Controlling the Center-of-Mass Motion of Ultracold Atoms

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I will describe recent experimental results, where we realize an asymmetric optical potential barrier for ultracold Rb 87 atoms using laser light tuned near the D2 optical transition. Such a one-way barrier, where atoms impinging on one side are transmitted but reflected from the other, is a realization of Maxwell's demon and has important implications for cooling atoms and molecules not amenable to standard laser-cooling techniques. In our experiment, atoms are confined to a far-detuned dipole trap consisting of a single focused Gaussian beam, which is divided near the focus by the barrier. The one-way barrier consists of two focused laser beams oriented almost normal to the dipole-trap axis. The first beam is tuned to present a state-dependent potential to the atoms. The second beam pumps the atoms irreversibly to the proper state on the reflecting side of the barrier, thus producing the asymmetry. We study experimentally the reflection and transmission dynamics of ultracold atoms in the presence of the one-way barrier. I will also describe our longer-term interests and efforts towards quantum measurement and control of the center-of-mass motion of atoms.