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A new experimental technique for the cold electron collision utilizing Synchrotron Radiation

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Introduction

The scattering of very low energy electrons by atomic and molecular targets are expected to be strongly dominated by quantum effects involving phenomena such as quantum interference and revealing new and unexpected behavior. Recently, experimental technique for measuring the total cross section of the electron-molecule collisions at very low energy of below a few hundred meV (a few thousand kelvin) was developed by Filed *et al* [1]. Mono-energetic photoelectrons produced in the near-threshold photoionization of atoms by monochromatized Synchrotron Radiation (SR) were used as a source in their technique. This technique made it possible to produce very low energy electron beam, even below the energy of ~40 meV, which corresponds to the room temperature. Some parallel may be drawn between low-energy electron collisions and cold atom collisions: an electron with 10 meV energy, equivalent to a temperature of 115 K, has a wavelength of 122 Å, which may be associated with a Rb atom at 5×10^{-4} K.

In their setup, however, the energy width of the electron beam depends on the spot size and the band width of the monochromatized SR, which are trade-off between the photon flux of the excitation photon beam. Therefore, highly brilliant incident photon beam was necessary.

Here we present a new experimental setup for very low energy electron collision utilizing the SR with much highly efficiency.

The apparatus

Figure 1 shows the schematic of the experimental apparatus. The photon beam was provided by the synchrotron radiation source of the KEK-PF BL-20A which is equipped with a 3 m normal incidence monochromator and a 2400 lines/mm grating. Photon bandwidths as low as 0.1 Å could be obtained with 50 µm slits.

The key of the present technique is to use the penetration field to correct only the “0” energy photoelectrons, instead of applying the constant filed across the photoionization region. The technique was developed as a highly efficient spectroscopic tool known as threshold electron spectroscopy [2].

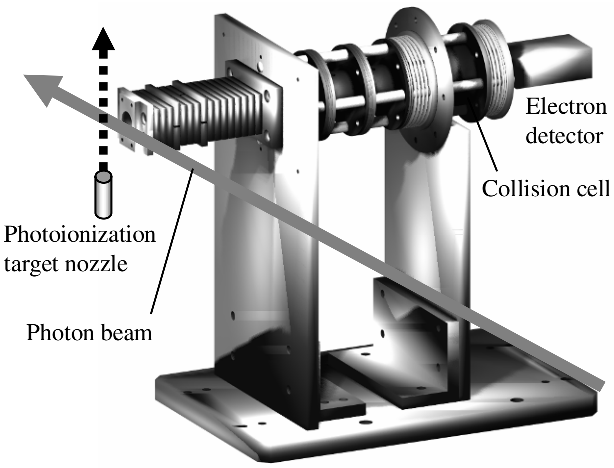

Figure 1. Schematic view of the apparatus. Electron lens at the left side corrects the photoelectrons and focus into the collision cell at the right side.

In the penetrating field technique a potential well is formed in the interaction region by field penetration from the potential of an extraction electrode through a screening electrode. The potential well collects only the very low energy electrons over large solid angles (~ 4π sr) and also focuses them into the lens system.

Under high resolution photon beam conditions, threshold peaks are asymmetric, characterized by a sharp rise and a more slow fall off in the high energy side. The slow fall off corresponds to energetic or ‘hot’ electrons that are emitted from the interaction region directly into the electron lens. The high energy tail can be reduced by appropriate potentials in the second stage of the optics.

Here, we measure the total electron scattering cross sections by the beam attenuation method at the collision cell shown in figure 1.

References

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