§84. Observation of Visible Forbidden Lines from Highly Charged Heavy Ions at Large Helical Device

Kato, D., Goto, M., Morita, S., Sakaue, H.A., Murakami, I., Sudo, S., Suzuki, C., Tamura, N., Watanabe, H. (Chubu Univ.), Nakamura, N. (UEC)

Forbidden lines from highly charged tungsten (W: Z=74) ions have been observed in a visible range at Large Helical Device (LHD) for the first time. Since W is a prime candidate of plasma-facing-component materials in ITER, visible forbidden lines from impurity W ions are potentially useful for measurements of the ion distribution in peripheral and core plasmas and plasma diagnostics. Its intrinsically narrow line width is suitable for identification of ion species and measurement of Doppler-broadening which represents ion temperature. Doron et al. [1] investigated theoretically electron density dependence of magnetic-dipole (M1) lines of N-shell W ions in the visible and UV ranges, and suggested that intensity ratios of some line pairs would be useful for the density diagnostics of fusion plasmas. It is also noteworthy that, in the visible range, remote measurement by using fiber optics is feasible, which is required to suppress neutron damages on detection systems.

In the present work, emission lines induced by Tracer Encapsulated Solid Pellet (TESPEL) injection are simply deduced by subtracting from spectra measured before the injection, because time-resolved measurements were performed successively at every 250 ms. An M1 line of W^{26+} at 389.4 nm was clearly identified in the visible spectra observed after the TESPEL containing W was injected into LHD plasmas (see Fig. 1). This M1 line has recently been measured by means of an Electron Beam Ion Trap (EBIT) [2, 3], and its wavelength is consistent with a large-scale multi-configuration Dirac-Fock calculation implemented with grasp2K [4]. As seen in the lower panel of Fig. 1, another unresolved line emission is observed at 389.9 nm, which is also presumably associated with an emission line of W ions. Photon emission was observed at 40 lines of sight divided along vertical direction of a horizontally elongated poloidal cross section of the LHD plasma. Radial distribution of the emitter, which may be essentially indicating the radial profile of electron temperature, is inferred from the line integrated intensity distribution along the vertical direction of the poloidal cross section. The M1 line intensity distribution is clearly localized in an inner region of the plasma where the local electron temperature may be suitable to produce abundant W^{26+} ions.

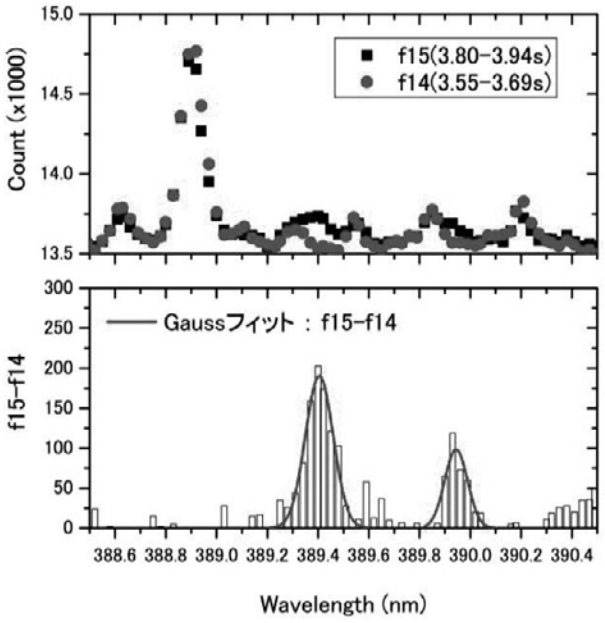

Fig. 1. Upper: Visible spectra observed before (red) and after (black) W-TESPEL injection (shot# 108785). W-TESPEL was injected at 3.8 s. Electron temperatures at the plasma center are 2.5 keV and 1.7 keV, respectively. Lower: subtraction of the two spectra. Curves are results of Gaussian fitting using an instrument function width of 0.045 nm.

1) Doron, R., Feldman, U.: Phys. Scr. **64** (2001) 319.
2) Komatsu, A. et al.: Phys. Scr. **T144** (2011) 014012.
3) Watanabe, H. et al.: Can. J. Phys. **90** (2012) 497.
4) Ding, X.-B. et al.: J. Phys. B **44** (2011) 145004.