SPECTROSCOPIC APPLICATIONS OF STATE-SELECTED SYMPATHETICALLY-COOLED MOLECULAR IONS

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Cold molecular ions prepared by sympathetic cooling with laser-cooled ions in an ion trap[a] represent attractive systems for new spectroscopic experiments. The long trapping times (up to hours) and state lifetimes (up to minutes)[b] in an almost perturbation-free environment enable the long interaction times required for the study of forbidden spectroscopic transitions which have not been accessible before in molecular ions.

Here, we present a proof-of-principle experiment for the investigation of dipole-forbidden infrared transitions in cold N_2^+ ions using quantum-cascade-laser technology in combination with action spectroscopy. Because sympathetic-cooling experiments typically use small ensembles of tens to hundreds of ions, the confinement of their population into a single quantum state is essential to improve the sensitivity of our experiments. This is achieved by state-selective generation of the ions using threshold photoionization followed by sympathetic cooling[c].

Finally, we discuss the experimental requirements for performing highly sensitive spectroscopic measurements on trapped, cold molecular ions and present an outlook on current developments which employ quantum-logic methods for non-destructive spectroscopic studies on single sympathetically cold molecular ions.[d]

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[b] X. Tong, A. Winney and S. Willitsch *Phys. Rev. Lett.* **105**, 143002 2010.
[c] X. Tong, D. Wild and S. Willitsch *Phys. Rev. A* **83**, 023415 2011.
[d] J. Mur-Petit, J. J. Carcia-Ripoll and S. Willitsch *et al. Phys. Rev. A* **85**, 022308 2012.