Title: Exploring many-body physics with extended-range interactions

Abstract:

The competition of different length scales in quantum many-body systems leads to various novel phenomena, including the emergence of correlated dynamics or non-local order. Realizing and investigating such phenomena in itinerant lattice-based quantum simulators, has been a long-standing goal, resulting in remarkable advances in the field of dipolar molecules and lanthanide atoms. Alternatively, it has been proposed to introduce such tunable long-range interactions using off-resonant optical coupling to Rydberg states, known as “Rydberg dressing”. So far however, this approach has been limited by collective losses, limiting Rydberg dressing to spin systems without motion.

In this talk, I present our recent findings on realizing a one-dimensional extended Bose Hubbard model using Rydberg-dressed ^{87}Rb atoms trapped in optical lattices. Here, we reduce the collective losses by two orders of magnitude using stroboscopic dressing. Harnessing our quantum gas microscope, we probe the correlated out-of-equilibrium dynamics of extended-range repulsively-bound pairs at low filling, and kinetically-constrained "hard rods" at half filling. Near equilibrium, we observe density ordering when adiabatically turning on the extended-range interactions. Our results pave the way to realizing novel light-controlled extended-range interacting quantum many-body systems.