§76. Analysis of EUV Spectra in the 20 nm Region from Tungsten Ions Observed in LHD

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Spectral emissions from highly charged tungsten ions have recently drawn considerable attention because tungsten will be used as a plasma facing component in the forthcoming International Thermonuclear Experimental Reactor (ITER). A number of experimental works on strong quasicontinuum emission in the 4–7 nm range have been reported so far in fusion device plasmas[1, 2], which can be attributed to $n = 4$–4 transitions from ions with 4d and 4p electrons in their outermost subshells. On the other hand, information on lower ion stages with 4f, 5s and 5p electrons in their outermost subshells is still insufficient even though these ions will be important at the edge region of ITER plasmas.

In this study we have measured extreme ultraviolet (EUV) spectra from tungsten ions in the 20 nm region from plasmas produced in LHD. Following an injection of a tungsten pellet into a hydrogen plasma, the spectra were recorded by a 2 m Schwob Fraenkel grazing incidence spectrometer[3]. Figure 1 shows a low resolution spectrum around 20 nm in a plasma with an injection of a tungsten pellet ablated in the low temperature edge region below 1 keV. As shown, the spectral feature just after the pellet injection shows quasicontinuum structure which has a peak around 18 nm and decreased intensity towards longer wavelength. The present data are comparable to the result in ASDEX Upgrade tokamak[1] where a broader structure in the 15–25 nm region was observed just after a laser ablation of tungsten at a plasma temperature below 1.3 keV. However, emissivity in longer wavelength side (22–26 nm) is more pronounced in LHD.

Simultaneous measurements around 5 nm and 20 nm ranges show that the emission from Ag-like W^{27+} near 5 nm almost disappears when a quasicontinuum feature appears in the 20 nm range. This fact suggests that charge states lower than W^{27+} are expected to contribute largely to the emission around 20 nm under low temperature conditions.

In order to interpret and give an insight into this feature around 20 nm, we have carried out atomic structure calculations for tungsten ions with open 5p, 5s and 4f subshells (W^{7+}–W^{27+}) with the Hartree Fock with con guration interaction suite of codes written by Cowan[4]. Con gurations of even and odd parities are calculated separately and con guration interactions were considered if necessary. As an example, distributions of wavelengths and gA values for 5s–5p transitions of W XX and W XXV (even and odd parities) are shown in Fig. 2. The lines can be divided into two groups in wavelength due to the spin orbit splitting, and the stronger group in shorter wavelength side can contribute to the observed emission around 20 nm. These calculations suggest that the emission around 20 nm largely arises from $n = 5$–5 transitions in stages lower than W^{27+}.

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

2) Harte, C. S. et al.: J. Phys. B: At. Mol. Opt. Phys. **43** (2010) 205004.

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

4) R. D. Cowan, *The Theory of Atomic Structure and Spectra* (Berkeley, CA: University of California Press, 1991).

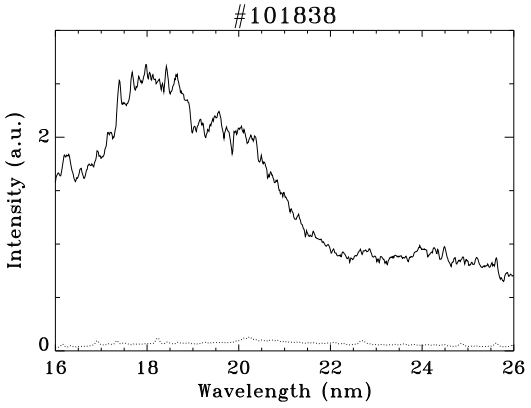

Fig. 1: Spectrum in the 20 nm region measured in the LHD plasma with a tungsten pellet injection.

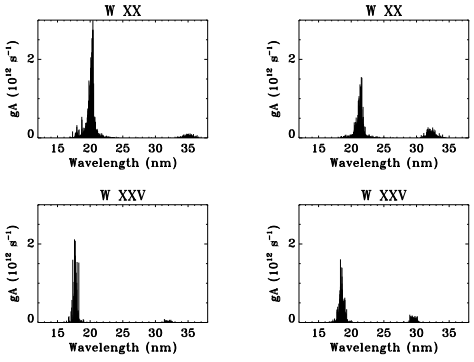

Fig. 2: Calculated distributions of wavelengths and gA values for $n = 5$–5 transitions of W XX and W XXV. Con gurations with even and odd parities are shown separately.