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Studies on forward scattering problem of electron transmission experiments employing the threshold photoelectron source

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1 Introduction

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. 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, can be determined with most reliability 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 the standard values for the normalization of cross-section data for individual scattering processes and also the bench mark of theoretical models [1].

The experimental technique regarded as the standard method 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 [2]. This problem rises up when the electron scattering is dominated by small scattering angles.

Electron collisions with polar molecules are known to be dominated by small scattering angles and hence almost all the experimental total cross sections for electrons scattering from polar molecules in the literature are criticized [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.

Recently, we have measured total cross section for electron scattering from NH_3, 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 instead of using the conventional hot-filament electron sources [2] were employed. The cross section has been determined by the electron transmission method where problems due to the forward scattered electrons may have influenced. As has been claimed [3], influence of the forward scattered electrons should be studied.

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. Simulations for electron trajectories of transmitted electrons have also been carried out.

2 Experiment

The electron transmission measurements were carried out at the beamline 20A of the Photon Factory, employing the threshold photoelectron source utilizing the synchrotron radiation [2]. 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. 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

From the comparison of the experimental and simulated electron intensities at several electron lens settings, unexpected strong position dependence for the detection efficiency of the electron detector was found. This position dependent detection efficiency may result in a very strong angle discrimination of the forward scattered electron. Therefore, present findings suggest that a new method to obtain correct cross sections of electron collision with polar molecules from the electron transmission experiment could be developed. Since correct cross sections for electron collision with polar molecules are significant in several basic and applied sciences, development of a new method may give an enlightening on the field.

References

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