§5. Study on Various Atomic Processes of Impurity Highly Charged Ions by Versatile Ion Sources

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Atomic processes of impurity highly charged heavy ions in magnetically confined fusion plasmas have been issues of study concerning plasma radiation cooling, precise measurements of ion temperature and local magnetic field at core plasmas, secondary-particle emission in plasma-wall interaction, and so on. Our research aims at collecting and evaluating relevant atomic data of highly-charged ions of heavy elements. To this end, we promote a cooperative research with a high performance electron beam ion trap (Tokyo-EBIT) at UEC and an electron beam ion source (NICE) at NIFS. In this fiscal year, dielectronic recombination (DR) processes have been studied for Fe ions, whose radiation power at the core plasmas of LHD have been issues of study.

At the Tokyo-EBIT, x-ray radiation from dielectronic recombination (DR) for H-like Fe was measured through high resolution x-ray spectroscopy. H-like Fe was produced by keeping the electron energy at 14 keV (refereed to as the 'cooking energy') for 300 ms. The electron energy was then quickly dropped to 5.5 keV and scanned with a triangular waveform between 5.5 keV and 4.3 keV, which cover the KLL resonant region. The scan was done only once for 0.5 ms, and then quickly returned to the cooking energy again. The electron energy was repeatedly switched between the cooking energy (7 ms) and the probe energy ramp (0.5 ms). Both the wavelength of emitted x-rays and the electron energy when the x-ray was detected were recorded. Figure 1 shows the x-ray spectrum obtained by integrating the x-ray counts obtained for the electron energy range which corresponds to the KLL resonance energy of the H-like Fe:

$$e + 1s \rightarrow 2l2l' \rightarrow 1s2l + h\nu \rightarrow 1s^2 + h\nu + h\nu' \quad .$$

The manifold around 1.79Å corresponds to the "first" photon ($2l2l' \rightarrow 1s2l + h\nu$), while that around 1.86Å the "second" photon, ($1s2l \rightarrow 1s^2 + h\nu'$). We are planning to measure the polarization of the emitted photons using the double crystal technique. The polarization measurements will enable us to obtain the absolute resonant strength for each resonant line. The spectrum obtained at the cooking energy contains Ly-α lines directly excited by the electron impact. By taking the time-averaged intensity ratio of the DR satellite lines to the Ly-α lines and normalizing it to the excitation cross section of 2p states, the DR cross section for each line can be experimentally obtained.

On the other hand at NIFS, in order to produce Fe ions with NICE, various injection methods have been tested. Since injection from an effusion cell, which is used for injection into the Tokyo-EBIT, can not be used for NICE because it does not have any accessible window, injection from metallic compounds such as $Fe(C_5H_5)_2$ and $Fe(CO)_5$ has been tested.

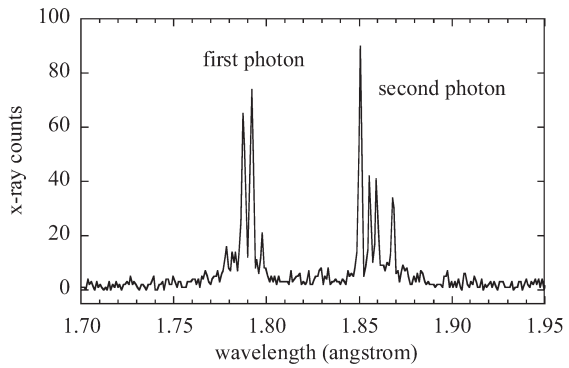

Fig. 1. DR satellite spectrum for H-like Fe