BL-20A/2022G529

Influence of the forward scattered electrons in the attenuation transmission method in electron-molecule scattering experiments

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1 Introduction

Present group has developed 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]. The cross-section data concerning electron-atom or -molecule scattering are important not only for the understanding of fundamental physics of the electron collisions but also for applications where electron driven processes take place, which include huge fields. Among the measurable quantities describing the electron scattering, the grand total cross section, which is the sum of the integral cross sections for all scattering channels, is the most experimentally reliable since it can be obtained without any normalization procedures. Therefore, accurate grand total cross sections for electron scattering from various atoms and molecules have been regarded as the standard values for the normalization of cross-section data for individual scattering processes and also the bench mark of theoretical models [2].

The standard experimental technique for the measurements of the grand total cross sections is the electron transmission method based on the Lambert-Beer's attenuation law. The method has been widely employed for numerous experimental works determining the electron scattering total cross sections. The electron transmission method, however, has a problem of omission of the forward scattered electrons due to incomplete discrimination against the electrons scattered at small angles with forward direction due to the finite angular resolution [1]. This problem becomes important for the cross-section measurements of electron scattering from polar molecules, since electron scattering is dominated by small scattering angles due to the long-range potential between electron and polar molecule. Therefore, almost all the experimental total cross sections for electrons scattering from polar molecules in the literature are criticized by theorists [3]. On the other hand, the demand for cross sections of electron collisions with polar molecules such as H_2O, NH_3 and so on, has been increasing.

The experimental technique of present group which utilizes SR has an advantage of high-stability of electron beam against the existence of the target gas compared to the conventional hot-filament electron sources [1]. This makes it possible to resolve the forward scattered electron problem accurately. Therefore, the influence of the forward scattered electrons in the transmission experiment utilizing the present threshold photoelectron source were studied in the present project.

2 Experiment

In the present project, in order to determine the influence of the forward scattered electrons in the transmission experiment utilizing the threshold photoelectron source, intensities of transmitted electrons under various experimental conditions have been measured.

The electron transmission measurements were carried out at the beamline 20A of the Photon Factory, employing the threshold photoelectron source utilizing the synchrotron radiation [1]. The electron beam produced by the threshold photoelectron source transmitted through the collision cell with several different conditions of electron lens system were analyzed by its intensities.

Simulations for electron trajectories of transmitted electrons have also been carried out. The trajectory of the electrons passing through the collision cell together with the electrons scattered at several positions inside the collision cell were calculated with the Charged Particle Optics computer program [4].

3 Results and Discussion

Comparison of the experimental and simulated electron intensities with several experimental conditions showed that strong position dependence for the detection efficiency of the electron detector exist. This position dependent detection efficiency results in a very strong angle discrimination of the forward scattered electron which may lead to a very small influence of the forward scattered electron, although the influence is not negligible. Further precise analysis on the influence of the forward scattered electron is continuing.

References

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