

## LOW TEMPERATURE TRAPPING: FROM REACTIONS TO SPECTROSCOPY

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The kinetics of ion - molecule reactions are investigated in higher-order multipole traps by observation of the temporal evolution of mass selected parent ions in the presence of a neutral reaction partner. Rate coefficients for fast reactions (proceeding at collision rate) and very slow reactions (taking millions of collisions) are determined over a wide range of temperatures. Endothermic or hindered reactions can be promoted by excitation of the ion via absorption of a photon. Scanning the photon energy while detecting the number of product ions establishes an action spectroscopy method which we developed over the last 10-15 years and termed LIR: laser or light induced reactions. <sup>a</sup> The main advantages of LIR are mass selection of the parent ion and low temperature conditions in the trap. Long storage times in combination with a near unity detection efficiency make LIR one of the most sensitive spectroscopy methods. The status quo of LIR will be discussed on selected examples. Recent measurements are concerned with ro-vibrational spectra of  $\text{CH}_2\text{D}^+$  <sup>b</sup> and  $\text{CH}_5^+$  <sup>c</sup> at highest resolution using cw OPO radiation. In the particular case of  $\text{CH}_5^+$ , the lines in the mid IR have been measured at a nominal temperature of 10 K and a frequency comb has been used for absolute calibration. Line positions can be determined to an accuracy which shall enable us in the future to obtain rotational spectra in a THz-IR double resonance approach. We tested the feasibility of this two photon method recently on  $\text{H}_2\text{D}^+$ .

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<sup>a</sup>S. Schlemmer, T. Kuhn, E. Lescop, and D. Gerlich, Laser excited  $\text{N}_2^+$  in a 22-Pole Trap: Experimental Studies of Rotational Relaxation Processes, *Int. J. Mass Spectrometry and Ion Processes*, 185-187, 589-602, (1999), S.D. Ivanov, O. Asvany, A. Witt, E. Hugo, G. Mathias, B. Redlich, D. Marx and S. Schlemmer, Quantum-induced symmetry breaking explains infrared spectra of  $\text{CH}_5^+$  isotopologues, *Nature Chemistry*, 2, 298302 (2010)

<sup>b</sup>S. Gaertner, J. Krieg, A. Klemann, O. Asvany and S. Schlemmer, Rotational transitions of  $\text{CH}_2\text{D}^+$  determined by high-resolution IR spectroscopy, *Astron. Astrophys.*, 516 (2010) L3.

<sup>c</sup>O. Asvany, J. Krieg, and S. Schlemmer, Frequency comb assisted mid-infrared spectroscopy of cold molecular ions, *Rev.Sci.Instr.*, 83 (2012), 076102.