A 1D Cold-Atom Lattice as a Platform for Quantum-Memory and Topological Photonics

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Abstract

We study cold rubidium atoms trapped in a one-dimensional optical lattice as a platform for investigating light–matter interactions in ordered atomic arrays. The atoms form a periodic structure with subwavelength spacing, producing photonic band-gap effects and strong Bragg reflection, while their transverse motion remains thermally disordered at about 100 μK. Transfer-matrix simulations predict steep dispersion near the band edges, and our current experiments examine the resulting group-velocity reduction ("slow-light" effect) for Gaussian probe pulses.
Building on earlier work combining the lattice with electromagnetically induced transparency (EIT), which realized an all-optical dual-port switch controlled by the laser detuning, we aim to extend this configuration toward a dual-port quantum memory. In such a system, collective atomic excitations could be stored and retrieved into either port by adjusting the control-laser parameters.
We are also exploring ways to introduce temporal and complex (gain/loss) modulations of the refractive index. Because the EIT control intensity directly determines the susceptibility, a standing-wave control field naturally enables spatially periodic absorption, while its temporal modulation could generate Floquet-type dynamics in the photonic band structure. These directions link our ordered atomic lattice to emerging concepts in non-Hermitian and topological photonics.

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