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Collisional Microscopy of Quantum Gases QI LIU, CRAIG PRICE, NATHAN GEMELKE, Pennsylvania State University — Ultracold atomic gases in optical lattices have emerged as an excellent tool in the study of strongly correlated many-body systems. However the energy and entropy scales often necessary to reveal exotic phenomena require new techniques to probe and new methods to cool quantum gases. We describe a promising technique, collisional microscopy, to image, quantum coherently manipulate, and cool strongly correlated atomic gases. In this microscope, pairwise entanglement is induced between atoms in a sample and an optical lattice of secondary atoms used as probes, and information read-out by classical light-scattering from the probes. We detail two collisional entanglement schemes, one via tunnel-gate operations, in which the shuffling of probe atoms is conditional on the presence or state of sample atoms, and a second, based on Ramsey-style interferometer sequences in which the collision process is tuned to extract information from the gas under study. Applications of the collision microscope will be discussed, including algorithmic cooling schemes for bosonic Mott insulators, in which localizing information of defects is non-destructively obtained from collisional microscopy and used to adiabatically cool the sample.

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