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Determinantal Quantum Monte Carlo simulations of fermions in optical lattices[1]

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The ability to cool fermions in optical lattices to ultra cold temperatures has led to an interdisciplinary area of research, that has attracted a lot of attention in recent years. An interesting development in this area is the possibility to realize models for strongly correlated fermions in the laboratory, such as the fermionic Hubbard Model. Determinantal Quantum Monte Carlo simulations have proven to be an important tool in the study of fermionic atoms. Nonetheless, it is important to compare the results and efficiency of different methods. Here comparisons with Numerical Linked Cluster Expansion and Dynamical Mean Field Theory data for double occupation and short range correlations, both relevant to current optical lattice experiments, will be presented and discussed. Another topic relevant in the context of optical lattice experiments is the study of metal insulator transitions. Indeed, the Mott insulating phase has been realized and observed in two-flavor mixtures of fermionic atoms loaded on optical lattices, being characterized both by the double occupation and the compressibility. An interesting point that has been addressed in the literature over the years is whether the same fermion-fermion interaction, responsible for the Mott insulating state, could drive an insulating system metallic. Here we show that, when fermions are loaded in optical lattices with spatially varying interactions a correlation induced Mott insulator to metal transition can take place. The spatial modulation of the interactions was recently demonstrated and opens the possibility for the experimental realization of such exotic phases.

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