4.7. DISSOCIATIVE RECOMBINATION AND EXCITATION OF O_2^+: CROSS SECTIONS AND PRODUCT YIELDS

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Dissociative recombination (DR) and excitation of O_2^+ have been investigated using the ion storage ring CRYRING at the Manne Siegbahn Laboratory at Stockholm University. DR of O_2^+ plays an important role in atmospheric physics and chemistry, in particular in the F-region (above 140 km) where it is the source of the 630.0 nm red airglow and the 557.7 green airglow (arising from the $O(^1S) \rightarrow O(^1D)$ transition).

The green airglow has a long history of controversy [1], which is related to the problems to measure or control the vibrational population of O_2^+ ions either formed in the laboratory of the Earth's ionosphere, the problems to measure the quantum yield of $O(^1S)$ in the laboratory, and the problems of quantal calculations of DR of O_2^+. In 1997 two important steps forward were taken. The $O(^1S)$ quantum yield for DR of O_2^+ populating a broad vibrational distribution was measured for an electron energy of nominally 0 eV using the ASTRID storage ring and an imaging technique [2]. Despite the complication with using vibrationally hot O_2^+, it was possible to deduce an $O(^1S)$ quantum yield of 0.05 for DR of O_2^+ (v = 0) [2]. A new mechanism was suggested [3] and showed to quantitatively give a yield in quite good agreement with experiment [2].

Three experimental improvements were implemented in the present work. An ultracold electron beam allowed cross sections and quantum yields to be measured at an energy resolution of about 1 meV, a specially designed ion source supplied O_2^+ in its zeroth vibrational level, and an image intensifier was added to our three-dimensional imaging detector [4]. The use of an image intensifier strongly reduced background events arising from collisions of O_2^+ in the rest gas.

Thus, for the first time one experiment combines absolute cross section measurements with quantum yield determinations as a function of electron energy for vibrationally cold O_2^+. Fig. 1 shows the DR cross section as a function of electron energy. Integration of the cross section in the usual way gives a thermal rate coefficient of 2×10^{-7} cm^3s^{-1} at 300 K, which is in very good agreement with several earlier measurements [1]. The $O(^1S)$ quantum yield shows a strong dependence on the electron energy.

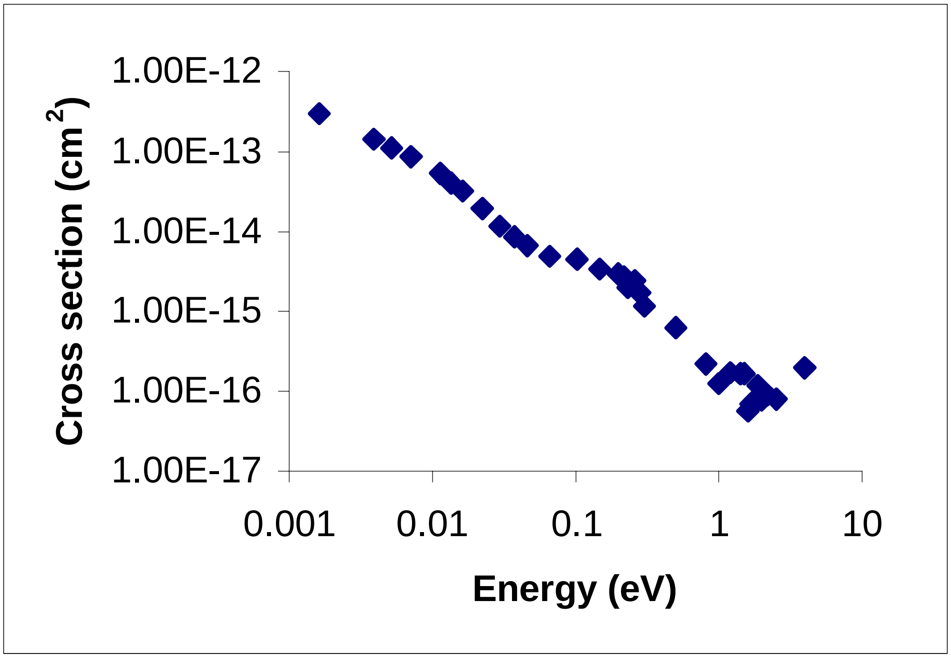

Figure 1. DR cross section for O_2^+

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