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Collisional Microscopy and Generation of Entanglement with Ultracold Quantum Gases QI LIU, CRAIG PRICE, NATHAN GEMELKE, The Pennsylvania State University — We describe an apparatus for cold collisional microscopy of quantum gases, in which pairwise entanglement is produced between a many-body gas and an optical-lattice-bound array of secondary atoms used as quantum-non-destructive probes. We discuss detailed implementation of collisional entanglement schemes based on Ramsey-style interferometer sequences, as well as tunnel-assist and -inhibit schemes, in which probe atoms are conditionally shuffled according to the presence or state of a sample atom. The technical implementation for precise manipulation of multichromatic optical lattices is discussed, including achromatic holographic projection microscopy at high numerical aperture and methods for achieving sufficient quantum state control within a lattice site. Applications of collisional microscopy will also be discussed, ranging from imaging of dynamical and non-equilibrium quantum many-body systems, to characterization of strongly entangled gases through extraction of entanglement entropy, to algorithmic cooling of quantum critical gases.

Qi Liu
The Pennsylvania State University

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