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Ultra-low-energy total cross sections for electron scattering from O_2

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1 Introduction

Accurate absolute cross section data for electron scattering from atoms and molecules provide important information not only for the fundamental physics of electron collisions but also for many fields such as electron-driven processes in the Earth and planetary phenomena, gaseous discharges, radiation chemistry and plasmas physics. Consequences of several interesting scattering phenomena such as Ramseur - Townsend effect, shape resonances, vibrational Feshbach resonances, and threshold structure due to a virtual state, appear in the scattering cross section curves especially at very-low collision energies, where the de Broglie wavelength of an electron become much longer than the typical size of target particles. The low energy behaviors of the electron scattering cross sections are also related to the scattering length which gives zero-energy scattering cross section.

Present group have developed a unique experimental technique in order to measure absolute total cross sections for electron scattering from atoms and molecules, which makes use of photoelectrons produced by the photoionization of atoms using Synchrotron Radiation (SR) instead of using the conventional hot-filament electron sources [1-4]. The technique enables one to measure total electron scattering cross sections down to very-low energies with extremely high energy resolution in the single collision condition.

In the present project, total cross sections for electron scattering from oxygen molecule were measured in a wide energy range including the very-low energy region, where rich structures due to shape resonances appear.

2 Experiment

In the present project, total cross sections for electron scattering from oxygen molecule were measured in a wide energy range including the very-low energy region below 100 meV with a very high energy resolution. The experiment has been carried out at the beamline 20A of the Photon Factory, KEK. Present experiment employs the threshold photoelectron source utilizing the SR which utilizes the penetrating field technique together with the threshold photoionization of noble gas atoms by the SR. The threshold photoelectrons produced by the threshold photoionization of Ar are extracted by a weak electrostatic field formed by the penetrating field technique and formed into a beam. The intensity of the electron beam passing through the collision cell without any collision with the target was detected by the channel electron multiplier. The counting rates of the detected electrons were measured as a function of the number density of the target gas filled in the gas cell in order to obtain the total cross section for electron scattering according to the attenuation law. The continuous injection operation of the PF ring is one of the key features for the reliable absolute value measurements of the total cross sections.

3 Results and Discussion

Total cross sections for electron scattering from O_2 at electron energies from 10 eV down to about 20 meV obtained in the present work are shown in Fig. 1 together with previously reported experimental cross sections. Present results showed that recommended cross sections reported in 2009 [5], which have been obtained from several previous experimental results, have overestimated the cross section values at energies below 1 eV. The striking vibrational features observed in the present total cross section curve below 1.5 eV represent the strong contribution of the $^2\Pi_g$ shape resonance. The $^2\Pi_g$ shape resonance occurs due to a temporary electron capture by O_2 to form vibrationally excited states of the negative ion of oxygen molecule, i.e., $O_2^-(X\ ^2\Pi_g)$. By analyzing the present cross sections, we also determined the resonance energies and the resonance widths of the $^2\Pi$g resonance.

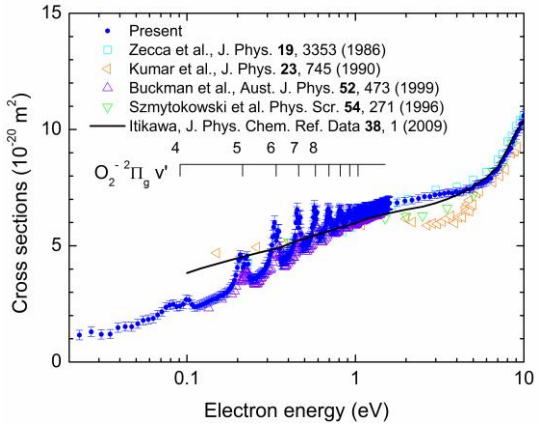

Fig. 1 Total cross sections for electron scattering from O_2.

References

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