

Institutsseminar

Ion processes in the interstellar medium and planetary ionospheres

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Ion processes play a pivotal role in the interstellar medium (ISM) and planetary atmospheres as intermediate steps in the build-up of larger complex molecules. Since the first detection of molecular anions in a circumstellar envelope several negative ions (HC₄⁻, HC₆⁻, and HC₈⁻, C₃N⁻ and, tentatively, C₅N⁻) have been identified in the ISM. In addition a multitude of large anions (up to a mass of 10000 Da) and a large number of nitrogen-containing cations have been observed by the Cassini Plasma Spectrometer (CAPS) and Ion and Neutral Mass Spectrometer (INMS) in the atmosphere of the Kronian satellite Titan. Also, several protonated nitriles were detected in this environment by the INMS. In addition the anions CN⁻, C₃N⁻ and, possibly, C₅N⁻ have been identified in Titan's ionosphere by CAPS. It is therefore necessary to investigate possible formation and destruction pathways of these species in order to explain their presence and abundances in the interstellar medium, star-forming regions and atmospheres. Whereas ion-neutral and ion-electron reactions (dissociative recombination) are the most important degradation processes for cations in these environments, feasible degradation processes of anions include photodetachment, ion-neutral reactions (e. g. associative detachment) as well as mutual neutralisations.

During the last years, ion traps and guided beam devices have been successfully employed to investigate ion-neutral processes. We have performed laboratory measurements of the reactions of different isomers of the cyanomethyl cation (c-C₂H₂N⁺ and CH₂CN⁺) with several saturated and unsaturated hydrocarbons (e.g. CH₄, C₂H₂, C₂H₄ and C₂H₆) using tandem mass spectrometric techniques and appropriate neutral precursors to ensure the production of specific isomers of the C₂H₂N⁺ ion. The principal aim was to identify possible growth mechanisms large carbon- and nitrogen-containing molecules in Titan's atmosphere via ion-molecule reactions. Such heavy entities can act as intermediates for the formation of tholines which are regarded as being responsible for the orange haze Titan is enveloped in.

Furthermore, ion traps have been employed to determine absolute cross sections of photodetachment of HC_{2n}⁻ ions C_{2n+1}N⁻ ions which have been detected in the interstellar medium and Titan's ionosphere. The obtained findings were included in state-of-the-art model calculations of dark clouds and circumstellar envelopes. Another series of experiments concentrated on reactions of cyano ions with unsaturated hydrocarbons present in Titan's atmosphere since these species have been identified as possible pathways to larger entities there. The guided beam devices at Prague has been employed to carry out these studies. Furthermore, the new electrostatic storage ring DESIREE, has been used to determine the lifetime of the electronically and rotationally excited state of the CH⁻ anion.