Electron Collisions with N_2^+: Temperature Dependent Processes

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Collisions between electrons and N_2^+ play an integral role in determining the chemical and physical properties of terrestrial atmospheric plasmas. One such plasma is that which is formed in the hypersonic shock layer of a vehicle re-entering the Earth's atmosphere. Calculations are being performed to determine temperature and vibrationally dependent properties of electron - N_2^+ collisions in such an environment using the R-matrix method and multi-channel quantum defect theory. The main concern of the study so far has been the dissociative recombination of N_2^+.

The environment surrounding hypersonic vehicles on re-entry is difficult to reproduce in a laboratory. As a result the reaction rate coefficients for elevated temperatures ($T \sim 10,000K$) are theoretically extrapolated values from measurements made at lower temperatures. Numerous attempts have been made to compile sets of data for reactions relevant to the conditions surrounding hypersonic re-entry [1, 2]. However, due to the lack of high temperature data the uncertainty in some of these rates is as high as one order of magnitude or even unknown [3]. This study aims to produce an accurate and reliable theoretical reaction rate for processes involving electrons and N_2^+ such as dissociative recombination for elevated temperatures typical of hypersonic shock layer plasmas.

Molecular data is being calculated using the R-matrix method [4]. This is a well established fully quantum, ab-initio, time-independent variational method that can be used to calculate electron-molecule scattering energies and cross-sections. The R-matrix method also incorporates the tools necessary to calculate the properties of the resonant states which facilitate dissociative recombination. To calculate an accurate reaction rate for a dissociative recombination process it is imperative that the point at which the resonant curve crosses the ground target state curve is known with a high level of confidence. In this study to date, the main focus has been establishing a highly accurate scattering target model in order to maximise the accuracy of the curve crossing points. An accurate target model (with respect to experimental data) has now been established and progress is being made in calculating the resonant states. Once the crossing points have been established, multi-channel quantum defect theory will be used to calculate the cross-sections. This study follows an earlier successful study of electron collisions with NO^+ [5].

References

[1] C. Park, *J. Thermophys. Heat Transfer* **7** (1993) 385-398.

[2] R.N. Gupta, J.M. Yos, R.A. Thompson and K.P. Lee, *NASA Reference publication No. 1232* (1990)

[3] C. Park, *Nonequilibrium Thermodynamics Hypersonic Aerothermodynamics* (Wiley, New York, 1990).

[4] J. Tennyson, *Phys. Rep.* **491** (2010) 26-79.

[5] O. Motapon, M. Fifirig, A. Florescu, F.O. Waffeu Tamo, O. Crumeyrolle, G. Varin-Brant, A. Bultel, P. Vervisch, J. Tennyson, I.F. Schneider, *Plasma Sources Sci. Technol.* **15**, (2006) 23-32.