Spectroscopy of Cold Molecular Ions

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Ions play an important role in many interesting environments like planetary atmospheres or the interstellar medium. These molecules are the messengers of the physical (pressure, number density) and chemical conditions. Therefore their spectra and chemical reactivity have to be known in the laboratory to interpret the data from remote sensing observations. Ion trapping is used in our laboratory to investigate both aspects of molecular physics. Over many years the method of laser induced reactions (LIR) has been used to study the spectra and state specific processes of molecular ions at low temperatures. The main advantages of this technique are: mass selection of the primary ion, low temperature trapping, and most importantly an unprecedented sensitivity as only a few hundred ions per wavelength step are needed to, e.g., record a spectrum. Moreover, the method only needs a single photon compared to other, more popular trap based spectroscopy methods like infrared multiple photon dissociation (IRMPD).

Recently our group pushed the limits of ro-vibrational spectroscopy of CH_2D^+ and CD_2H^+ [1] to predict rotational spectra in the THz regime helping to identify this molecule in astrophysical observations. Employing a frequency comb in combination with cw-OPOs, transition frequencies of ro-vibrational lines of CH_5^+ have determined with sub-MHz resolution [2]. This can be considered a breakthrough since it paves the road to pinpoint combination differences (CDs) of complex spectra where thousands of lines lead to an enormous number of CDs [3]. Within the last year pure rotational transitions of several molecular ions have been detected by using the state-dependent association rate of these ions with He at 4 K. This is another significant advancement since this approach allows to record THz spectra of virtually any ion. Very recently such laboratory spectra led to the identification of l-C_3H^+ in space [4]. Also IR-THz two photon double resonance spectroscopy has been used to record the J=1-0 rotational transition of OH^- [5].

References

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