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Ultra-low-energy electron scattering cross sections for He measured employing the threshold photoelectron source

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1 Introduction

The scattering of low-energy electrons by atoms and molecules has been the subject of extensive experimental and theoretical investigations. The cross-section data concerning electron-atom or -molecule scattering are of great importance in understanding fundamental physics of the electron collisions and applications such as electron-driven processes in the Earth and planets' phenomena, radiation chemistry, gaseous discharges, plasmas, and so on. When the collision energy becomes very low such as less than 100 meV, the de Broglie wavelength of electrons becomes very much greater than the typical size of an atom or molecule. In this area so called "cold electron collisions" [1], the interaction tend to be governed by asymptotic long range potentials and the scattering of cold electron is a subject closely related to the field of cold atom collision.

Recently, we developed a new method for producing an electron beam at very low energy for a cold electron collision experiment employing the threshold photoelectron source [2]. The technique enables one to perform high energy resolution experiments at very low electron energies by employing the penetrating field technique together with the threshold photoionizaion of atoms by the synchrotron radiation. The total cross sections for electron scattering from Ar, Kr and Xe in the energy range from around 10 meV to 20 eV were obtained at an electron energy width of 10 -12 meV with the apparatus employing the threshold photoelectron source [2-4]. In the present study, we measured the total cross sections for electron scattering from helium in the very low electron energy range.

2 Experiment

The experiment has been carried out at the beamline 20A of the Photon Factory, KEK, in Japan. An overview of the experimental setup is shown in Fig. 1. The setup consists of an electron scattering apparatus with a photoelectron source, an Au mesh monitor, and a microchannel plate (MCP). The electron scattering apparatus consists of a photoionization cell, three electrostatic lens systems, a collision cell, and a channel electron multiplier. The monochromatized SR tuned just at the first ionization threshold of Ar (15.760 eV) was focused on the center of the photoionization cell, filled with argon atoms. The threshold photoelectrons produced are extracted by a weak electrostatic field formed by the penetrating field technique and formed into a beam. The electron beam from the threshold photoelectron source is focused on the collision cell filled with target gas. The electrons passing through the cell without any collision with the target are detected by a channel electron multiplier (CEM). The counting rates of the detected electrons in the presence and absence of target gas are converted to the total cross section for electron scattering according to the attenuation law.

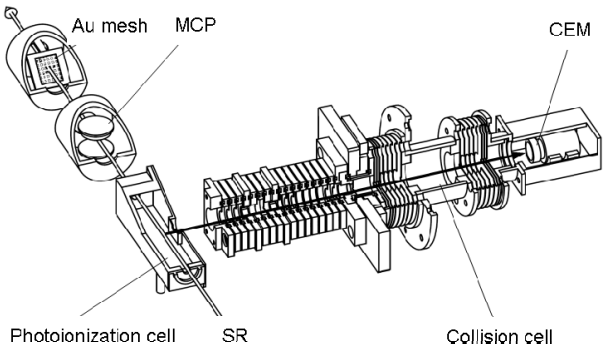

Fig. 1. Overview of the present experimental system.

3 Results and Discussion

Total cross sections for electron scattering from He at electron energies ranging from 7 meV to 20 eV were obtained using the threshold photoelectron source. The measured absolute values of the total cross sections agree with those obtained by other groups in the energy region above a few hundred meV where several experimental works have been reported. At very-low-energy region, where no experimental data exists, a reasonable agreement was obtained between our cross-section values and the theoretical prediction of Nesbet [5].

References

[1] D. Field *et al.*, Acc. Chem. Rev. **34**, 291 (2001)
[2] M. Kurokawa *et al.*, Phys. Rev. A **82**, 062707 (2010)
[2] M. Kurokawa *et al.*, Phys. Rev. A **84**, 062717 (2011)
[4] M. Kitajima *et al.*, Eur. Phys. J. D **66** 130 (2012)
[5] R. K. Nesbet, Phys. Rev. A **20**, 58 (1979)

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