BL-20A/2018G516

High-resolution measurements of cross section for low-energy and very-low-energy electron scattering from NH_3

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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.

Beam experiments with hot-filament electron sources have provided accurate cross-sections in a wide energy region. However, experiments in the collision energy region below a hundred meV have been limited, due to the difficulty for producing an electron beam at this low-energy region.

Ammonia (NH_3) is one of the simplest polyatomic molecules and its accurate electron scattering cross section has been required in many fields. Therefore, several experimental work on measurements of cross section for electron scattering from NH_3 have been reported as shown in the recent compilation [1]. For the total cross section, however, experimentally reported cross sections differ from each other below 10 eV. Thus, accurate measurements of total cross section at low energy region are highly demanded.

Recently, we have measured total cross section for electron scattering from diatomic molecules such as N_2 and O_2, in a wide energy range including the very-low energy region below 100 meV [2,3]. 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 [4] 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.

In the present project, cross sections for electron scattering from NH_3 were measured in the energy range below 10 eV, especially for the energy region, where accurate cross sections were not known.

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. 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

Present measurement shows that total cross section of NH_3 are much larger than previously reported values measured using the conventional technique. Cross section below 3 eV, the obtained total cross section curve showed increasing feature with decreasing the electron energy toward the lowest energy and reaches to 1000×10^{-20} m^2 which is a huge value compared to the size of the molecule.

References

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