Quantum State Control in Optical Lattices.

Poul S. Jessen
Optical Sciences Center
University of Arizona, Tucson, AZ 85721

Optical lattices offer the opportunity to trap large numbers of neutral atoms in a periodic array of almost dissipation-free micro-traps. Because the atoms are readily confined deep in the Lamb-Dicke regime, initial preparation of a pure quantum state and subsequent coherent manipulation can be accomplished using techniques originally developed for trapped atomic ions. In a recent experiment we have explored a new method for resolved-sideband Raman cooling in a two-dimensional optical lattice. Of order 10^6 atoms were individually trapped in independent potential wells of the lattice, and cooled to a mean vibrational excitation of ~0.01 per degree of freedom, corresponding to a population of ~98% in the two-dimensional vibrational ground state associated with the $|F = 4, m = 4\rangle$ hyperfine state. The minimum-uncertainty atomic wavepackets were subsequently used to generate position- and momentum squeezed states, and to obtain ultralow temperatures by adiabatic expansion. I will discuss the possibility of extending our sideband cooling scheme to various three-dimensional lattice geometries, and to explore phenomena such as quantum entanglement and quantum degeneracy.