Rotational State Cooling of Trapped Polyatomic Molecules

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Due to their rich internal structure and long-range dipole-dipole interactions, polar molecules cooled to cold and ultracold temperatures promise fascinating applications ranging from cold chemistry to quantum information processing. In addition to cooling of the motional degrees of freedom, a key prerequisite for such applications is to gain and maintain control over the internal molecular states.

In this contribution, we present rotational state cooling of methyl fluoride (CH_3F) molecules. By exploiting a vibrational spontaneous decay, molecules in 16 M-sublevels of four rotational states are optically pumped into a single M-sublevel. Combined with motional Sisyphus cooling [1,2], this results in a cold (30 mK) ensemble of trapped CH_3F molecules with more than 70 % of all molecules populating a single rotational state. We expect our method to be applicable to a wide variety of molecule species, thus opening a route for quantum controlled experiments with polyatomic molecules.

References

[1] M. Zeppenfeld *et al.* Phys. Rev. A **80** 041401 (2009)
[2] M. Zeppenfeld *et al.* Nature **491** 570–573 (2012)