2C/2005G087

Resonant Raman scattering in 1s-shell photoionization of O_2 molecules

Tatsuji HAYAISHI*[1], Satoshi IIZUKA[1], Hisako YOSHIDA[1], Kaori YAMASHITA[1], Eigoro MURAKAMI[3], Jun-ichi ADACHI[4] and Akira YAGISHITA[4]
[1]Institute of Applied Physics, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan
[2]Faculty of Medical Science, University of Fukui, Matsuoka, Fukui 910-1193, Japan
[3]Department of Physics, Chiba Institute of Technology, Narashino, Chiba 275-0023, Japan
[4]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Doubly charged ions or more are observed in inner-shell photoionization of atoms. However, singly charged ions in 1s-shell photoionization of Ne have been observed by means of coincidence spectroscopy with ions and threshold photoelectrons [1]. Normally, Auger decays following inner-shell photoionization result in the formation of doubly charged ions or more. On other hand, radiative decays instead of Auger decays take part in the formation of singly charged ions. Namely, the decay process can be expressed as follows,

$$h\nu_1 + M \rightarrow M^+ + e^-(\text{threshold}) + h\nu_2 .$$

This process is the so-called continuous radiative resonant Raman scattering [2].

In inner-shell photoionization of N_2 molecules, singly charged ions, that is parent ions of molecules, have been also observed in coincidence with threshold photoelectrons [3]. The spectral structure was revealed by the radiative decays.

Experimental method

Experiments were carried out at the undulator beamline BL-2C. The beam line is equipped with a grazing incidence soft X-ray monochromator. A varied space plane grating with 1000 lines/mm was used. The spectral resolution of the monochromator with $50\mu \times 10\mu$ slits was about 0.15 eV at 550 eV photon energy. Multiply charged ions in coincidence with threshold electrons were measured using a time-of-flight mass spectrometer coupled with a threshold-electron energy analyzer. The energy resolution of the analyzer was estimated to be about 0.03 eV.

Results and discussion

Figure1 shows the yield spectra of ions, threshold photoelectrons and O_2^+, O^+ and (O^{++} + O^{+++}) ions in coincidence with threshold photoelectrons near the 1s-shell photoionization region of O_2 molecules. The total yield spectrum of ions is correspond to the photoabsorption spectrum, and exhibits some resonance peaks of 1s-shell photoexcitaion. The yield spectra of threshold photoelectrons and ions in coincidence with the threshold photoelectrons exhibit broad and distorted profiles due to post-collision interaction [4] in the 1s-shell photoionization threshold, in addition to some resonance peaks. However, the profile of parent ions O_2^+ has symmetry just in the ionization threshold. Therefore, the formation of parent ions is due to continuous radiative resonant Raman scattering [2].

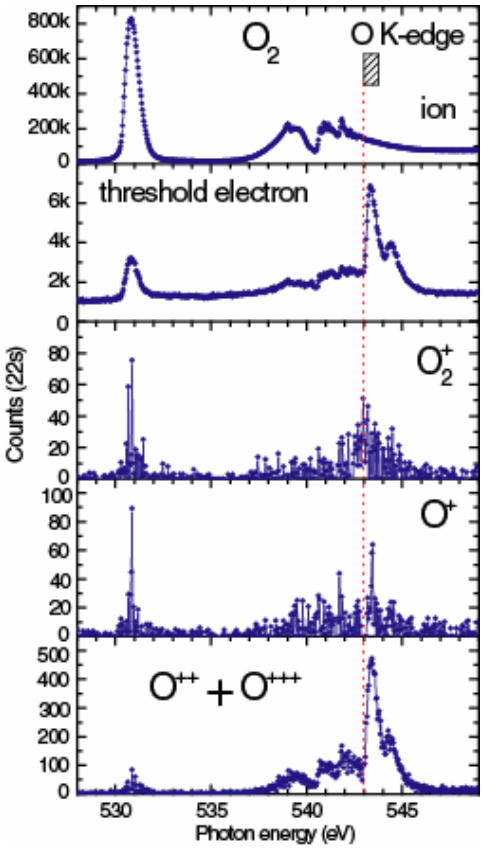

Figure1. Yield spectra of ions, threshold electrons and ions in coincidence with threshold electrons near the 1s-shell photoionization region of O_2 molecules.

References

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*hayaishi@bukko.bk.tsukuba.ac.jp