Zeeman-Sisyphus deceleration of CaF molecules

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Since the first demonstration of direct laser cooling of molecules, an ever-expanding set of molecular species are being investigated including heavier molecules, polyatomic molecules and "chemically interesting" molecules. While making fast beams of complex and interesting molecules is becoming routine, slowing them to rest such that they can be trapped remains a significant challenge.

Direct laser slowing has been successfully implemented for a select subset of molecules. However, the 10^4 photons required to bring the molecular beam to rest makes it impractical for many species. These species include those with unfavourable branching ratios and heavier molecules which require an even greater number of scattered photons.

Zeeman-Sisyphus deceleration presents a novel way to address both concerns. Molecules travel through a spatially varying magnetic field and are optically pumped between high and low field seeking states, meaning they continually climb a potential hill. The optical pumping requires at least two orders of magnitude fewer photons to be scattered compared to direct laser slowing.

The technique has previously been demonstrated for CaOH [1] and YbOH [2], in a two-stage decelerator made up of cryogenic superconducting solenoids. Here, we present our progress and results in building upon this work to experimentally realise a Zeeman-Sisyphus decelerator for CaF. Our implementation follows [3], using 80 stages of permanent magnets at ambient temperatures.

References

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[3] N.J. Fitch, and M. R. Tarbutt, *ChemPhysChem* **17**, 22 (2016).