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Detection of Antiferromagnetic Correlations in the Fermi-Hubbard Model[1]

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The Hubbard model, consisting of a cubic lattice with on-site interactions and kinetic energy arising from tunneling to nearest neighbors is a "standard model" of strongly correlated many-body physics, and it may also contain the essential ingredients of high-temperature superconductivity. While the Hamiltonian has only two terms it cannot be numerically solved for arbitrary density of spin-1/2 fermions due to exponential growth in the basis size. At a density of one spin-1/2 particle per site, however, the Hubbard model is known to exhibit antiferromagnetism at temperatures below the Néel temperature T_{N}, a property shared by most of the undoped parent compounds of high-T_{c} superconductors. The realization of antiferromagnetism in a 3D optical lattice with atomic fermions has been impeded by the inability to attain sufficiently low temperatures. We have developed a method to perform evaporative cooling in a 3D cubic lattice by compensating the confinement envelope of the infrared optical lattice beams with blue-detuned laser beams. Evaporation can be controlled by the intensity of these non-retroreflected compensating beams. We observe significantly lower temperatures of a two-spin component gas of ^{6}Li atoms in the lattice using this method. The cooling enables us to detect the development of short-range antiferromagnetic correlations using spin-sensitive Bragg scattering of light. Comparison with quantum Monte Carlo constrains the temperature in the lattice to 2-3 T_{N}. We will discuss the prospects of attaining even lower temperatures with this method.

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