Experimental Setup for the Study of Photoabsorption Processes of Multiply Charged Ions

Masaki OURA1,2), Takao M. KOJIMA2), Hitoshi YAMAOKA1,2), Yohko AWAYA2), Yoh ITOH3), Kiyoshi KAWATSURA4), Masahiro KIMURA5), Tetsuo KOIZUMI6) and Tsuguhisa SEKIOKA7)

1) JAERI-RIKEN SPring-8 Project Team, Kamigori, Ako-gun, Hyogo 678-12, Japan
2) The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-01, Japan
3) Physics Laboratory, Josai University, Sakado, Saitama 350-02, Japan
4) Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto 606, Japan
5) Department of Physics, Osaka University, Toyonaka, Osaka 560, Japan
6) Department of Physics, Rikkyo University, Toshima-ku, Tokyo 171, Japan
7) Faculty of Engineering, Himeji Institute of Technology, Himeji, Hyogo 671-22, Japan

1. Introduction

In order to study the photoabsorption (photoexcitation and photoionization) and subsequent processes to understand the characteristics of multiply charged ions, we have designed a new photon-ion merged-beam apparatus. Autoionizing states in photoexcited multiply charged ions will be surveyed by means of photoion-yield spectroscopy. The branching ratio of the excited primary ions into each product charge state will be deduced from the observed spectrum, and the dynamics of relaxation processes will be discussed by considering the branching from the excited states of multiply charged ions as a function of incident photon energy. Systematic studies along isoelectronic-, isonuclear-, and isoionic-sequences will provide information on the changes in the characteristics and their dynamics of multiply charged ions as the nuclear charge or ionicity is changed. The electronic structure of multiply charged ions will be also studied by comparing with theoretical results.

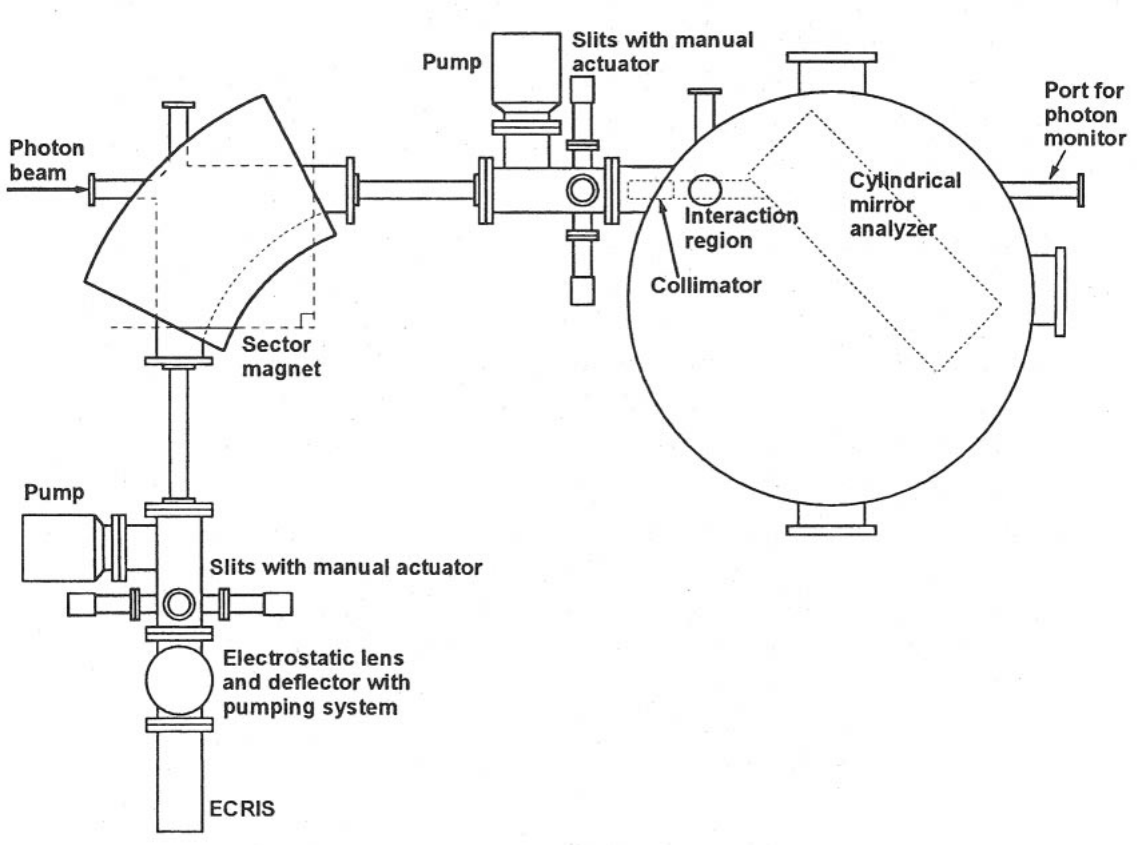

Fig.1 Schematic diagram of the photon-ion merged-beam apparatus

2. Outline of Experimental Setup

The schematic diagram of the apparatus is shown in Fig.1. Main components of the apparatus are a multiply charged ion source, a charge-selecting magnet, an interaction region and an analyzer for product ions.

Ions, produced in a compact electron cyclotron resonance ion source (ECRIS), are accelerated by an extraction voltage of 10 kV and are focused by an electrostatic lens system. The specific ions are selected by a double focus 90˚-sector magnet with an orbital radius of 270 mm. The monoenergetic ion beam is transported through a collimator consisting of a pair of 2-mmϕ orifices (100 mm apart), and then introduced into the interaction region whose length is 12 cm. The beam of Aq+ ions (A is the atomic symbol and q the charge state) will be collinearly merged with the monochromatic photon beam in the interaction region and the ions are photoexcited. The interaction region is biased to a certain voltage in order to distinguish the product ions of higher charge-state from background ions produced outside this region.

When an inner-shell electron of Aq+ ion is excited by photons, it emits electrons through Auger (or very often multiple Auger) processes and A(q+1)+, A(q+2)+, ..., A(q+n)+ ions are produced. Going out of the interaction region, these ions are re-accelerated by a voltage applied there. They have different kinetic energies according to their charge state (q+i). The resulting mixed ion beam then pass into an electrostatic analyzer of cylindrical mirror type [1], whose geometry is chosen to produce first and second order focusing of the primary beam. In the analyzer, the ion beam is subjected to a radial electrostatic field which separates the mixed ion beam into its constituents. Different ionic species are deflected to differing extents according to their kinetic energy and charge state. The charge distribution will be analyzed according to their spatial distribution on the pulse counting position sensitive detector. Two identical Faraday cups are arranged to intercept the primary beam at different positions corresponding to the different operating voltage of the analyzer.

Total photoabsorption cross section can be obtained from the summation of the A(q+i)+ ion yields. For the determination of the absolute photoabsorption cross sections, a degree of overlapping of beam densities (form factor) is an important factor, and is determined at three points along the beam axis by using a couple of beam scanning devices. The absolute flux of the monochromatic photon beam is measured by using a specific photon monitor designed for the soft x-ray region. The background pressure downstream from the interaction region should be maintained to be better than 5 x 10-11 Torr during the measurement in order to increase the signal to noise ratio since the main part of the noise
comes from charge-exchange processes of primary ions with the residual gas.

References

[1] H.Z.Sar-el, Rev. Sci. Instrum., 38, 1210 (1967).