8. Electron Energy-loss Spectra of Helium and Xenon

Yasuhiro Sakai

1. Introduction

A new apparatus has been completed for the study of the inner-shell excitation and ionization processes in atoms and molecules using the technique of the inner-shell electron energy-loss spectroscopy(ISEELS). This apparatus is designed to be capable to obtain the 'electron impact' photo-absorption spectra by using the high energy(up to 10keV) incident electrons and observing the forward scattered(0 deg) electrons,i.e. under the conditions where the first Born approximation can be expected to be valid.[1)]

A lot of efforts during five years has been exerted by succesive members of our group since this projrct was proposed, and it is now at the final stage of the project. Nothing can give me greater pleasure than this completion. I expect it will be one of the most powerful apparatus all over this field of study.

In this paper, I would like to describe the construction and the performance of the new apparatus, and present some results of energy-loss spectra of the outer-shell excitation of helium and xenon,which have been obtained on the way of the tuning of the electron spectrometer.

2. Apparatus and Experimental Procedures

A schematic drawing of the apparatus used is shown in fig.1.

This apparatus has an energy-selector(monochromator) and two energy-analyzers. One of the analyzer is for scattered electrons, the other is for the ejected electrons. The former is applied to get the simulated photo-absorption spectra, while the latter is useful for the simulated photoelectron spectroscopy when it is used in coincidence with the signal of the scattered electron. The energy analyzer for scattered electrons is designed as the tandem-type analyzer, for it prevents electrons reflected on the inner surface of the analyzer from coming into the detector. Each analyzer and selector are so called Jost-type, for which the electric fields are very similar to the hemi-spherical energy analyzer.[2)]

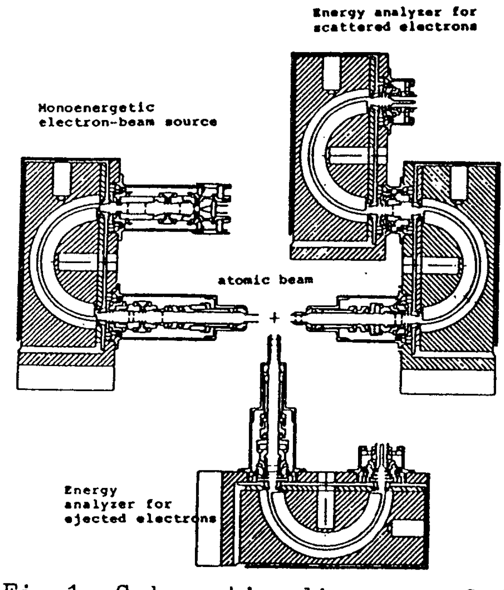

Fig.1. Schematic diagram of the experimental apparatus.

The earth's magnetic field is reduced by a mu-metal shielding within the vacuum chamber. The residual magnetic field in the collision region is less than 10mG.

Electrons emitted from a heated

tungsten filament are selected by energy selector ,and are formed into a parallel beam by the outlet lens system of the selector.

The typical intensity of incident electron beam,which was about 0.05nA was observed by Farady cup temporarily situated behind the inlet lens system of the analyzer for scattered electrons.

The electrons scattered by target atoms(He or Xe) enter the energy analyzer and are detected by an electronic multiplier after analyzed. Pulses from the multiplier are amplified and fed into a multichannel pulse-height analyzer,where the electron spectra are displayed.

There are two modes of the voltage scanning are usable to measure the energy-loss spectrum. One is the scanning of the voltage between the inner and outer electrodes of the analyzer, which corresponds to be the sweeping of energy of electrons which pass through the analyzer.The other is scanning of the deceleration voltage on the lens system before the analyzer, with a fixed voltage on the analyzer. This mode is called a constant resolution mode, because the energy of electrons which pass through the analyzer is fixed resulting a constant half width for a line spectrum.

The typical resolution, respected as the FWHM, is 160meV at high impact energy.

3.Result and Discussion

In fig.2 we present an example of the energy-loss spectrum of helium. The resolution is considered to be fine enough to determine the generalized oscillator strengh by the observation of forward scattered electrons. The intencity ratios,such as that of 2^1P to 2^1S, agree well with the existing data of the differential cross sections.

In fig.3 we present a typical energy-loss spectrum of xenon. Accurate intensity measurements have been carried out by Geiger[3] on the rare gases including Xe, at very high energy(32keV). However, these spectra at medium high energy is the first observations.

We will show the Xe-4d excitation spectrum in a forthcoming paper,before long.

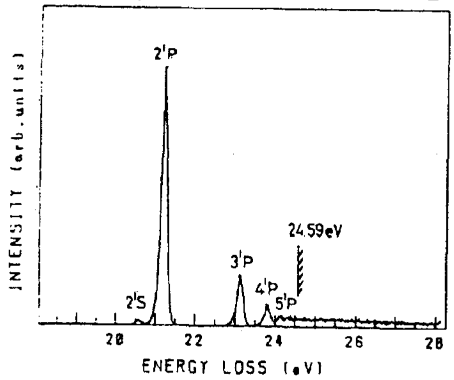

Fig.2. Energy-loss spectrum of He at energy of 300eV (0deg).

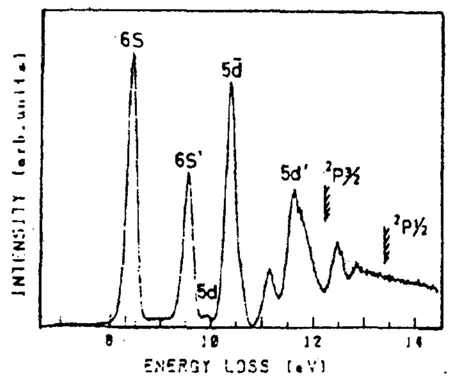

Fig.3. Energy-loss spectrum of Xe at energy of 1keV (0deg).

References

1) R.A.Bonham "Electron Spectroscopy"(Academic Press,1979),Vol.3,127.

2) K.Jost.K J.Phys. E:Sci.Instrum. 12 (1979) 1006.

3) J.Geiger Z.Physik A 282 (1977) 129.