Observation of forbidden infrared spectra in Coulomb-crystallized molecular ions: Towards precision measurements on single molecules

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The recent progress in the preparation of neutral molecules and ions at temperatures close to the absolute zero point has paved the way for a range of new research directions in atomic, molecular and chemical physics. Ensembles of cold, spatially localized ions in traps, often referred to as Coulomb crystals, are particularly attractive systems in this context in which it is possible to observe, manipulate and control single isolated particles under precisely controlled conditions [1].

The long storage times (exceeding tens of minutes) of Coulomb-crystallized ions in the minimally perturbed environment of an ion trap enable to perform highly sensitive spectroscopic experiments and study molecular spectra which have not been accessible before. Here, we present recent results on the - to our knowledge first - observation of the electric-dipole forbidden infrared spectrum of a molecular ion. Specifically, we studied hyperfine components of rotational lines in the infrared fundamental excitation of N_2^+ in a Coulomb crystal [2]. These extremely weak and therefore narrow transitions, the line strength of which is about ten orders of magnitude smaller than the one of typical dipole-allowed infrared lines, form an ideal basis for precision-spectroscopic measurements. Applications include the development of precise clocks and tests of fundamental concepts such as a possible time variation of fundamental physical constants [3,4]. In the talk, we will discuss new developments in the study of forbidden spectra of molecular ions and present an outlook towards realizing precision-spectroscopic measurements on single isolated molecules [5].

References

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