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Cold electron collision of He and Ne

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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 have developed a new method for producing an electron beam at very low energy for a cold electron collision experiment employing the synchrotron radiation (SR), i.e., the threshold photoelectron source [2-4]. 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 [2-4]. In the present study, we measured the ultra-low energy total cross sections for electron scattering from He and Ne in the cold electron collision regime.

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, a photon flux monitor, and a photoion collector. 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 was focused on the center of the photoionization cell, filled with Ar 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. 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.

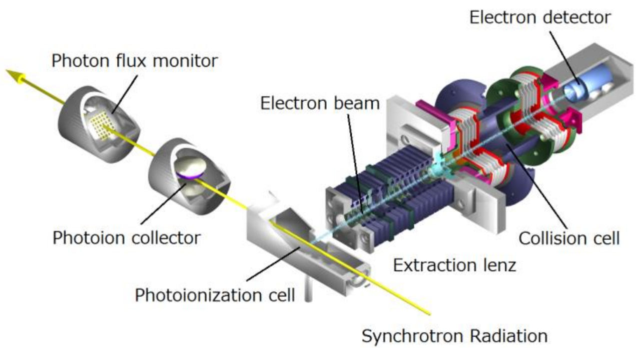

Fig. 1 Overview of the experimental apparatus.

3 Results and Discussion

Total cross sections for electron scattering from He and Ne at electron energies down to about 5 meV were obtained for the first time in the present study. A reasonable agreement was obtained between our cross-section values and the theoretical prediction Nesbet [5] and Saha [6] known as standard calculations. The good overall agreement between present experimental cross sections and the standard theoretical cross sections for He and Ne in the cold electron collision regime show that modern treatment of the scattering calculation of the few body systems represents the asymptotic behavior of the interactions in an adequate way.

References

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