CFEL SCIENCE

SEMINAR

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Action Spectroscopy in Cryogenic Ion Traps

Molecular ions are important constituents of the interstellar medium. They are major drivers of the chemistry particularly in cold and dense molecular clouds, which are sites of star formation. Their identification in space relies on accurately known transition frequencies provided by laboratory spectroscopy. Conventional absorption spectroscopy has in the past successfully been applied for spectroscopic studies of molecular ions, but is often hampered by low number densities and spectral congestion due to the multitude of species produced at high excitation energies in the discharge cells used for their formation.

These limitations can be overcome by performing experiments on mass-selected ions in cryogenic ion trap instruments. In the Cologne laboratory astrophysics group we have in the past years developed sensitive action spectroscopic methods based on Laser Induced Reactions (LIR). For LIR measurements only a few thousand mass-selected ions are stored and cooled in a 22-pole ion trap, and their light-induced excitation is probed by the outcome of an endothermic ion-molecule reaction. Highly accurate ro-vibrational transition frequencies are obtained by using a narrow-bandwidth cw optical parametric oscillator (OPO) calibrated with a frequency comb as excitation source in combination with the cold temperature of the ions. In certain cases even purely rotational transitions have been measured with high-resolution either directly or via a two-photon double-resonance scheme. Very recently, our group used an even more general action spectroscopic scheme based on LIR, which utilizes a change of the rate of ternary He-attachment to the stored, cold ions depending on their internal ro-vibrational or rotational excitation.

In this talk we will give details on the experimental and methods development for high-resolution ro-vibrational and rotational ion spectroscopy in cryogenic traps. We will also demonstrate the strong interplay of our laboratory work and astrophysical observations with selected examples, e.g. the confirmation of l-C3H+ in photon-dominated regions and the diffuse interstellar medium, and the first detection of para-H2D+ in the cold molecular envelope around a young protostellar core.

Host: Melanie Schnell - CFEL Molecular Physics seminar