

Rotational Cooling of Coulomb-Crystallized Molecular Ions by a Helium Buffer Gas

A.K. Hansen¹, O.O. Versolato², Ł. Kłosowski³, S.B. Kristensen¹, A. Gingell¹, M. Schwarz²,
A. Windberger², J. Ullrich^{2,4}, J.R. Crespo López-Urrutia², and M. Drewsen¹

¹*QUANTOP – The Danish National Research Foundation Center for Quantum Optics, Department of Physics and Astronomy, Aarhus University, DK-8000 Aarhus C, Denmark*

²*Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany*

³*Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5, 87-100 Torun, Poland*

⁴*Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116, Braunschweig, Germany*

Presenting Author: drewsen@phys.au.dk

In this talk, I will discuss recent experimental results on helium buffer-gas cooling of the rotational degrees of freedom of MgH^+ molecular ions, which are trapped and sympathetically crystallized in a linear radio-frequency quadrupole trap [1]. With helium collision rates of only $\sim 10 \text{ s}^{-1}$, i.e. four to five orders of magnitude lower than in usual buffer gas cooling settings, we have cooled a single molecular ion to an unprecedented measured low rotational temperature of $7.5^{+0.9}_{-0.7} \text{ K}$. In addition, by only varying the shape and/or the number of atomic and molecular ions in larger Coulomb crystals, we have tuned the effective rotational temperature from $\sim 7 \text{ K}$ up to $\sim 60 \text{ K}$ by changing the micromotion energy. The very low helium collision rate may potentially even allow for sympathetic sideband cooling of single molecular ions, and eventually make quantum-logic spectroscopy of buffer gas cooled molecular ions feasible. Furthermore, application of the presented cooling scheme to complex molecular ions should have the potential of single or few-state manipulations of individual molecules of biochemical interest. This latter perspective can hopefully be exploited to disentangle various processes happening in complex molecules, like light harvesting complexes.

References

[1] A. K. Hansen *et al.* Nature (2014) doi:10.1038/nature12996