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# High-resolution measurements of total cross section for low-energy and very-low-energy electron scattering from $CH_4$

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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 the virtual state, appear in the scattering cross section curves. Investigations of scattering cross sections are especially interesting 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.

Methane is one of the simplest organic molecules and its accurate total electron scattering cross section has been required in many fields. Therefore, several experimental work on measurements of total cross section for electron scattering from $CH_4$ have been reported as shown in the recent compilation [2]. However, the low-energy limit of the total cross sections, where the accurate vales have measured were about 100 meV due to the difficulties in producing the electron beam below this energy.

Recently, we have measured total cross section for electron scattering from $CH_4$ molecule, in a wide energy range including the very-low energy region below 100 meV. A unique experimental technique to measure absolute total cross sections for electron scattering from atoms and molecules at very-low energies, 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] were employed. 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.

## 2 Experiment

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. In the present measurements, the gas cell of the 45 mm length has been employed in order to obtain precise cross section values [3]. 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 section for electron scattering from $CH_4$ in the energy region from 10 meV to 10 eV were obtained. Present cross section agrees well with the known cross section values in the energy region where experimental values have been reported including the energy region of the Ramseur minimum. Below 100 meV, the obtained total cross section curve showed increasing feature with decreasing the electron energy toward the lowest energy and reached to $15 \times 10^{-20}$ $m^2$. Present high-resolution measurement also reviled small structures in the total cross-section curve, which are due to the threshold effect of the vibrational excitation of $CH_4$.

## References

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