N_2 dissociative ionization by electron impact

Y. Zhang*, X. Wang* [1], L. F. Zhu†, D. Lu*, R. Hutton*, Y. Zou*, and B. Wei* [2]

* Institute of Modern Physics, Department of Nuclear Science and Technology, Fudan University, Shanghai 200433, China

† Hefei National Laboratory for Physical Sciences at Microscale, Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

Synopsis Dissociative single, double and triple ionization of N_2 induced by 200, 400 and 1000 eV electron impact are studied using the cold target recoil-ion momentum spectroscopy (COLTRIMS) technique. Kinetic energy releases (KERs) are determined for dissociation channels ($N_2^+ \rightarrow N^+ + N$, $N_2^{2+} \rightarrow N^{2+} + N$) and Coulomb explosion channels ($N_2^{2+} \rightarrow N^+ + N^+$, $N_2^{3+} \rightarrow N^{2+} + N^+$). It is observed that as the electron-impact energy increasing, different channels behave quite differently. Through analyzing the electronic states of the precursor molecular ion in each channel, the present KER measurements show that ionization from different valance orbitals plays a very important role in the dissociation of molecules.

Nitrogen, as a diatomic molecule with a triple bond, is in abundance in planetary atmospheres, *e.g.* Titan's upper atmosphere. The dissociative ionization dynamics or kinematics of N_2 following the interaction with electrons has been the research focus for many years. In collisions with electrons, N_2 molecules might dissociate subsequent to ionization, thereby resulting in the formation of fragments accompanied by the kinetic energy release (KER). In this work, taking advantage of the COLTRIMS technique [1], we report the dissociative single, double and triple ionization kinematics of N_2 molecules impact by 200, 400 and 1000 eV electrons, covering another electron-impact energy range.

The KER spectra of different ions or channels resulting from N_2 impact by 200, 400 and 1000 eV electrons respectively are shown in Figure 1. The N^+ yield from the dissociative channel $N^+ + N$ can be mainly separated into two parts – from the $F^2\Sigma_g^+$ state with an increasing relative cross section and the H band of N_2^+ with a decreasing relative cross section as the electron-impact energy increases, which can be explained by the ionization from the inner valance orbital of nitrogen. The charge symmetric decay (CSD, $N_2^{2+} \rightarrow N^+ + N^+$) channel is mainly originated through two electrons removal from the outer valance orbitals of N_2, while the charge asymmetric dissociation (CAD, $N_2^{2+} \rightarrow N^{2+} + N$) channel is formed through one hole in $2\sigma_g$ orbital and one hole in an outer valance orbital.

The present KER measurements of N_2 show that ionization from different valance orbitals plays a very important role in the dissociation of molecules. For nitrogen, ionization from the inner valence orbital $2\sigma_g$ gives rise to the abundance change of N^+ ions or neutral N atoms in the channel $N_2^+ \rightarrow N^+ + N$ and on the other hand determines the charge distribution of N_2^{2+}, i.e. the dissociation channel (CSD or CAD). Moreover, although the response of the KER distributions of different dissociation channels to the increase of the electron-impact energy is very different, the contributors or peak energies of the KER distributions at different impact energies are not changed for each channel. This phenomenon indicates that for a Coulomb explosion channel or a non-Coulomb-explosion channel, the KER distributions depend much more on the properties of the molecular ions, i.e. electronic states with different potential energy curves and branching ratios, rather than the electron-impact energy.

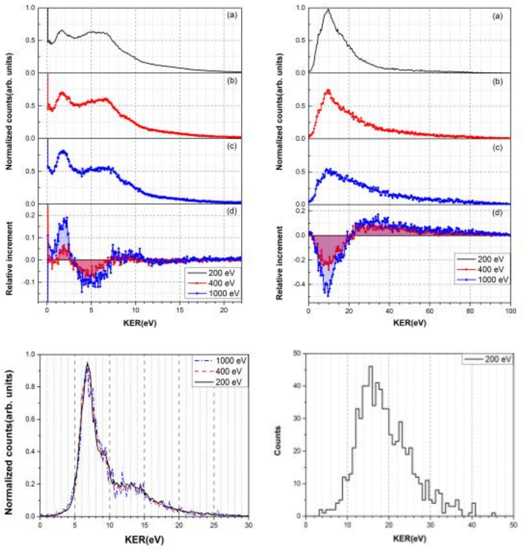

Figure 1. Upper panel: The normalized KER spectra of N^+ (left) and N^{2+} (right); Lower panel: The KER spectra of the channel $N_2^{2+} \rightarrow N^+ + N^+$ (left) and $N_2^{3+} \rightarrow N^{2+} + N^+$ (right).

References

[1] Y. Zhang *et al.* 2014 *Nucl. Instr. and Meth. B* **337**, 39.

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[1] E-mail: xinchengwang@fudan.edu.cn

[2] E-mail: brwei@fudan.edu.cn