## §7. Excited Atomic Processes as Fundamental Researches for New Plasma Diagnostic

Iiyama, K., Matsuda, W., Sakai, Y., Jin, W.G., Takagi, S. (Dept. of Phys. Toho Univ.),
Sakaue, H.A., Yamada, I.

The charge exchange spectroscopy (CXS) is widely used for a plasma diagnosis. Since collisions between highly charged ions (HCIs) and neutral species are dominant processes in charge exchange mechanism, we had carried out the HCI collision experiments with some atoms and molecules.[1) In this work, we used the excited atoms as a target. When target species are excited, it is well known that charge exchange cross sections are resonantly increased under the classical overbarrier model. Using this mechanism, we can discuss the probability of the resonant charge exchange spectroscopy (RCXS). In order to propose the RCXS as a new method for a plasma diagnosis, we have carried out this study. On the other hand, since neutral atoms are usually excited in the fusion reactor, it is important for understanding the cooling mechanisms to measure the cross sections for the excited atomic processes like a charge exchange process.

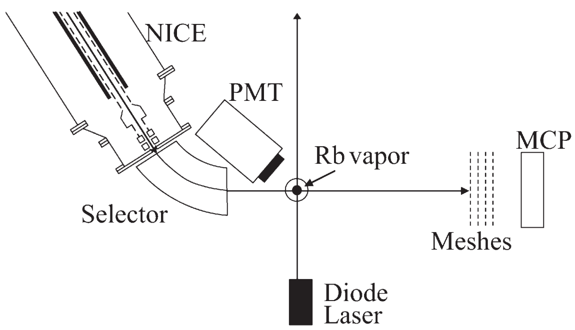


Figure 1: The experimental apparatus

The present experiments have been carried out as a series of a Naked Ion Collision Experiment (NICE) project in NIFS. The used apparatus which is based on the electron beam ion source (cryo-NICE) is shown in fig.1. The produced HCIs collide with the excited target beam after the charge selection. The iodine ions were used as the projectile. For the target we chose rubidium (Rb) atoms because it is easy to generate the atomic beam and excite to the resonant level. Rb atoms are excited with the diode laser from ground state to excited one after the Rb beam was generated through a thermal oven. The light from laser at the center wavelength 780 nm was delivered to the collision region, and operated on the 5s → 5p transition. The Rb target density was estimated with a surface ionizer and the excitation was confirmed with the photo -multiplier tube (PMT) combined with a band-pass filter. When the fluorescence light from the excited Rb was saturated, the $50\%$ Rb atoms were excited in the beam. Both the charge exchange ions and no-exchange ions are detected with micro-channel plate (MCP) after passing through the retarding meshes. We can select the charge of detect ions by applying the retarding voltage into the meshes and obtain the HCI intensity according to the initial charge of HCIs. The related voltage is easily decided by,

$$V_{q-i} = E_0 \times \frac{q}{q-i}, \qquad (1)$$

where $E_0$ is the energy of incident ions, $q$ is the initial charge, $i$ is the exchange charge.

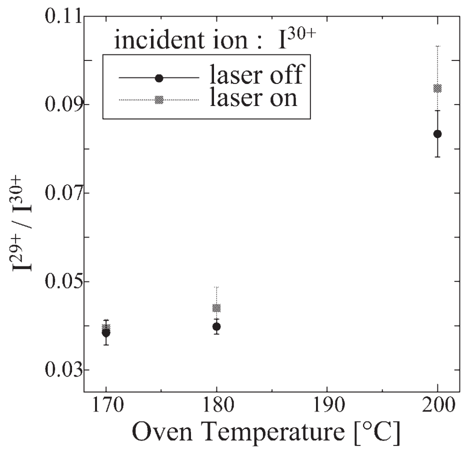


Figure 2: Ratio of $I^{29+}/I^{30+}$ for $I^{+30}$ - Rb and excited Rb collision experiments.

In this work, we succeeded in observing the signal from the HCI collision with the excited Rb. Figure 2 shows the experimental results of the ratio of $I^{29+}/I^{30+}$ for $I^{30+}$ - Rb and excited Rb collisions. As the oven temperature rises the ratio of $I^{29+}/I^{30+}$ increases. This fact indicates that the target density depends on the oven temperature and the density is still low enough in the collision region for single collision. The character labeled "laser on" is for the ratio from the target including excited Rb. Thus although the absolute charge exchange cross sections for the excited Rb target have not determined yet, we confirmed the growth in charge exchange cross section for excited target. Using the absolute value of the charge exchange cross sections for $I^{q+}$-Rb collision that had been already measured[2), we can determine ones for $I^{q+}$-excited Rb collision by comparing our results, as follows.

$$\sigma_{ex} = \sigma_n \times \frac{2I_{ex} - I_n}{I_n}, \qquad (2)$$

where $\sigma_{ex}$ and $\sigma_n$ mean total charge exchange cross sections, and $I_{ex}$ and $I_n$ are signal intensities, the subscript $ex$ is for the excited target and $n$ is for the no-excited one, respectively. In the near future, we will not only determine the charge exchange cross sections for excited Rb but also for excited cesium and potassium.

**References**

1) M.Kimura et.al., J.Phys.B **28**, L643 (1995).
2) H.A.Sakaue et.al., Abstracts of Contributed Papers of 21st. ICPEAC **2**, 552 (1999).