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Assembling and probing strongly correlated fluids of light

Monday, June 12, 2023 11:00 AM (40 minutes)

Learning how to create and manipulate highly-entangled many-body systems is a central challenge of modern quantum science, with promising applications from quantum computation to many-body physics and quantum-enhanced metrology. Analog quantum simulators provide a rich playground for exploring the emergent collective phenomena in synthetic quantum systems, and how to harness these many-body effects for future quantum technologies.

In this talk, I will describe various approaches for assembling quantum matter from strongly interacting microwave photons. Our quantum circuit platform consists of an array of capacitively coupled transmon qubits acting as a Hubbard lattice for photons. I will highlight a novel approach to constructing low-entropy quantum fluids of light by employing particle-resolved assembly combined with adiabatic control of lattice disorder. Studying these fluids with site-resolved microscopy of entanglement and two-body correlations reveals how the photons delocalize and avoid one another, behaving as noninteracting fermions.

The precise time- and space-resolved control of the lattice potential landscape presents another unique capability in our platform for investigating out-of-equilibrium quantum dynamics. Using controlled perturbations in the lattice potential, we can spectroscopically probe quasiparticle excitations, prepare superpositions of many-body eigenstates and observe the propagation of sound modes of light in the lattice. Towards developing practical tools for quantum computers, I will show how we can leverage many-body dynamics in these fluids for preparing highly-entangled states useful for quantum information processing and metrology.

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