§17. Observation of EUV Spectra from Highly Charged Tungsten Ions in LHD

Suzuki, C., Kato, T., Sakaue, H.A., Kato, D., Murakami, I., Sato, K., Tamura, N., Sudo, S., Yamamoto, N. (Osaka Univ.), O'Sullivan, G. (Univ. College Dublin)

Recently the needs for experimental databases of radiation from highly charged tungsten (W) ions have been increasing because tungsten is a candidate material for a plasma facing component in the forthcoming ITER project. Though several works on extreme ultraviolet (EUV) spectra from highly charged tungsten ions in torus plasmas have been reported so far,[1)] the experimental database is still insufficient especially for lower charged states. In this context, we have measured EUV spectra from highly charged tungsten ions in the LHD by a grazing incidence spectrometer.

A small amount of tungsten was introduced into a hydrogen plasma by a tracer encapsulated solid pellet (TESPEL). The EUV spectra were monitored by a grazing incidence spectrometer SOXMOS[2)] whose groove density and focal length are 600 mm^{-1} and 1 m, respectively. The overall spectral resolution is about 0.01 nm. The absolute wavelength was calibrated by observing neon, carbon, and boron ion lines with an accuracy of ±0.01 nm over the whole spectral region. An example of the time evolution of a discharge with a tungsten pellet injection is shown in Fig. 1, where neutral beam injection (NBI) heating power (P_{NBI}), stored energy (W_p), line averaged electron density ($\langle n_e \rangle$) and total radiated power (P_{rad}) are drawn. Though the total radiated power rapidly increased at the time of the pellet injection at 2.3 s, the plasma was sustained afterward consequently. According to a Thomson scattering diagnostic, the central electron temperature gradually decreased from 3.0 keV after the pellet injection, but was kept above 0.8 keV until the end of the discharge.

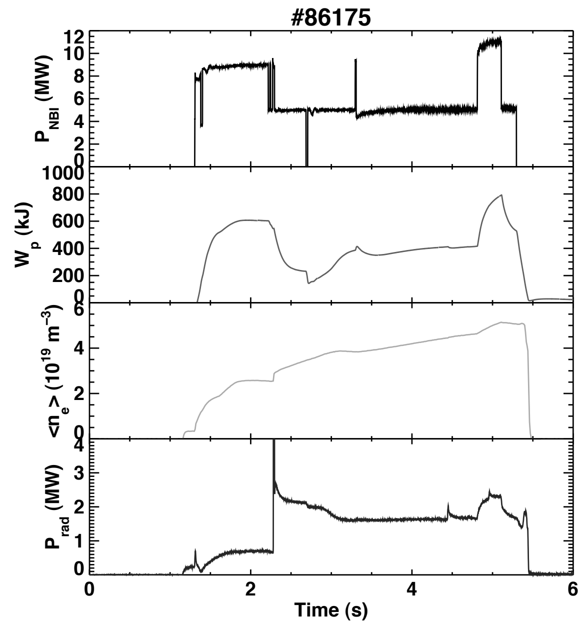

Fig. 1: Time sequences of NBI heating power (P_{NBI}), stored energy (W_p), line averaged electron density ($\langle n_e \rangle$) and total radiation power (P_{rad}) in a LHD discharge with a tungsten pellet injection at 2.3 s.

The measured EUV spectra around 5 nm for different timings before and after the pellet injection in this discharge are drawn in Fig. 2. A broad spectral feature arising from unresolved transition array (UTA) of $4p^6 4d^m$–$4p^5 4d^{m+1}$ + $4p^6 4d^{m-1} 4f$ transitions of open $4d$ subshell ions are observed around 5.0 nm. The strong line group between 4.9 and 5.1 nm can be attributed to the previously identified $4d$-$4f$ resonance lines of Ag- to Rh-like tungsten ions[1)]. Moreover, smaller broad peak structure appearing around 6 nm region is quite noticeable.

To further investigate the contribution of various transitions to the structure, detailed calculations were performed with the Cowan code. The result suggests the contribution of open $4f$ subshell tungsten ions to the smaller broad peak observed around 6 nm. However, the calculated gf values for $4f$-$5d$ transitions are considerably smaller than those of $4d$-$4f$ transitions, which is not in agreement with the observation. Hence the further investigation is necessary for the assignment of this spectral feature.

1) Pütterich, T. et al.: Plasma Phys. Contrl. Fusion **50** (2008) 085016.

2) Schwob, J. L., Wouters, A. W., and Suckewer, S.: Rev. Sci. Instrum. **58** (1987) 1601.

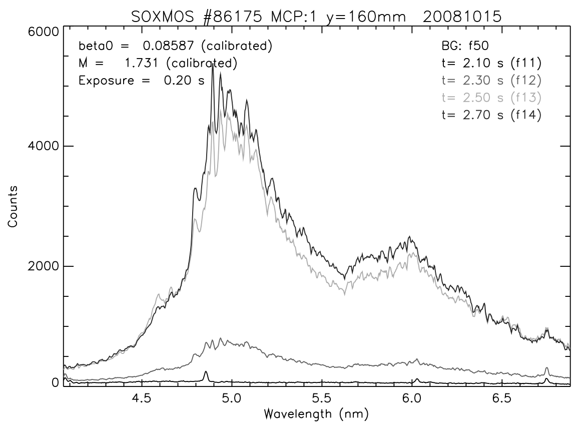

Fig. 2: The EUV spectra observed in the discharge shown in Fig. 1 for different timings before and after the tungsten pellet injection.