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Qubit Control and Entangling Collisions in an Optical Lattice
WORAWARONG RAKREUNGDET, BRIAN E. MISCHUCK, POUL S. JESSEN, College of Optical Sciences, University of Arizona, Tucson, AZ 85721 — We describe recent progress in an experiment to observe and control coherent ground state collisions between Cs atoms in a 3D optical lattice, in a configuration that lends itself to the implementation of two-qubit quantum logic. The collisional phase shifts can be probed in ensemble experiments where individual atoms interfere in overlapping Mach-Zender interferometers. In our experiment the lattice is loaded with atoms from a Magneto-Optical Trap, and sideband-cooled close to the vibrational ground state of individual sites. The resulting sparsely filled lattice requires new techniques to detect and distinguish pairs of qubits that pick up collisional phase shifts from the background of atoms that don't have a collision partner. We will discuss some essential steps, such as our ability to perform high fidelity ($\sim$99%) single qubit rotations, coherent transport by real-time control of the lattice polarization, and a novel real-time detection method used for both one- and two- qubit gate experiments.

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