SYMPATHETICAL LASER COOLING OF MOLECULAR IONS TO THE $\mu$K 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 $\mu$K regime.

[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).