§75. Spectroscopic Studies on Transport of Heavy Impurities

Nakano, T. (Japan Atomic Energy Agency),
Suzuki, C., Murakami, I.

Tungsten is one of the candidates for plasma facing components in future fusion devices such as ITER. However, because of its high Z number, tungsten is not fully ionized in the plasma, and the intense line-radiation dissipates plasma energy, leading to plasma collapses. Hence it is of significance to avoid accumulation of tungsten ions in the core plasma. For this purpose, it is required to establish a method to determine the tungsten ion density quantitatively. Spectroscopic method has been widely used, and in the present work tungsten spectrum measured in LHD is analyzed with an atomic code.

Tungsten accumulation was observed in a plasma with NB heating of 2 units at a line-averaged electron density of 4 x 10^{19} m^{-3}, while tungsten accumulation was NOT observed in a plasma with NB heating of 3 units at 2 x 10^{19} m^{-3}. In the tungsten accumulated plasma, radiative power was kept high for long after the tungsten Tespel injection. Figure 1 shows a spectrum recorded in this discharge with a vacuum ultra violet spectrometer, called SOXMOS. Sharp peaks between 4.7 nm and 5.0 nm and a broad peak around 5.7 nm appeared after the tungsten Tespel injection. Thus, it is interpreted that these peaks are from highly ionized tungsten ions.

In order to identify these peaks, calculation with an atomic code, called FAC [1], was performed. Figure 2 shows the spectrum calculated with FAC. In the calculation, for instance, for W^{27+} (Ag-like tungsten ion), the following electron configurations besides the ground state ($4d^{10}$ 4f) were considered:

$4d^9 + 4f^2$

$4d^{10}$ + 5s, 5p, 5d, 5f, 5g, 6s

$4d^9$ 4f + 5s, 5p

Further, a collisional-radiative model, which included the processes of (de-) excitation between these levels and radiative transition from these levels, was used to calculate the spectrum. The spectra shown in Fig. 2 was calculated at an electron temperature of 0.5 keV and an electron density of 4 x 10^{19} m^{-3}, which were measured with the Thomson scattering system. As shown in Fig. 2, many spectral lines due to transitions between 4p - 4d and 4d - 4f are distributed between 4.5 nm and 5.5 nm. These spectra were summed up and the synthesized spectrum was obtained. In Fig. 1, comparison of the measured and the synthesized spectrum is shown. The wavelengths of the peaks of the synthesized spectrum between 4.7 nm and 5.0 nm are in rough agreement with those of the measured spectrum. However, the broad peak around 5.7 nm and the overall intensity ratio of the sharp peaks and the broad peak are not reproduced.

This comparison indicates that disagreement for the broad peak around 5.7 nm is significant. One of the reasons of this disagreement is limitation of the present version of the FAC code; the FAC code cannot calculate the spectrum of tungsten ions with a charge state lower than 25. Around 5.7 nm, quasi-continuum spectrum is seen for the spectrum calculated for W^{25+} and similar spectrum is expected for tungsten ions with a charge state lower than 26 because these tungsten ions have similar electron configurations. Hence it is probable that a spectrum synthesized for tungsten ions with these charge states reproduces the measured spectrum. Modification of the FAC code, which enables to calculate spectra for those tungsten ions, might be necessary to obtain further agreement between the measured and the synthesized spectrum.

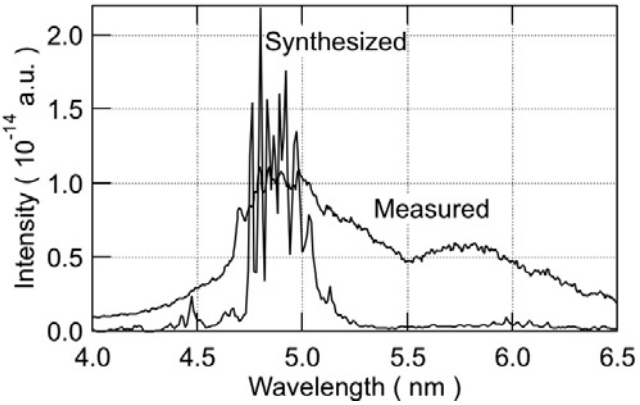

Fig. 1. Measured and synthesized spectrum.

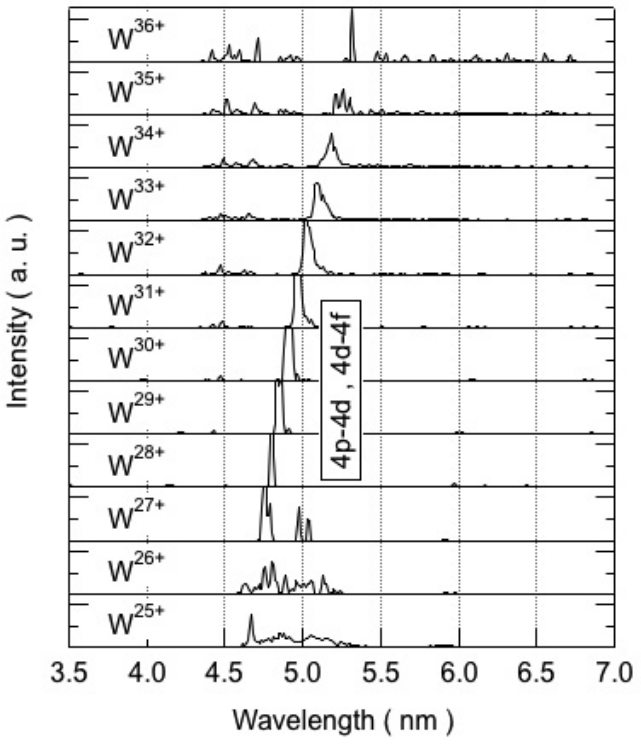

Fig. 2. Spectra calculated by the FAC code.

1) Gu, M. F. et al.,: Astrophys. J. **582** (2003) 1241.