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Towards a MOT for CaF and prospects of laser cooling SrOH

Laser cooling and trapping of atoms has been a significant scientific milestonegiven its broad impact on many areas of physics and other disciplines. Frequencystandards with unprecedented performance, precision spectroscopy, quantum computing, degenerate quantum gases are only a few types of experiments derived fromthe availability of cold and ultracold atomic samples in the laboratory. Recent proposals suggest to extend the range of ultracold species to molecules and to use their additional degrees of freedom for novel experiments. In particular, polar molecules with their long-range dipole-dipole interaction are considered as candidates for experiments such as: novel hybrid approaches to quantum computing, controlled ultracold chemistry, and searches for physics beyond the standard model [1].
To this end, our goal is to load a beam of CaF molecules, originating from a cryogenic buffer-gas beam [2], into a magneto-optical trap (MOT). Buffer-gas beams enable atoms to be directly loaded into a MOT, bypassing the need for a Zeeman slower [3]. However, additional slowing stages are required to load a molecular MOT, whose capture velocity is lower than < 10 m/s. I report on the progress to slow aCaF buffer-gas beam, using laser light at 606 nm and two vibrational repumpers at 548 nm and 628 nm. All lasers are frequency-broadened to cover a range of velocity classes and remain resonant with the molecules during the slowing process. Since the cooling transition in CaF exhibits magnetic dark states, we also implement an alternating-current (AC) MOT for active remixing. Our approach is similar to those of slowing and trapping of SrF and YO [4,5,6]. Furthermore, we currently study the possibility of laser cooling triatomics. With a Franck-Condon factor of ~ 96%, SrOH is a very promising candidate. We expectto be able to scatter ~ 10^4 photons using only four lasers, including three vibrational repumpers, before falling into an off-resonant vibrational state. Here, I report on our preliminary experiments and progress to deflect and slow a buffer-gas beam of SrOH.

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