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High resolution measurement of total cross section for electron scattering from CO_2

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1 Introduction

The scattering of low-energy electrons by atoms and molecules has been the subject of extensive experimental and theoretical investigations. The cross-section data concerning electron-atom or -molecule scattering are of great importance in understanding fundamental physics of the electron collisions and applications in many fields. Electron scattering from CO_2 is one of the basic processes involving the molecule and studied both theoretically and experimentally since the 1920s. A large number of papers have been published to report data for the total cross sections and differential cross sections for electron scattering from CO_2. Several reports for cross section measurements in the energy region down to 1 eV are consistent with each other and recommended cross section data were presented [1]. Low-energy electron scattering from CO_2 represents a particularly interesting system, which is dominated by the $^2\Pi_u$ shape resonance at around collision energy of 4 eV and a dramatic rise in the total cross section below 1 eV, which has been attributed to the effect from the virtual state [2]. In addition to the large enhancement of the cross section, an oscillatory structure in the transmitted electron current has been observed at the $^2\Pi_u$ shape resonance region [3]. The oscillatory structure at the shape resonance region was enhanced in the vibrational excitation cross sections, however, the position and its spacing differs with different excitation channels. The oscillations of the cross sections are due to the rapid variation of the resonance width with the change of the nuclear coordinate of the parent molecule. Although the oscillatory structures in the differential cross sections have been obtained in the several experiments, the structures have not been obtained in the total cross section measurement.

Recently, we have developed a new method for producing an electron beam at very high resolution employing the synchrotron radiation (SR), i.e., the threshold photoelectron source [4]. In the present project, we have measured total cross sections of electron scattering from CO_2 below 10 eV.

2 Experiment

The experiment has been carried out at the beamline 20A of the Photon Factory, KEK. Present experiment utilizes the penetrating field technique together with the threshold photoionizaion of atoms by the synchrotron radiation. 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 are detected by the channel electron multiplier. The counting rates of the detected electrons in the presence and absence of target gas are converted to the total cross section for electron scattering according to the attenuation law.

3 Results and Discussion

Total cross sections for electron scattering from CO_2 at electron energies down to about 150 meV are shown in Fig. 1. A reasonable agreement was obtained between present cross-section values and the previous results down to around 1 eV. In the present measurement, the oscillatory structure at the $^2\Pi_u$ shape resonance region was successfully observed on the total cross-section curve, which was turned out to be very weak. At very low energy region below 200 meV, the present results agree well with the results obtained by Field et al. [2], which shows slightly larger cross-section values from others.

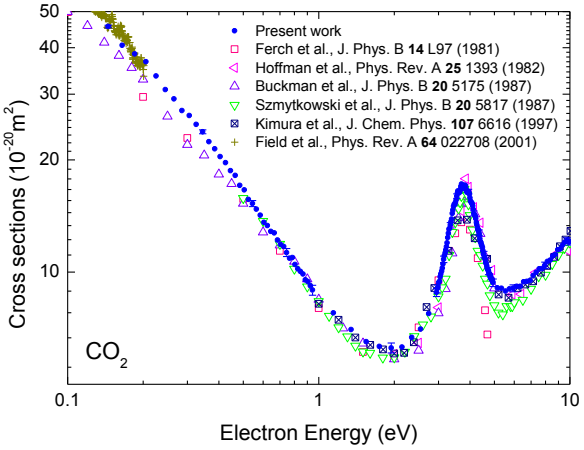

Fig. 1 Total cross section of electron scattering from CO_2.

References

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