Solid State, Atom-based Devices for Analog Quantum Simulation and Quantum Manipulation

Richard Silver, Fan Fei, Pradeep Namboodiri, Jonathan Wyrick, Xiqiao Wang, FNU Utsav, and Joseph Fox
Atom Scale Device Group, National Institute of Standards and Technology, Gaithersburg, MD
Department of Physics, University of Maryland, College Park, Maryland

NIST is using atomically precise fabrication to make single atom transistors, few-donor/quantum dot devices, and arrayed few-donor devices for analog quantum simulation (AQS). The goal of the AQS experiments is to explore the Hubbard phase space by fabricating atomically engineered materials whose properties, such as magnetic ordering or Mott insulating phase, depend on the detailed parameters of the atomic configurations. In this presentation I will describe arrays of few-atom clusters in silicon that form the sites of a Hubbard model array in the strong interaction regime, where we vary the tunnel coupling with atomic precision between nearby dots from a weakly to strongly tunnel coupled regime. We map the Hamiltonian parameters onto the physical system to tune the charge occupation, the spatial distribution of the eigenstates, and Hubbard band structure. We extract the magnetic field dependence of the electron addition energy from which we determine the electron spin filling for an array. Using numerical simulations of an extended Hubbard model, we simulate the spin/charge occupation, the spatial distribution of the many-body states, and magnetic correlations which are compared to the physical system.