The fate of the Mott-Hubbard transition in two dimensions

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The single-band Hubbard model on a (hyper)cubic lattice is a paradigm for strongly correlated electron system. In infinite dimensions it can be solved exactly by means of dynamical mean field theory (DMFT) showing (at half-filling) the existence of correlation-driven Mott-Hubbard metal-to-insulator transition (MIT) which is hidden by a broad antiferromagnetically ordered phase. This picture remains qualitatively unchanged upon lowering the dimension down to $d = 3$[1]. The situation is, however, very different in two dimensions where the antiferromagnetic phase is restricted to $T = 0$ due to the Mermin-Wagner theorem. Combining dynamical vertex approximation (DΓA)[2], lattice quantum Monte Carlo, and variational cluster approximation, we demonstrate[3] that in this situation, scattering at long-range antiferromagnetic fluctuations, i.e., Slater-like paramagnons, opens a spectral gap at weak-to-intermediate coupling, irrespective of the preformation of localized or short-range magnetic moments. This is the reason why the two-dimensional Hubbard model has a paramagnetic phase which is insulating at low enough temperatures for any (finite) interaction and no Mott-Hubbard transition is observed. Nevertheless, local correlations still play a crucial role for the temperature dependence of several quantities, even at weak coupling. We demonstrate this by analyzing the quasiparticle scattering rate which diverges according to a power-law upon reducing the temperature in our DΓA calculations[4], in contrast to an exponential divergence predicted by weak-coupling theories.

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