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Quantum gas microscopy: an atomic scale probe of strongly-correlated many-body systems

WASEEM BAKR, Massachusetts Institute of Technology

Ultracold atomic systems can be used to simulate a range of phenomena in strongly-correlated materials ranging from high-T_c superconductors to quantum magnets. The micron-scale spacing of atoms in these systems provides an opportunity to optically image fluctuations and correlations in strongly correlated systems in a way not possible in condensed matter. In this talk, I will present quantum gas microscopy (QGM), which allowed for the first time, optical imaging and manipulation of strongly-interacting quantum gases containing thousands of atoms at the single atom level. I will describe a range of experiments we realized using this technique, including site-resolved imaging of atom number fluctuations and correlations across the superfluid to Mott insulator transition in an optical lattice, and the first simulation of a lattice spin system, exhibiting a quantum phase transition between antiferromagnetic and paramagnetic phases. QGM also allowed us to observe orbital excitation blockade, which we used for algorithmic cooling of lattice gases. The ideas introduced in QGM are quite general and can be applied to a range of other systems including fermionic and dipolar gases. In addition, it provides a path to quantum computation in a system with a scalable architecture.