§2. Z_{eff} Measurement Using the LHD Thomson Scattering System

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Effective ionic charge, Z_{eff}, is one of the important plasma parameters to characterize the plasma state. Since bremsstrahlung light emission is expressed by a function of Z_{eff}, the information of Z_{eff} is obtained by measuring plasma bremsstrahlung. The bremsstrahlung power spectrum, $j(\varepsilon)$, is given by,

$$\mathrm{j}(\varepsilon) = \frac{8}{3} r_e^3 \frac{m_e c^3}{\lambda_i (1+\epsilon)^2} n_e^2 Z_{eff} \times \sqrt{\frac{2m_e c^2}{\pi T_e}} \exp\left[-\frac{hc}{T_e \lambda_i (1+\epsilon)}\right] \ln\left[\frac{4T_e \lambda_i (1+\epsilon)\gamma}{hc}\right] \quad (1)$$

where ε is the normalized wavelength, r_e and m_e are the classical electron radius and mass respectively, n_e and T_e are electron density and temperature respectively, h is the Plank constant, and γ is the Euler constant. [1]

Basically Thomson scattering systems observe not only Thomson scattered light but also bremsstrahlung light simultaneously. From the point of view on Thomson scattering diagnostic, the bremsstrahlung light is a background light to be subtracted from measured raw signals, however it can be used for the estimation of Z_{eff}, and some Thomson scattering teams have proposed Z_{eff} measurement using Thomson scattering system. [1-3] If the contribution from line spectrum is less than 10 %, accurate measurements of Z_{eff} will be possible. [1]

We have installed a plasma light measurement system on the LHD Thomson scattering system. For the Thomson scattering measurements, only the fast Thomson scattering signals are recorded by the FASTBUS data acquisition system. [4] We added an analog-to-digital converter (ADC) system to acquire plasma light detected by the Thomson scattering polychromators. [5] Currently, plasma light signals detected by 80 polychromators have been recorded whereas 144 polychromators are operated for Thomson scattering measurements. The number of measurement points of the plasma light measurement system will be increased by adding ADCs up to 144. Current sampling frequency is 1 kHz.

Figure 1 shows an example of temporal evolutions of plasma light signals measured by a polychromator that sees the LHD plasma center, R=3.63 m. The observed wavelength range is λ= 650-1050 nm. As a reference, temporal evolutions of T_e and n_e at the same position are also plotted (broken and solid curves respectively). It is noted that the T_es and n_es are local values, however the plasma light signals are line-integrated values. In the plasma discharge, ECH is first applied at t=3-5 sec, and after then, NB is injected. Figures 2 a) and b) show plasma light profiles, T_e and n_e profiles at t=4.0 and 6.0 sec respectively. The plasma light profiles show hollow shapes similar to n_e profiles, and seem to have weak dependence on T_e, as expected. Careful analysis to determine Z_{eff} is now in progress.

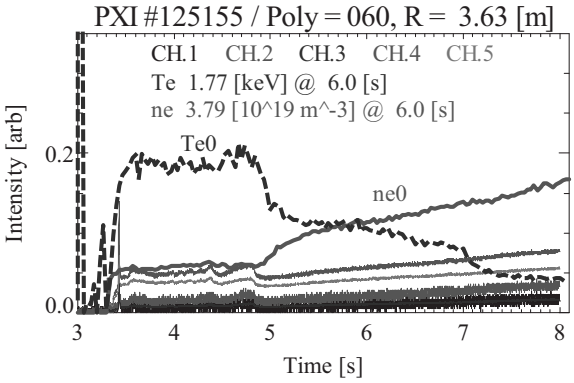
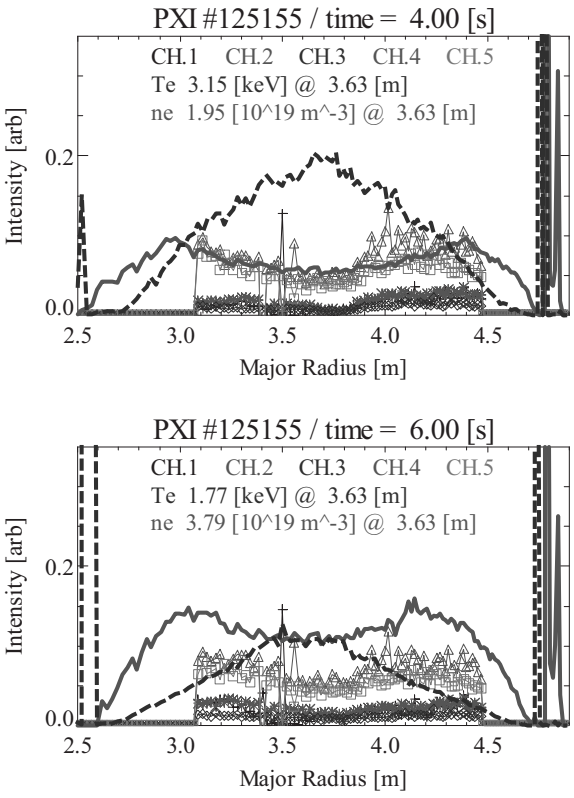


Fig.1. Temporal behaviors of the plasma lights measured by a Thomson scattering polychromator. T_e0 and n_e0 are also plotted (thick curves).



Figs.2 a) and b). Plasma light profiles at t=4 sec and 6 sec. T_e and n_e profiles are also plotted (thick curves).

1) O. Naito and T. Hatae, JAERI Res, 33 (2002).
2) J. H. Lee *et al.*, Rev. Sci. Instrum. 83, 10E334 (2012).
3) M. Aftanas *et al.*, Rev. Sci. Instrum. 83, 10E350 (2012).
4) I. Yamada *et al.*, Fusion Sci. Tech, 58, 351 (2010).
5) K. Narihara *et al.*, Plasma Fusion Res., 2, S1107 (2007).