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High Resolution Dissociative Recombination of cold H_3^+

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Abstract.
The triatomic hydrogen ion H_3^+ is an important reaction agent in interstellar chemistry networks. In diffuse interstellar clouds the Dissociative electron Recombination (DR) is supposed to be the dominant destruction mechanism for H_3^+. Hence many experiments tried to determine the DR rate coefficient, but the results obtained by different methods scatter over several orders of magnitude. It was conjectured that different internal excitations of the H_3^+ ions might be responsible for this discrepancy.

The advent of ion storage rings equipped with electron coolers made it possible to wait for the radiative cooling of vibrational degrees of freedom before the recombination measurement is initiated. The situation is less simple for rotational excitations: since H_3^+ lacks a permanent dipole moment, certain rotational states have extremely long lifetimes and can only be cooled by buffer gas collisions. In order to be able to perform DR experiments with ions in specific states a cryogenic ion source has been installed at the storage ring TSR of the Max-Planck-Institute for Nuclear Physics. The centerpiece of the new cryogenic ion injector is a 22-pole ion trap (Gerlich D. (1995)) mounted on a 10 K coldhead. Up to $\sim 2\times10^6$ H_3^+ ions from a RF storage ion source were stored for variable storage times (1-100 ms) in the 22-pole trap where they interact with a helium buffer gas at a nominal temperature of 13 K, prior to injection into the TSR.

In the ring the ion beam was phase space cooled by merging a velocity matched electron beam in the electron cooler (electron density of $n_e \sim 1.8\times10^7\,\mathrm{cm}^{-3}$) while the cross section scans were performed with another merged cold electron beam of much lower density ($n_e \sim 4\times10^5\,\mathrm{cm}^{-3}$). This low temperature electron beam was produced by the new photocathode electron source (Orlov D.A. (2004)) at a temperature of $kT_\parallel = 20\,\mu$eV and $kT_\perp = 0.5$ meV.

The observed cross section shows good agreement with a previously published measurement from Cryring and a thorough theoretical treatment that became available only recently (Greene C.H. (2003)) yields a rate coefficient of similar magnitude, while the discrepancy with stationary afterglow measurements (Plašil R. (2002)) still persists.

Keywords. ISM: abundances, ISM: molecules, molecular processes

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