DISSOCIATIVE RECOMBINATION AND EXCTTATION OF N_2^+: CROSS SECTIONS AND BRANCHING RATIOS

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Dissociative recombination (DR) of N_2^+ has been an area of much controversy[1]. The importance of N_2^+ in ionospheric chemistry has prompted many investigations of its DR rate coefficient[1], cross section[1], and most recently, branching ratios[2].

The dependence of the DR cross section, or rate coefficient, on the vibrational level is unclear. The experiment by Zipf[3] indicated a very weak dependence on the amount of vibrational excitation in N_2^+ and the accepted recombination rate was for a long time 2×10^{-7} cm^3s^{-1}. The weak vibrational dependence has been questioned by Johnsen[4], and also by Noren *et al*[5] on the basis of a single-pass merged-beams experiment. The single-pass result was claimed for N_2^+ in its zeroth vibrational level, and leads to a v = 0 rate coefficient of about 4 x 10^{-8} cm^3s^{-1}. This is considerably smaller than Guberman's[6] theoretical value of 1.6 x 10^{-7} cm^3s^{-1}.

It is a major problem to produce N_2^+ in its zeroth vibrational level only. Storage of N_2^+ in a heavy-ion cooler ring is not a remedy because of the absence of a dipole moment in N_2^+, which is needed to drive infrared transitions. In the present work we have made use of a hallow cathode ion source developed at SRI International as injector to the storage ring CRYRING at the Manne Siegbahn Laboratory at Stockholm University. The hollow cathode source is operated in the torr pressure region, which leads to collisional deactivation of excited vibrational levels in N_2^+. Even though the collisions lead to vibrational cooling, they do not completely quench vibrationally excited levels. The cross section for dissociative recombination and excitation of N_2^+ was measured in the electron cooler section of CRYRING, where the ion beam is merged with close-to velocity matched electrons.

In order for the cross section results to be meaningful, one must be able to determine the vibrational state distribution. To this end we used a three-dimensional, position-sensitive imaging detector consisting of three microchannel plates (MCPs) linked to a phosphor screen and a charged-coupled-device (CCD) camera. The third MCP was supplied with metal strips that measured the difference in time-of-arrival between two nitrogen atoms originating from the same DR event. Figure1 shows the N - N distance spectrum for nitrogen atoms arriving less than 800 ps after each other. In practise this means that spectrum shows the recombination products of N_2^+ ions recombining nearly perpendicular to the electron beam. The spectrum is best fit assuming a vibrational distribution of v = 0 (55%), v = 1 (23%), v = 2 (13%) and v = 3 (10%). The cross section measured for this vibrational distribution is clearly larger than those measured by Noren *et al*[4].

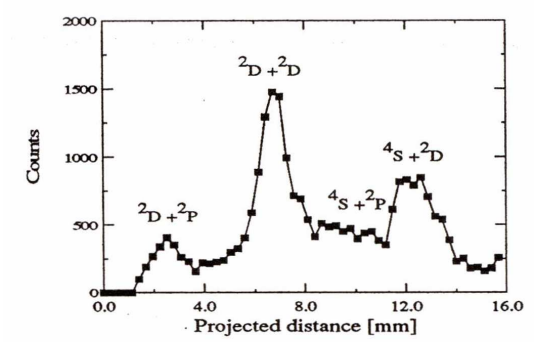

Figure1. Projected distance between two N atoms following DR of N_2^+.

The experiment was repeated with the hollow cathode source replaced by a low-pressure, hot filament discharge source. The distance spectrum measured by the imaging detector now showed that the ions contained more vibrational excitation. Despite this, *the cross section did not change.*

References

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