MAR07-2006-005937

Abstract for an Invited Paper
for the MAR07 Meeting of
the American Physical Society

Enhanced polaron formation, suppression of superconducting T_c, and the isotope effect in the Hubbard model with phonons[1]

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Using a dynamical cluster quantum Monte Carlo approximation we investigate the effect of dynamical Holstein, buckling and breathing phonons on the physics of the 2D Hubbard model at small doping. For all three phonon modes the interplay of electronic correlations and the electron-phonon interaction produces two competing effects, an enhancement of the effective d-wave pairing interaction and a strong suppression of the single-particle quasiparticle weight. Due to the later effect we find that Holstein, buckling and breathing phonons suppress superconductivity in the region of parameter space relevant for cuprate superconductors. The renormalization of the single- particle propagator, associated with polaron formation, is significantly enhanced by the presence of antiferromagnetic correlations. Moreover, as a complementray effect, the electron-phonon scattering strongly enhances the spin correlations at finite doping, showing a synergistic interplay between the electron-phonon coupling and antiferromagnetic correlations. The suppression of superconductivity due to polaron formation can explain the isotope effect observed in cuprates. We find a positive and large isotope exponent in the underdoped region where the antiferromagnetic correlations are strong and a small positive isotope exponent in the optimally doped region, in agreement with experiment.

[1]Supported by: CMSN DOE DE-FG02-04ER46129 and NSF DMR-0312680