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A study of threshold photoelectron source using undispersed synchrotron radiation for an intense very-low energy electron beam

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1 Introduction

Electron scattering from atoms and molecules at very low energy are expected to have unique quantum effects, since the de Broglie wave of the electron is extremely longer than the typical size of atoms and molecules. 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 [1].

Present group has developed a unique experimental technique to measure absolute grand total cross sections for electron scattering from atoms and molecules at such very low energy region [2]. The method makes use of threshold photoelectrons produced by the threshold photoionization of Ar atoms using monochromatized synchrotron radiation (SR) instead of using the conventional hot-filament electron sources. The technique has enabled us to measure grand total electron scattering cross sections for several atoms and molecules down to about 10 meV by the transmission method with extremely high energy resolution [3-7].

In addition to the grand total cross section, the angular differential cross section (DCS) is an important physical quantity which is the absolute square of the scattering amplitude of the wavefunction describing the scattering system. However, the DCS measurements in the very-low-energy region are scarce, up to now, due to technical difficulties. Therefore, we plan to perform very-low-energy DCS measurements using a synchrotron radiation (SR) threshold photoelectron source.

In order to measure DCS for electron scattering from atoms and molecules, one needs to detect electrons scattered from target atoms or molecules in the crossed beam arrangement. Since number densities of target atoms or molecules available in the ordinary experiment is not so large, a much intense incident electron beam compared to those employed in the transmission experiment for grand total cross section measurement is necessary for the DCS measurements. The intensity of the electron beam from threshold photoelectron source employed for grand total cross section measurement was about 1 - 10 fA. Therefore, new method for producing sufficiently intense electron beam of at least a pA order at very low energy examined in the present study.

2 Method

In the present study, undispersed SR from the VUV beamline BL-20A is employed instead of dispersed monochromatized SR in order to accomplish producing intense electron beam at very-low-energy. Only the threshold electrons produced in the photoionization region were drawn out by a very weak electric field and formed into the electron beam. Since there are much more electrons and ions in the photoionization region compared to the case of using the monochromatized SR, several difficulties still arise. However, electron of order of a pA have been obtained successfully up to now.

References

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