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Bottom-up approaches to quantum many-body physics with atoms

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Quantum simulations, in which well-controlled collections of atoms are engineered to emulate an interacting quantum system of interest, will provide a powerful tool for studying many-body dynamics. In this talk, I discuss two promising platforms for this goal. First, I briefly describe experiments wherein tunable, long-range spin-spin interactions are implemented in chains of trapped atomic ions. This platform has enabled many sophisticated simulations of quantum magnetism, including, e.g., measurements of nonequilibrium dynamics in spin chains of 25 or more atoms. Next, I discuss approaches where individual neutral atoms in microtraps are positioned near photonic crystals, allowing for strong interactions between atoms and single photons. I describe progress toward deterministically generating photon-induced interactions between a pair of atoms, which will be a key ingredient for extending this system toward many-body physics.