Diagrammatic routes to nonlocal electronic correlations

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Strong electronic correlations play a crucial role in the physics of important and technologically relevant classes of materials such as, for example, transition metal oxides or rare earth compounds. From the theoretical side, in the last two decades, a big step forward was achieved by the dynamical mean field theory (DMFT), which accounts non-perturbatively for an important part of the electronic correlations, namely the local ones. However, many fascinating phenomena such as, e.g., unconventional superconductivity or quantum criticality originate (or are at leas strongly affected by) nonlocal correlations. In this walk I will discuss a class of extensions of DMFT which are based on a systematic resummation of specific classes of nonlocal Feynman diagrams. These so-called diagrammatic methods allow for an inclusion of nonlocal electronic correlations on all length scales in addition to the local ones of DMFT. I will emphasize the applicability of such approaches using the example of the Dynamical Vertex Approximation (DΓA)[1]. Adopting this technique for the analysis of the critical behavior[2] of the three-dimensional half-filled Hubbard model demonstrates its strength in capturing the effects of nonlocal correlations. More specifically DΓA predicts a sizable reduction of the transition temperature to the antiferromagnetically ordered state compared to DMFT. Its validity is further confirmed by an investigation of the critical exponents which can be shown to be consistent with those of the three-dimensional Heisenberg universality class.

[1] A. Toschi, A. A. Katanin, and K. Held, Phys. Rev. B, 75, 045118 (2007).

[2] G. Rohringer, A. Toschi, A. A. Katanin, and K. Held, Phys. Rev. Lett. 107, 256402 (2011).