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Fermions in Optical Lattices: Cooling Protocol to Observe Anti-ferromagnetism[1]

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Experiments on ultracold atoms in optical lattices have the potential of probing the complex phase diagrams arising from simple Hamiltonians. One of the most challenging problems for an optical lattice emulator is that of cooling fermions to observe interesting broken symmetry phases. In this talk I will discuss recent theoretical progress on this question for the simplest model of interacting fermions: the Hubbard model. We determine the equation of state, the density $\rho(\mu, T, U/t)$, and the entropy of the 3D repulsive Hubbard model using exact determinental Quantum Monte Carlo (QMC) simulations. Using the local density approximation (LDA), we calculate the spatial variation of density, entropy density, double-occupancy, local compressibility and local spin correlations for different trap curvatures and interaction strengths U/t. In contrast to a homogeneous system, we show that in a trap we can locally squeeze out the entropy from certain regions and observe antiferromagnetic order, even though the total entropy per particle in the cloud is quite high. We show that significant cooling due to entropy redistribution in the trap can be achieved by two mechanisms: (a) by increasing the lattice depth, and (b) by decompressing the cloud. Our calculations can be an important guide in the race to observe antiferromagnetic order in optical lattices.

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