§19. Impurity Injection by Laser Blow-off

Funaba, H., Sato, K.,
LHD Experimental Group

The laser blow-off technique is one of the methods of impurity injection into plasmas. In the 11th cycle of the experimental campaign of LHD, aluminum (Al) and tungsten (W) were injected by the laser blow-off. The target chamber is installed at the 2.5L port of LHD, and it can include three impurity targets which are the glass plates with thin foils of evaporated metals. The thickness of these thin foils is almost $3 \sim 5\,\mu$m. The targets are irradiated by the laser pulse from the Nd:YAG laser which has 1.2 J of the pulse energy at the laser head position.

Figure 1 shows a VUV spectrum which is observed in one of the Al injected plasmas. The timing of the laser pulse is 1.0 s. Two lines of Al XI were observed at 550.03 and 568.15 Å(2s-2p). The VUV spectrometer (SOXMOS) locates at 7O port, and the exposure time of the spectrometer was 100 ms. The ablated number of impurity atoms is almost 6×10^{18}, however the number of injected atoms into the plasma may a few percents of this number.

Figure 2 shows the time development of these two lines. The values of each line intensity are integrated in the wavelength range. Since the signals of these two lines appeared until more than 5 frames after the injection timing, the density of Al XI remained in the plasma for more than 0.5 s.

The observed intensity of Al XI lines are compared with the calculated intensity by the impurity transport code. An example of calculation results by MIST [1] is shown in Figure 3. In this figure, the timing of the impurity injection is 0.0 s. For this calculation, a constant diffusivity of the impurity, $D = 2.5\,\mathrm{m}^2$/s is assumed in the whole plasma region, and no convection velocity, v, is assumed. The calculated emissivities of the two lines are integrated in the spatial range of the line of sight of the spectrometer. This result is shown by the solid and dotted curves in Fig. 3. The symbols of ● and ◇ are the averaged values of the calculation results during the temporal resolution of the spectrometer. Therefore, the values of these symbols should be compared with the experimental results which are shown in Fig. 2. The calculated intensity at $t = 0.1$ s is much smaller than that at $t = 0.0$ s, while the intensity at $t = 1.1$ s in Fig. 2 is more than 40% of that at $t = 1.0$ s in Fig. 2. It is considered from this difference that the assumed D and v are not suitable for this plasma, especially inward v at the peripheral region may be needed to reproduce the experimental results.

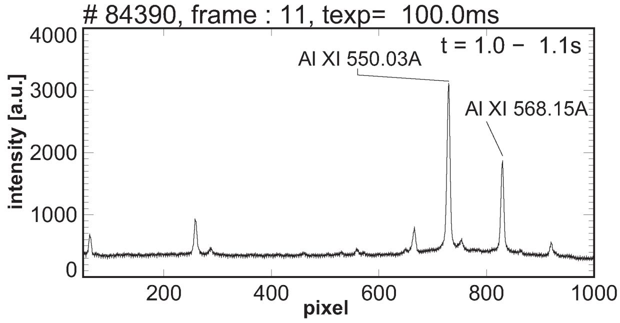

Fig. 1. A VUV spectrum of one of aluminum injected plasmas.

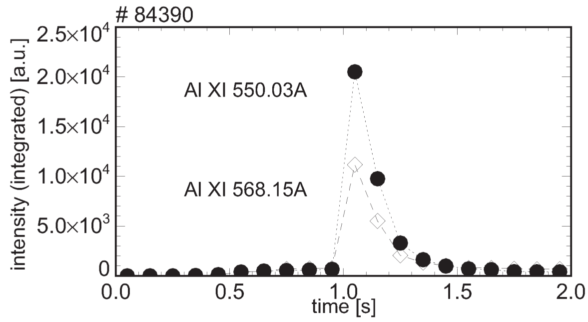

Fig. 2. Time development of the two lines of Al XI.
● 550.03 Å(2s-2p),
◇ 568.15 Å(2s-2p).

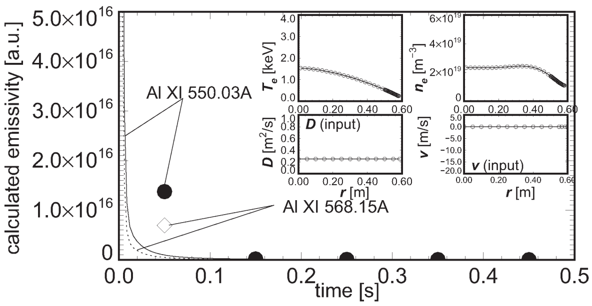

Fig. 3. An example of calculation results of Al XI lines by MIST.
Solid curve and ● : 550.03 Å,
dashed curve and ◇ : 568.15 Å.

[1] R.A.Hulse, Nucl.Tech./Fusion **3**(1983)259.