Quantum Monte Carlo simulations of ultracold fermions on optical lattices within dynamical mean-field theory

Within the last few years, ultracold fermionic atoms on optical lattices have been established as highly tunable model systems for strongly correlated materials. Most notably, the prototypical Mott metal-insulator transition has been detected recently in binary mixtures of $^{40}$K, based on signals in the double occupancy of lattice sites and on cloud compressibilities. However, despite significant efforts, low-temperature ordered phases could not yet be seen in cold-atom systems.

In my talk, I will first introduce the systems of interest and the corresponding Hubbard-like models and characterize the relevant theoretical approaches. In particular, I will discuss recent developments in Quantum Monte Carlo (QMC) methods for solving the impurity problems arising within the dynamical mean-field theory (DMFT). I will, then, present results for Mott transitions in ternary fermionic mixtures on an optical lattice, including signatures of an unforeseen semi-compressible phase [1]. Finally, I will turn to our recent studies of antiferromagnetic order in harmonically trapped lattice fermions at low temperatures. As we have shown, the Néel transition is clearly signaled, in the strong-coupling regime, by an enhanced double occupancy. The detailed quantitative predictions possible using our QMC based implementation of real-space DMFT should provide essential guidance for experimentalists.