ANTIFERROMAGNETISM AND FERROMAGNETISM OF FERMIONIC ATOMS IN OPTICAL LATTICES

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The accurate simulation of fermionic quantum many body problems is one of the most important challenges in theoretical physics, with huge impact especially on the understanding and design of materials. However, the exponential scaling of the Hilbert space make direct simulations impossible for all but the smallest systems and Monte Carlo simulations suffer from the negative sign problem. On the computational side the goal thus has to be to develop efficient approximate methods for fermionic systems, while on the experimental side ultracold fermionic atoms in optical lattices provide a near-perfect realization of strongly correlated systems and allow the same phases to be "simulated" using experiments. I will report on recent progress in the simulation of fermionic systems, focusing on magnetic phenomena. We can now simulate the Hubbard model in three dimensions down to the Néel temperature, substantially lower than the lowest temperature achieved in optical lattice experiment s so far - and provide accurate results for the approach to the Néel state. In shallow optical lattices the simulation and the physics become more complex, as band mixing and orbital effects become important, and multi-band models are hard to derive and simulate. Here we use density functional theory for such systems, using a new exchange correlation functional for ultracold atomic gases instead of electrons, and in our first simulations focus on the competition between paramagnetism, antiferromagnetism and ferromagnetism as the optical lattice depth and interaction strengths are independently varies.