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Single- and Multi-Mode Channels for Neutral Atom Ensembles,[1]
N. CHATTRAPIBAN, S. MITRA, I.V. ARAKELYAN, W.T. HILL, III, University of Maryland — An ability to move coherent ensembles of neutral atoms through single-mode channels is key to realizing a host of future applications ranging from atom interferometry to quantum computing. While a number of promising chip-based approaches for guiding and splitting thermal and coherent atomic clouds have been demonstrated recently, they lack some flexibility offered by all-optical approaches – an ability to create optical elements that can be co-located with atom traps and to rearrange them in real time. We have investigated various ways to create single-mode channels with blue-detuned tunnels. In particular, we have calculated the energy levels in a tunnel with an impenetrable wall (i.e., infinite potential) as well as in a finite Bessel potential, $V_0 J_m^2(\kappa r)$. Our results show that single-mode operation should be possible at condensate temperatures for tunnels diameters $\sim$ 1 μm. At the same time, the degeneracy between energy levels could provide a platform for generating interesting spatial superpositions, which can be controlled by the Bessel order, m, and V_0, which depends on the optical field intensity.

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