Use of spin-orbit coupling to manipulate atomic motion

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Abstract

Spin-orbit coupling of an alkali-metal atom produces a Zeeman-like ac Stark shift when the atom is inside a circularly polarized light. The polarization-dependent shift is quantified in terms of vector polarizability β, while usual scalar polarizability α produces a polarization-independent shift. I will discuss a few experiments carried out in our laboratory using β to manipulate ground-state alkali-metal atoms: (i) When a laser is circularly polarized and properly detuned, the α term vanishes and the Stark shift takes the form of a pure Zeeman shift. We constructed an optical analog of a magnetic trap and carried out an optical Stern-Gerlach experiment. (ii) For an atom in an optical trap, a differential ac Stark shift of a ground-hyperfine transition can be tuned out by adjusting polarization of the trapping field. By using the "magic polarization" for ^{7}Li, we achieved sub-Hz linewidth for a hyperfine transition. I will describe how we use the capability to coherently manipulate atoms in an optical lattice in a site-specific manner. (iii) In a circularly-polarized optical trap, hyperfine-transition frequency of an atom depends on the vibrational quantum number n. I will describe a new scheme to cool optically trapped atoms using the n-dependence: motion-selective coherent population trapping.