RESONANT ION PAIR FORMATION IN THE RECOMBINATION OF NO^+ WITH ELECTRONS: CROSS SECTION DETERMINATION

A. Le Padellec,[1] N. Djurić,[2] A. Al-Khalili,[3] H. Danared,[4] A. M. Derkatch,[3] A. Neau,[3] D. B. Popović,[2] S. Rosén,[3] J. Semaniak,[5] R. Thomas,[3,6] M. af Ugglas,[4] W. Zong,[2,3] and M. Larsson[3]

[1]*LCAR UMR 5589 Universite Paul Sabatier-Toulouse III 118, route de Narbonne Bât. III R1, b4 31062 Toulouse Cedex 4 France*
[2]*JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado 80309-0440*
[3]*Department of Physics, Stockholm University, Box 6730, S-113 85 Stockholm, Sweden*
[4]*Manne Siegbahn Laboratory, Stockholm University, S-104 05 Stockholm, Sweden*
[5]*Institute of Physics, Pedagogical University, 25-430 Kielce, Poland*
[6]*FOM Instituut AMOLF, Kruislaan 407, 1098 SJ Amsterdam, The Netherlands*

Dissociative recombination (DR) is a process in which a molecular ion AB^+ captures an electron followed by molecular dissociation into neutral fragments. Resonant ion pair formation (RIP) proceeds very much in the same way, the difference being that charged species rather than neutral species are formed. In most cases the RIP process is endothermic. As a result, the cross section exhibits a threshold behavior. For a diatomic ion, the ion pair formation can be represented by $AB^+ + e^- \rightarrow AB^{**} \rightarrow A^+ + B^-$ +KER, where KER is the kinetic energy release.

The NO^+ ion, together with N_2^+ and O_2^+, is very important in the terrestrial ionosphere where dissociative recombination and photodissociation are the only chemical loss processes[1]. The DR process of NO^+ with electrons had been studied previously, both experimentally[2] and theoretically[3]. To the best of our knowledge, this was not the case for the RIP process.

The experiment was performed at the heavy-ion storage ring CRYRING, located at the Manne Siegbahn Laboratory of Stockholm University. The NO^+ ions were produced in a hollow cathode ion source, extracted at 40 keV, mass selected, injected into the ring and accelerated to 3.2 MeV. In the electron cooler section, the ion beam was merged with a collinear, quasi-monoenergetic electron beam. While the ions were circulating in the main orbit, the negatively charged products O^- from the RIP process, and O^- produced from NO^+ collisions with the rest gas molecules, were bent to the outside of the main trajectory, where they hit an energy-sensitive surface barrier detector and got recorded by a multichannel scaler (MCS). However, as mentioned earlier, a non-negligible part of the detected O^- fragments came from collisions with the rest gas molecules and had to be separated from the true signal.

The absolute cross sections for the RIP process as a function of center-of-mass energy are presented with error bars in Fig. 1. These were measured by recording the O^- fragments coming from the $N^+ + O^-(^2P)$ channels. The thresholds for the formation of N^+ in the ^3P, ^1D, and ^1S states at 10.3 eV, 12.2 eV, and 14.4 eV, respectively, are indicated by the arrows. Also shown are the data of Erman *et al.*[4] (in dashed line) obtained from photoionization of NO X $^2\Pi_r$ and leading to the same exit channel. Our RIP cross sections consist of two parts, a broad structure centered at about 11.8 eV and a sharp peak at 12.5 eV. This latter one is seen in both experiments and is in perfect agreement. In addition, the magnitude of the cross section is 8.5×10^{-19} cm^2. Nevertheless, there are also few differences: our data contain fewer structures, and especially striking is the absence of the four resonant structures lying above the first threshold of $N^+(^3P)+O^-(^2P)$ but below the second one, $N^+(^1D)+O^-(^2P)$.

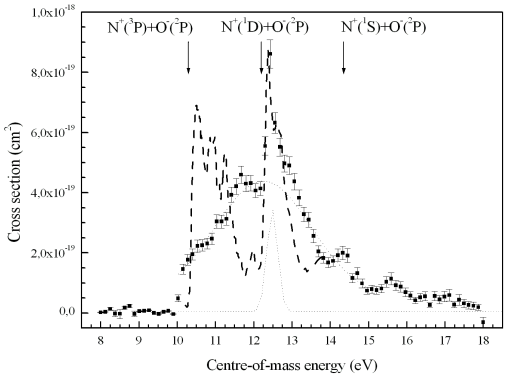

Fig. 1

1. V. I. Shematovich, D. V. Bisikalo and J. C. Gerard, J. Geophys. Res. **99**, 23217 (1994).
2. L. Vejby-Christensen, D. Kella, H. B. Pedersen, and L. H. Andersen, Phys. Rev. A **57**, 3627 (1998).
3. H. Sun, K. Nakashima, and H. Nakamura, in *Dissociative Recombination: Theory, Experiment and Applications*, edited by B.R. Rowe, J.B.A. Mitchell and A. Canosa (Plenum Press, New York, 1993) p. 25.
4. P. Erman, A. Karawajczyk, E. Rachlew-Källne and C. Strömholm, J. Chem. Phys. **102**, 3064 (1995).

E-mail: Mats.Larsson@physto.se