SYMPATHETICAL LASER COOLING OF MOLECULAR IONS TO THE μK REGIME

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The complexity of molecular spectra prevents direct laser cooling of most molecules. Molecular ions can be indirectly laser-cooled by a Columbic interaction with a neighboring atomic ion. This sympathetic cooling method has been used to lower the temperature of molecular ions ranging from CaO^+ to C_{60}^+ to less than 100 mK by Doppler cooling the atomic ions[a].

Starting with two ions of Ca^+ in the trap, we introduce oxygen gas until one CaO^+ is produced. The motion of a CaO^+ molecular ion and a Ca^+ atomic ion are coupled by the Coulomb interaction in the same trap. The frequencies of the normal modes of the atom-molecule crystal are first measured by observing the fluorescence quenching of the Ca^+ atoms. The normal modes can be cooled to the motional ground state by addressing the sidebands of the Ca^+ quadrupole transition. The result is an atom-molecule crystal with a translational temperature in the μK regime.

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[a] M. Drewsen, A. Mortensen, R. Martinussen, P. Staanum and J. L. Sørensen *Phys. Rev. Lett.* **93**, 243201 (2004). V. L. Ryjkov, XZ. Zhao and H. A. Schuessler *Phys. Rev. A* **74**, 023401 (2006). A. Ostendorf, C. B. Zhang, M. A. Wilson, D. Offenberg, B. Roth, and S. Schiller *Phys. Rev. Lett.* **97**, 243005 (2006).