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Ultra low energy electron – atom / molecule collision experiment by threshold photoelectron source

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Introduction

Collisions between electrons and atoms or molecules at very low-energy, where the de Broglie wavelength of an electron become much longer than the typical size of target particles, show unique quantum effects. Recently, experimental technique for measuring the total cross section of electron scattering from atoms and molecules at very low energy below a few hundred meV was developed by Field and co-workers [1]. In their technique, mono-energetic photoelectrons produced in the photo-ionization of atoms by monochromatized Synchrotron Radiation (SR) were used as an electron beam source, instead of a conventional hot filament. The photoelectrons were collected with a weak constant field applied across the photoionization region. One of the experimental difficulties employing a photoelectron sources is the trade-off problem between the resolution and the intensity of the electron beam. The electric field applied across the photoionization region degrades the energy resolution of the electron beam. Therefore, it is necessary to narrow the size of the photon beam used for photoionization that reduces the intensity of the photon beam for ionization.

Recently, we presented a new method for producing an electron beam at very low energy for cold electron collision experiment employing a threshold photoelectron source [2]. The method overcomes the trade-off problem between the resolution and the intensity of the electron beam by applying the combination of the threshold photoionization of atoms and the field penetrating technique [3].

Experimental

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.

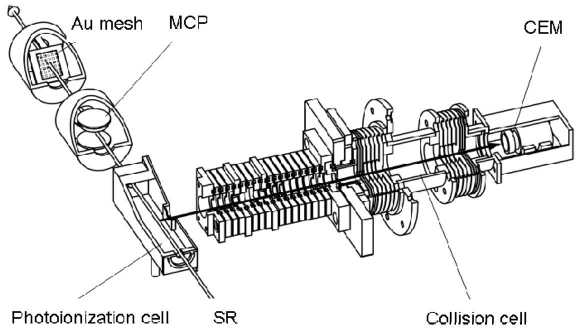

Fig. 1. Overview of the present experimental system. The system consists of an electron scattering apparatus with a photoionization cell, an MCP for the measurements of photoion yield spectra, and an Au mesh to monitor the flux of the monochromatized SR.

Results and discussion

Total cross sections for electron scattering from Ar, Kr, Xe at electron energies ranging from 10 meV to 20 eV were obtained using the threshold photoelectron source. Total cross electron scattering sections data for rare gas atoms at energies below thermal energy have been obtained for the first time. 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. On the other hand, the cross-section values reported by Gus'kov et al. [4] at the very-low-energy region turned out to be too large.

References

[1] D. Field et al., Acc. Chem. Rev. **34**, 291 (2001)
[2] M. Kurokawa et al., Phys. Rev. A **82**, 062707 (2010)
[3] S. Cvejanović and F. H. Read, J. Phys. B **7**, 1180 (1974)
[4] Yu. K. Gus'kov et al., Sov. Phys.-Tech. Phys. **23** 167 (1978)

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