§6. Excited Atomic Processes as Fundamental Researches for New Plasma Measurement

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To propose the resonant charge exchange spectroscopy (RCXS) as one of the new plasma measurement methods that obtain information on the ion in plasma, we researched the base of RCXS. Highly charged ions (HCIs) dominantly strips off the electron from the atom when HCIs collide with atoms in plasma. This process is called electron capture. Because this reaction works as a cooling mechanism in the fusion reactor, the research in the collision of HCIs and atoms has been studied before. The experiment concerning the collision of HCI and ground state atoms is conducted, but it is thought that atoms are usually excited in the fusion reactor. RCXS used collision of HCIs and excited atoms, because electron exchange happens resonating. We propose the collision experiment HCIs and the excited atom.

First, we selected rubidium (Rb) as a target atoms because it is easy to make Rb excited. We can make it excite by the laser of 780nm. Rb is heated, and Rb vapor is made a beam with the nozzle. Then, the density of the Rb is measured by the surface ionizer. Rb atoms excited from the ground state to up resonance state with a tunable diode laser. The light from laser at 780nm excites Rb from 5s to 5p. It is con rmed by observing the uorescence by photomultiplier tube (PMT).

By the way, HCIs are made from Naked Ion Collision Experiment (NICE) that is electron beam ion source (EBIS). The HCIs of the iodine was used in this experiment. HCIs are selected with the selector magnet and only the same charged ion we need is throughout. We had this HCIs collide with the excited Rb beam.

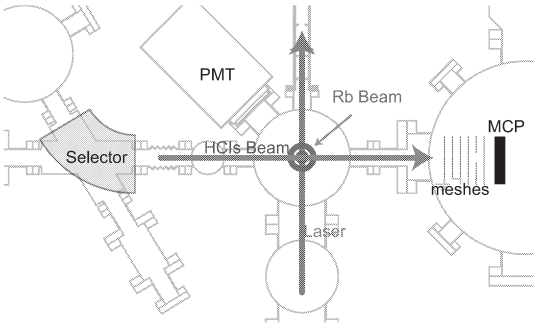

Figure 1: Illustration of the experimental apparatus

Figure 1 is illustration of the experimental apparatus. An actual experimental chamber almost keeps the vacuum level of 3×10^{-5}Pa with turbo molecular pump (TMP). It is possible to experiment while measuring the wavelength of the laser with the wavelength monitor. After it collides with Rb, HCIs strength are measured by Micro-Channel Plate (MCP). We installed the mesh forward of MCP, and applied retarded voltage (V_{q-i}) into this mesh. We can measured HCIs strength according to the initial charge of HCIs. The retarded voltage can be easily decided by

$$V_{q-i} = I_0 \times \frac{q}{q-i}, \tag{1}$$

where I_0 is energy of incident ion, q is the initial chage of the incident ion, $q - i$ is initial chage of the ion that wants to be obtained.

We can determine ones for I^{q+} - excited Rb collision by comparing our results, as follows.

$$\sigma_{ex} = \sigma_n \cdot \frac{AI_{en} - I_n}{I_n} \cdot B \tag{2}$$

where σ_{ex} and σ_n mean total chage exchange cross sections, and I_{ex} and I_n are intensities, the subsection ex is for the excited target and n is for the no-excited one respectively. A, B are coef cient. Because all target not excited, we have to estimate how much excited. Target Rb is Rb^{85} and excited one is $\sim$18 % according to statistical weight.

Figure 2 shows an actual experimental result. The more the temperature of Rb (density of Rb) increases, the more the value of I^{29+}/I^{30+} (probability that HCIs captures the electron from Rb) increases. And, the value of excited state, is larger than one of grand state. It corresponds to capture of electrons as for the excited target easily.

However, it has not arrived at the measurement of absolute electron capture cross section (σ_{total}) that is the purpose of the actual experiment. As the reason, it is given that the wavelength of the laser cannot be x ed, and there is not suf- cing the density of the beam of Rb. It is thought that the measurement of electron capture is possible if these problems can be solved. After Rb experiment, it experiments similarly by using cesium (Cs) instead of Rb.

In the near future, we will determine the charge exchange cross section not only for excited alkali metal but also for alkaline earch metal. In these materials, particularly Li date will be useful because that used in fusion reactor.

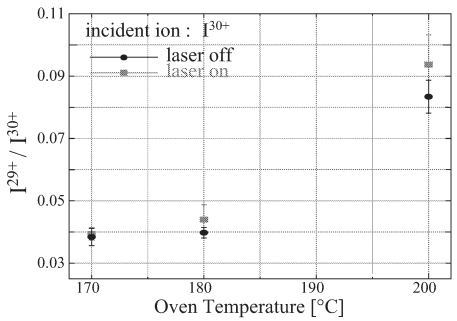

Figure 2: Ratio of I^{29+}/I^{+30+} for I^{+30} - Rb and excited Rb collision experiments

Reference

1) H.A.Sakaue et.al., Abstracts of Contributed Papers of 21st. ICPEAC **2**, 552 (1999).