Observation of antiferromagnetic phase transition in the fermionic Hubbard model

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The repulsive fermionic Hubbard model (FHM) is central to our understanding of electron behaviors in strongly correlated materials. At half filling, its ground state is characterized by an antiferromagnetic phase, which is reminiscent of the parent state in high-temperature cuprate superconductors. Introducing dopants into the antiferromagnet, the fermionic Hubbard (FH) system is believed to give rise to various exotic quantum phases, including stripe order, pseudogap, and d-wave superconductivity. However, despite significant advances in quantum simulation of the FHM, realizing the low-temperature antiferromagnetic phase transition in a large-scale quantum simulator remains elusive. In this talk, I will present our recent progress on the realization of a low-temperature repulsive FH system in three dimensions, consisting of lithium-6 atoms in a uniform optical lattice with approximately 800,000 sites. Using spin-sensitive Bragg diffraction of light, we measure the spin structure factor (SSF) of the system. We observe divergences in the SSF by finely tuning the interaction strength, temperature, and doping concentration to approach their respective critical values for the phase transition, which are consistent with a power-law scaling in the Heisenberg universality class. Our results successfully demonstrate the antiferromagnetic phase transition in the FHM, paving the way for exploring the low-temperature phase diagram of the FHM.

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