluster hopping t' for small hole-doping concentration x. We have found a sign error in the derivation of the effective fermion hopping amplitude in the low energy effective Hamiltonian for the "checkerboard Hubbard model" given in Eq. (3). Consequently, in the second line of Eq. (3), which reads

$$-\sum_{\langle ij\rangle}\sum_{\sigma,\lambda\lambda'}(\tau_{ij,\lambda\lambda'}a^{\dagger}_{i,\sigma,\lambda}a_{j,\sigma,\lambda'}+\mathrm{H.c.}), \tag{1}$$

the hopping matrix elements have a sign which depends on the orientation of the bond connecting neighboring squares $\tau_{ij,\lambda\lambda'}=i\tau\phi_{ij}\epsilon_{\lambda\lambda'}$ where ϵ is the Levi-Civita symbol and $\phi_{ij}=1$ for neighboring squares along the x-axis and $\phi_{ij}=-1$ along the y-axis. ($a^{\dagger}_{i,\sigma,\lambda}$ creates an electron with spin σ and orbital moment $\lambda=\pm 1$ on square i, and the lattice constant of the checkerboard lattice, $2a$, is twice the distance between sites.)

As a result, for $U_c<U<U_T$ in the Fermi liquid (FL) state at small doping x, the Fermi surface consists of two small circles around $\vec{k}=(0,\pi/2a)$ and $(\pi/2a,0)$, rather than the points $\vec{k}=(0,0)$ and $\vec{k}=(\pi/2a,\pi/2a)$, as we had previously found. It is still the case that, approaching the superconducting state from the FL (by reducing U), the transition is BCS-like, and the superconducting state has d-wave symmetry (d-BCS), but a feature of the revised band structure is that the line of gap zeros does not intersect the Fermi surface, and consequently there are no nodal quasiparticles in the superconducting state. We have recomputed the phase diagrams using the proper effective parameters. Figures 1 and 2 shown below should replace Figs. 3 and 4 in Ref. 1. The shape of the resulting phase diagram, especially the location of the d-wave superconducting phase, is hardly changed, other than an enhanced stability of the superconducting state in the sense that the phase boundary at $T=0$ in Fig. 1(a) between the d-BCS and the FL is shifted (by $\sim\mathcal{O}(t')$) to larger U. However, in both Figs. 1 and 2, the line formerly identified as the point of a Lifshitz transition from a nodal to a nodeless d-SC phase, becomes a crossover from a BCS-like region, where quasi-particle fluctuations are dominant (d-BCS), to a regime of pre-formed pairs, where phase fluctuations of the order parameter dominate the physics (d-BEC). No nodal d-SC phase occurs in this model for this range of parameters.

Finally, in Fig. 2, the asymptotic form of T_c near the FL has been corrected to $T_c\sim t'xe^{-\Delta_p/t'}$.



(a) (b)

FIG. 1. (Color online) (a) Zero-temperature phase diagram of the checkerboard Hubbard model for small x(=0.025) and (b) of H^{eff} on the checkerboard lattice. The two superconducting phases both have d-wave symmetry and *no* nodal quasi-particles, but one is BCS-like (d-BCS) and the other is a Bose condensate of preformed two-particle bound states (d-BEC). The dashed lines indicate a crossover between them rather than a sharp phase transition. The two Fermi liquid phases (FL and FL′) are distinguished by the quantum numbers of the quasi-particles. The dotted curve with arrows in (b) represents the effective trajectory corresponding to the Hubbard model with fixed t'/t (=0.005) as a function of increasing U.

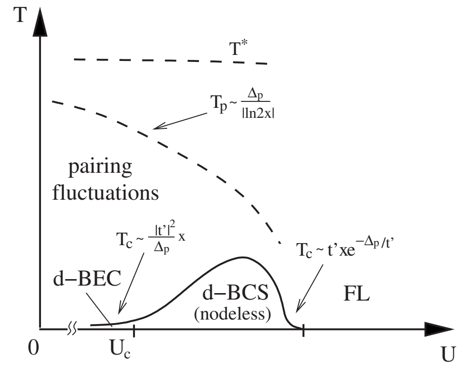


FIG. 2. Schematic finite temperature phase diagram of the checkerboard model. Notice that this figure is not drawn to scale and the x-axis has been offset from zero. As in Fig. 1(a), there is a crossover within the superconducting phase from a *d*-BEC to a *d*-BCS limit. For large enough U there is a FL phase. Above $T^* \sim \mathcal{O}(t'^0)$, indicated by the top dashed curve, the effective theory breaks down. The lower dashed curve, T_p, signifies the crossover between a normal Bose liquid of preformed pairs for $T < T_p$ and a high temperature state with little electron pairing for $T > T_p$. The range $T_c < T < T_p$ is a pseudo-gap regime. This can be a broad regime since the energy scale of coherence between preformed pairs would be down to $\mathcal{O}(t'^2)$ as indicated by the solid curve.

We thank Tim Goodman, who alerted us to the possibility of a sign error in H^{eff} with an insightful symmetry argument.

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[1] W.-F. Tsai and S. A. Kivelson, Phys. Rev. B **73**, 214510 (2006).