Electron-impact excitation and recombination of molecular cations of astrophysical interest

O. Motapon[1,2], F. Colboc[1], K. Chakrabarti[1,3], D. A. Little[4], J. Zs Mezei[1,5,6,7], N. Pop[8], M. D. Epée Epée[1,2], D. Talbi[9], A. Faure[10], K. Hassouni[7], O. Dulieu[5], J. Robert[5], J. Tennyson[4] and I. F. Schneider[1,5]

[1] Laboratoire Ondes et Milieux Complexes, CNRS, Univ. du Havre, Le Havre, France
[2] Department of Physics, Faculty of Sciences, University of Douala, Douala, Cameroon
[3]Department of Mathematics, Scottish Church College, Kolkata, India
[4]Department of Physics and Astronomy, University College London, United Kingdom
[5]Laboratoire Aimé Cotton, CNRS, ENS Cachan and Univ. Paris-Sud, Orsay, France
[6]Instititute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary
[7]Laboratoire des Sciences des Procédés et des Matériaux, CNRS, Univ. Paris 13, France
[8]Dept. of Physical Foundation of Engineering, Politehnica Univ., Timisoara, Romania
[9]Laboratoire Univers et Particules de Montpellier, CNRS, Univ. de Montpellier, France
[10]Université UJF-Grenoble 1, CNRS-INSU, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), Grenoble, France
ioan.schneider@univ-lehavre.fr

The modeling of the media characterizing the early Universe, the interstellar molecular clouds and the planetary atmospheres requires rate coefficients for the major elementary reactions. In diffuse environments, electrons are expected to be the dominant exciting species for molecular ions, as the cross sections for electron impact excitation are several orders of magnitude larger than those corresponding to excitation by neutral atomic or molecular species. Electron impact rotational excitation of the molecular cations is competed by electronic dissociative recombination, a major process for the charged particle kinetics and an important link in the various reaction networks involving most of the major species [1].

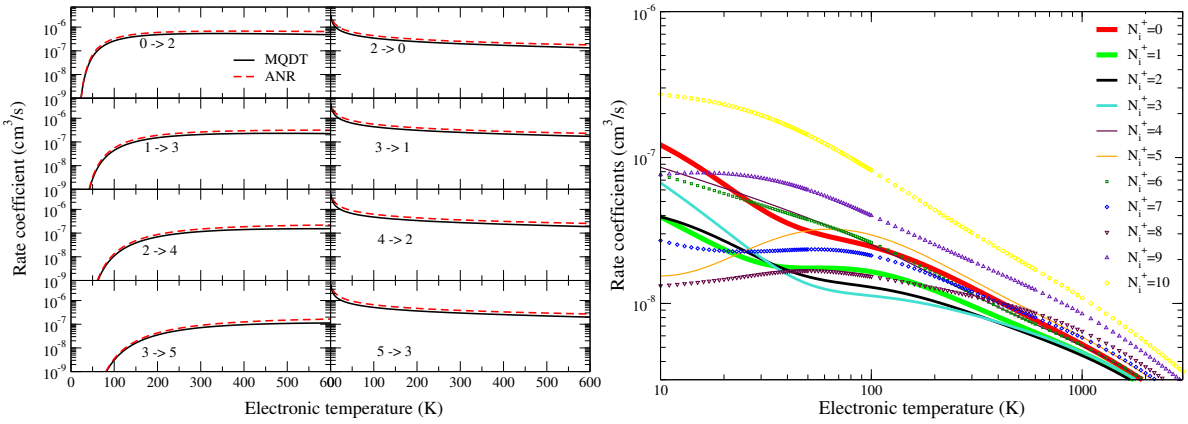

Figure 1: Maxwell rate coefficients for rotational excitation (left) and dissociative recombination (right) of vibrationally relaxed HD^+ on its lowest rotational levels N_i^+ [3].

Using the Multichannel Quantum Defect Theory (MQDT) [2, 3] and the Adiabatic-Nuclei Rotation (ANR) approximation [3], cross sections and rate coefficients have been obtained for *rotational* transitions induced in H_2^+ and HD^+ molecular ions – Figure 1. New

data on vibrational transitions in CO^+ [4] – Figure 2 - have also been produced and, following a careful study of the role of the core-excited Rydberg states in the dynamics, dissociative recombination rate coefficients have been obtained for N_2^+ [5]. For all these species, comparison with measurements in CRYRING and TSR heavy-ion-storage-rings resulted in very good agreement.

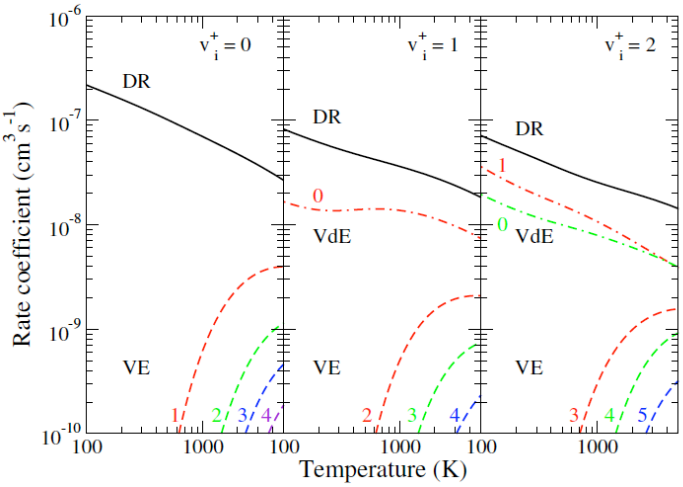

Figure 2: Maxwell rate coefficients for dissociative recombination (DR), vibrational excitation (VE) and vibrational de-excitation (VdE) of CO^+ in its vibrational state v_i^+ [4]. The colored numbers stand for the final vibrational level of the transition.

Besides analyzing these recent results, we will discuss the huge role of the resonant electron capture into Rydberg states in the dissociative recombination of H_3^+, and we will present a very effective reduced analytical model [6], which can be applied for the estimation of rate coefficients for a large number of polyatomic species.

Finally, we will display preliminary promising data on CH^+, SH^+ and AlO^+ ions.

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