§9. EUV Spectrum of Highly Charged Tungsten Ions in CoBIT

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Tungsten is planned to use as material for the divertor plates in ITER because of higher sputtering threshold energy for light ion bombardment, the highest melting point among all the elements, and less tritium retention compared with carbon-based materials. However impurity tungsten enters the high-temperature plasma and is ionized to highly charged ions, and then highly charged ions emit very strong photons of EUV and/or X-ray. This emitted photon has very important information on plasma diagnostics; information on electron and ion temperature, electron density, impurity ion abundance and impurity transportation. Nevertheless, it is the present conditions that those emission spectra are very complicated and those spectral data are very poor. Therefor, we observed spectra of highly charged tungsten ions in the extreme ultra-violet (EUV) by using electron beam ion traps.

An electron beam ion trap is a useful device for the systematic spectroscopic studies of highly charged tungsten ions. We have constructed a compact electron beam ion trap, called CoBIT 1)-3), and observed extreme ultraviolet (EUV) spectra of highly charged tungsten ions. The electron energy dependence of spectra was investigated of electron energy from 540 to 1370*eV*. Previously unreported lines were presented in the EUV range, and some of them were identified by comparing the wavelengths with theoretical calculations. To identify the observed lines, we have calculated the spectra using a collisional-radiative (CR) model. From the comparison, the observed lines have been identified as 5f-4d, 5p-4d, 5g-4f transitions of $W^{20\text{-}32+}$, and 4f-4d transitions of $W^{27\text{-}30+}$.

We observed an unidentified emission lines which are expected from theoretical calculations from W^{26+} around 100Å in CoBIT. As electron energy of CoBIT is increased across the ionization energy (*Ip(25+)*=786.3eV) of W^{25+} from 770eV to 870eV, new emission lines appeared in this emission spectrum which is shown in fig.1. These emission lines are identified as emission lines from W^{26+} and W^{27+}. Strong peak was observed at 102Å and other emission lines were also observed at both ends of this strong peak. These lines are emission lines of W^{26+} 4f5s $\rightarrow$ 4f^2 by electron excitation. And these lines were observed at LHD plasma too. In the same way, we observed 5s-4f transition lines of W^{27+} around 90 Å. The two strong peaks were confirmed at CoBIT. These two lines were identified as the E3 transitions (5s $\rightarrow$ 4f, J=1/2 $\rightarrow$ J=5/2,7/2) by comparing with the CR-model. These CR-model spectra of LHD and CoBIT are shown in fig.2. However, these lines were not confirmed at LHD plasma. It became clear that these two emission lines have strong electron density dependence by comparing with experimental spectra and CR-model calculation spectrum.

In future, we will promote detailed studies for the spectroscopic diagnostics of plasma, such as electron energy dependence and electron density dependence of these tungsten highly charged ions.

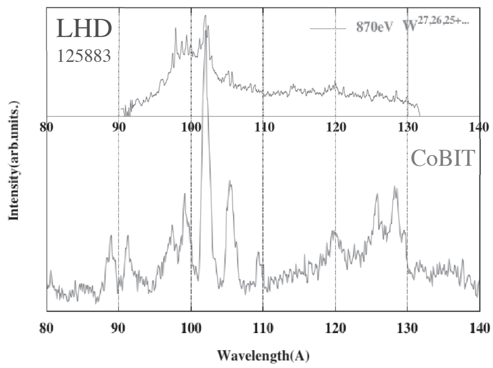

Fig.1 W^{q+} EUV spectra of LHD and CoBIT.

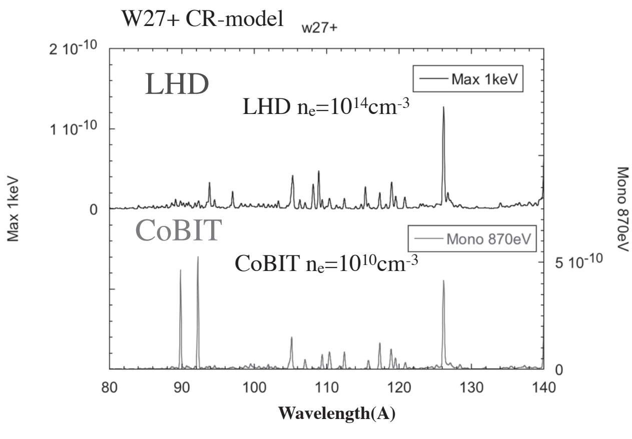

Fig.2 The CR-model calculation spectra of LHD and CoBIT.

1) Nakamura, N. *et al.*: *Rev. Sci. Inst*rum. **79** (2008) 063104
2)Sakaue, H. A. *et al.*: J. Phys.:Conf. Ser. **163** (2009) 012020
3)Sakaue, H. A. *et al.*: *AIP Conf. Proc.* (2012) 143891