DISSOCIATIVE RECOMBINATION AND EXCITATION OF D_3^+; ISOTOPE AND ELECTRIC FIELD EFFECTS

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The recent detection[1] of H_3^+ in interstellar space is a major discovery which supports the premise that H_3^+ plays the pivotal role in much of the chemistry in molecular clouds. Model calculations of dark molecular clouds have shown that they may have two different steady-state solutions for which chemical abundances differ at least an order of magnitude[2]. The rate constant for dissociative recombination (DR) plays an important role in this scenario. The DR rate constant for H_3^+ has been controversial for many years, and is still a topic of heated debate.
The major problem in rationalizing a rate constant on the order of 10^{-7} cm^3s^{-1} has been the lack of a favourable neutral-state curve crossing of H_3^+(v=0). In view of the recent results for HeH^+, which, despite the lack of a favourable curve crossing, recombines to He + H (n = 2) at 0 eV electron energy[3,4], this argument is now fading. Theoretical calculations have shown that the non-adiabatic radial coupling between the electron-molecular ion system and non-crossing Rydberg can drive dissociative recombination[5,6]. It remains to be proven that the same or a similar mechanism is operative in H_3^+ and its isotopomers.

Two important issues have been addressed in the present work concerning the DR of H_3^+ and its isotopomers: what is the isotope effect, and what is the influence of electric fields in the electron-molecular ion interaction region. We have used the merged electron-ion beams facility at the heavy-ion storage ring CRYRING at the Manne Siegbahn Laboratory at Stockholm University.
The absolute rate coefficient in the electron cooler of CRYRING (which equals the effective cross section times the electron velocity) for the DR of D_3^+ was measured over wide range of electron energies. The result is shown in Figure.1 and compared with the corresponding results for H_3^+ and H_2D^+. The thermal rate constant for D_3^+ measured in the present work, 3 10^{-8} cm^3s^{-1}, is a factor of 3.8 smaller than the corresponding CRYRING value for H_3^+ [7].
An electric field of 30 V/cm was introduced in the electron -ion interaction region. The field was added

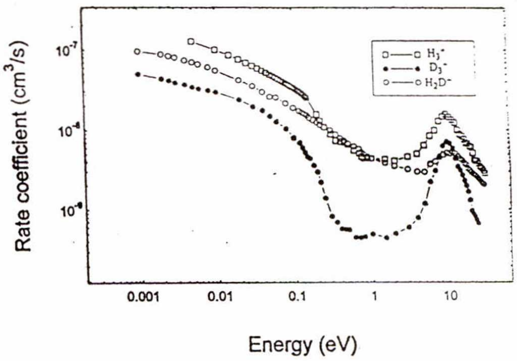

Figure1. The rate coefficient measured in the CRYRING electron cooler as a function of electron energy. The data for D_3^+ are from the present work and the data for H_2D^+ from Ref. 8. The data for H_3^+ [7] below 0.2 eV have been modified to account for the fact that they were obtained with a warmer electron beam.

by slightly misaligning the electron beam with respect to the ion beam, so that the ion beam crossed the electron-beam-guiding solenoid magnetic field at a finite angle. Within the error bars, no measurable electric-field effect on DR of D_3^+ was observed.

Finally, we have observed resonant enhanced dissociative excitation of D_3^+. The process combines electron capture with autoionization into the vibrational continuum. It has previously been observed and explained for HeH^+ [3,9].

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