PROSPECTS FOR RAPID DECELERATION OF DIATOMIC MOLECULES WITH OPTICAL BICHROMATIC FORCES

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Direct laser deceleration and cooling of molecules to ultracold temperatures remains an elusive goal, although successful transverse cooling using a near-cycling transition in the polar diatomic molecule SrF has recently been reported.[a] The optical bichromatic force, which employs alternating cycles of excitation and stimulated emission from opposing directions, is an attractive prospect for multiplying the number of decelerating momentum transfers that can take place before a molecule is "lost" to radiative decay into a dark state. In metastable helium atoms, forces more than 100 times the normal radiative force have been demonstrated.[b] We describe detailed estimates of the laser requirements and the available momentum transfer for transverse deflection and longitudinal slowing of CaF molecules, using the $Q_{11}(0.5)$ branch of the (0,0) band of the $A\,^2\Pi_{1/2} \leftrightarrow X\,^2\Sigma^+$ transition. Deceleration by up to 150 m/s should be possible, sufficient to bring a slow thermal molecular beam to rest. In addition, significant laser-induced cooling is expected due to the non-adiabatic velocity profile of the bichromatic force, significantly enhancing the brightness of a potential ultracold beam source. As a prelude to actual molecular experiments, we are conducting measurements on non-cycling transitions in atomic helium, and preliminary results will be described.

[a] E. S. Shuman, J. F. Barry, and D. DeMille, *Nature* **467**, 820 (2010).
[b] M. Cashen and H. Metcalf, *J. Opt. Soc. Am. B* **20**, 915 (2003).