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Dark State Optical Lattice with a Subwavelength Spatial Structure

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Q&A

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We report on the experimental realization of a conservative optical lattice for cold atoms with a subwavelength spatial structure. The potential is based on the nonlinear optical response of three-level atoms in laser-dressed dark states, which is not constrained by the diffraction limit of the light generating the potential. The lattice consists of a one-dimensional array of ultranarrow barriers with widths less than 10 nm, well below the wavelength of the lattice light, physically realizing a Kronig-Penney potential. We study the band structure and dissipation of this lattice and find good agreement with theoretical predictions. Even on resonance, the observed lifetimes of atoms trapped in the lattice are as long as 44 ms, nearly 10^5 times the excited state lifetime, and could be further improved with more laser intensity. The potential is readily generalizable to higher dimensions and different geometries, allowing, for example, nearly perfect box traps, narrow tunnel junctions for atomtronics applications, and dynamically generated lattices with subwavelength spacings.

Q&A

Q. Why they used Yb instead of Rb?

A. I think Yb^{171} has small scattering length and this non-interacting property seems essential for simplifying KP potential experiment. (If particles are interacting, then KP potential would not clear)

Q. Why does the time-of-flight image of the dark state has square shape?

A. Because $k_B T$ is less than the band gap, the band edge of first Brillouin zone shows sharp edge in the time-of flight image.

Q. What's the meaning of trap lifetime?

A. Sorry for the misleading words. Lifetime in this paper means lifetime of the dark state. Because of non-adiabatic coupling, population of $|E_0\rangle$ goes to $|E_\pm\rangle$ states. In this context, lifetime of the dark state is measured.