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Dynamical Vertex Approximation for the Hubbard Model

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A full understanding of correlated electron systems in the physically relevant situations of three and two dimensions represents a challenge for the contemporary condensed matter theory. However, in the last years considerable progress has been achieved by means of increasingly more powerful quantum many-body algorithms, applied to the basic model for correlated electrons, the Hubbard Hamiltonian. Here, I will review the physics emerging from studies performed with the dynamical vertex approximation [1], which includes diagrammatic corrections to the local description of the dynamical mean field theory (DMFT). In particular, I will first discuss [2] the phase diagram in three dimensions with a special focus on the commensurate and incommensurate magnetic phases, their (quantum) critical properties, and the impact of fluctuations on electronic lifetimes and spectral functions. In two dimensions, the effects of non-local fluctuations beyond DMFT grow enormously, determining the appearance of a low-temperature insulating behavior for all values of the interaction in the unfrustrated model [3]: Here the prototypical features of the Mott-Hubbard metal-insulator transition, as well as the existence of magnetically ordered phases, are completely overwhelmed by antiferromagnetic fluctuations of exponentially large extension, in accordance with the Mermin-Wagner theorem. Eventually, by a fluctuation diagnostics [4] analysis of cluster DMFT self-energies, the same magnetic fluctuations are identified as responsible for the pseudogap regime in the holed-doped frustrated case, with important implications for the theoretical modeling of the cuprate physics.

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