Atomic and Molecular Data provided by Multiply Charged Ion Beam Collision Experiments at Low Energies

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Fundamental atomic and molecular data consist of spectroscopic data and dynamical data. Ion beam experiments have been used for the measurements of both kinds of data. Historically, beam-foil spectroscopy has provided atomic spectroscopic data including the radiative transition rates of for highly charged ions. In the experiments with gaseous targets, various kinds of elastic, inelastic, and reactive processes have been measured in collisions of ions.

In Tokyo Metropolitan University, a 14.25 GHz electron cyclotron resonance ion source (ECRIS) have been used to produce various multiply charged ions, namely, C^{q+} (q = 4-6), O^{q+} (q = 6-8), Fe^{q+} (q = 7-16), Sn^{q+} (q = 3-21), and Xe^{q+} (q = 7-23), and photo-emission spectra following charge transfer collisions with neutral gases have been observed in visible-ultraviolet [1], extremely ultra-violet (EUV) [2], and soft X-ray regions [3]. Charge exchange spectroscopy is very useful technique to obtain transition wavelengths of multiply charged ions and measure the emission cross sections.

As tungsten will be used as a component of plasma-facing devices in the ITER, a number of spectroscopic studies have been reported in this decade. Recently, we observed emission spectra from tantalum ions. Because tungsten has five isotopes of the mass numbers from 180 to 186, it is not suitable for the ion beam experiment with the charge state separation. On the other hand, tantalum has 181-Ta with the natural abundance of 99.988%, and it is suitable for the charge-selected ion beam experiments. Because the atomic number of tungsten is 74 and that of tantalum is 73, the electronic structure and spectroscopic properties might be similar for isoelectronic ions. Therefore, we have decided to use tantalum ions instead of tungsten ions, and the measurements of EUV spectra of multiply tantalum ions after charge transfer collisions are now in progress.

It is well known that remarkable amounts of metastable helium-like ions, $1s2s\ ^3S_1$, are produced in the ECRIS. Therefore, in the cross section measurements of helium-like ions, we should consider the contribution of metastable state. According to the classical over the barrier model, we suppose that the ground and metastable states of ions have similar capture cross sections in collisions with the same target. However, in the collisions of helium-like C, N, and O ions with neutral gases, we have observed soft-X ray emissions corresponding to $1s^22s$ - $1s2snl$ transitions. As the $1s2snl$ state should be autoionized, the capture cross section will be reduced by this effect. Therefore, for the accurate cross section measurements, we should consider the fraction of metastable states and the detail mechanism in the collisions of metastable ions with neutrals.

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