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Deborah Jin Award for Outstanding Doctoral Thesis Research in Atomic, Molecular, or Optical Physics Recipient: Quantum Simulation of the Hubbard Model[1]

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"Take an ensemble of spin-1/2 fermions and place them in the lowest band of a square lattice. Allow them to tunnel between neighboring sites and interact if they sit on the same site." The Hubbard model is so simple that it can be defined in an abstract, yet it contains incredibly rich quantum many-body physics intricately tied to high-temperature superconductivity, one of the biggest puzzles in condensed matter. In this talk, I will discuss recent work developing quantum gas microscopy of fermionic atoms in an optical lattice for quantum simulation of the Hubbard model. The starting point is a two-dimensional antiferromagnet of approximately 80 sites; from here, we pursue two directions. First, we examine a new quantum state engineering technique to prepare states of lower temperature through dynamic control over the parameters of the Hubbard Hamiltonian. Second, we investigate the interplay between hole motion and spin order through doping the antiferromagnet, and explore the potential for new pattern-based microscopic observables in evaluating candidate microscopic theories. Our findings reveal numerous areas for exploration, including the development of more advanced quantum state engineering protocols and characterizing the dynamics of a hole placed in an antiferromagnet.

[1]Thesis adviser Markus Greiner, Harvard University.