A consistent mean-field solution of the t-J model

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Recently, N. Fukushima (cf. Phys. Rev. B **78** (2008)) proposed a systematic grand-canonical (GC) extended Gutzwiller approximation for the t-J model. In the present paper we construct for this approach an effective single-particle Hamiltonian, which leads to a renormalized mean-field theory (RMFT). By doing this, we use the method proposed by us recently and based on the maximum entropy principle, which in turn yields a consistent statistical description of the problem. We examine in detail [1] the cases of d-wave resonating valence bond (dSC) and staggered-flux (SF) solutions and compare various selections of the Gutzwiller renormalization schemes, i.e. the one proposed by Fukushima with that proposed by Sigrist et al. (cf. Phys. Rev. B **49**, 12 058 (1994)). We also confront the results coming from out variational solution with the self-consistency condidions build in with those based on the Bogolyubov-de Gennes self-consistent (non-variational) results. It turns out that combination of the present variational approach with the renormalization factors taken from Fukushima work provides for the first time an upper critical doping $x_c \approx 0.27$ for the disappearance of the d-wave superconductivity, in accordance with experimental results for high-T_c superconducting cuprates. We also interpret the results in qualitative terms.

[1] J. Jędrak and J. Spałek, arXiv: 0908.4411 [cond-mat.str-el]