§53. Development of Collective Thomson Scattering Diagnostic for Bulk and Fast Ions in the Large Helical Device

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For the feasibility studies of a collective Thomson scattering system in the Large Helical Device (LHD), the signal level of scattered radiation and the frequency shift from the incident wave have been estimated by the scattering theory with electrostatic term, based on the scattering form factor. The heterodyne receiver system has been developed. However, their detected fluctuations still needs the treatment of geometrical form factor included the plasma dispersion relation for the incident and scattered electromagnetic waves. The geometrical form factor is included in our CTS spectrum calculations.

In the last campaign of 2008, we have installed the CTS receiver system, and then have obtained the initial result of the scattered spectra measured by CTS diagnostic [1, 2]. Then the probe beam is provided by the 77 GHz gyrotron with ~ 500 kW. The scattered radiation is resolved into 8 channels at the receiver system. For more accurate velocity distribution function measurements, the number of channels is increased from 8 to 32 channels.

Fig. 1(d) shows the spectrogram of the scattered radiation by CTS during the neutral beam injection in a typical LHD plasma shot. The measured signal is averaged over 1 ms. The probing beam power of 640 kW is modulated at the frequency of 50 Hz, and then the scattered radiation is obtained by subtracting the background radiation just after the off timing of the rectangular wave form from the measured signal at the on timing. Plasma parameters are also plotted in the figures from (e) to (g). The intensity of scattered radiation is normalized by the electron density n_e, which is measured by the incoherent Thomson scattering, in order to compare between CTS spectra. The co-NB3, the counter-NB2, and the perpendicular NB4 are injected with each power of 4 MW for the plasma production and sustainment. At the time frame from 4.2 to 4.8 s during only NB4 injection, the CTS spectrum for the bulk ions (< ± 0.4GHz) is narrower than that at the time frame of 5.0 s and later. The expansion of the CTS spectrum is reasonably explained by the increase of T_i in Fig. 1(e).

In the same shot, when the fast ions originated from perpendicular neutral beams and no tangential neutral beams exist at t < 4.8s, the excited waves are observed at ~ 0.8 GHz in CTS spectra with NB4 injection [3]. These frequencies are compared with the lower hybrid wave calculated with the measured density and temperature. These are close to or slightly lower than those of the lower hybrid wave. The detail analysis and experiments are still necessary for the identification of excited waves.

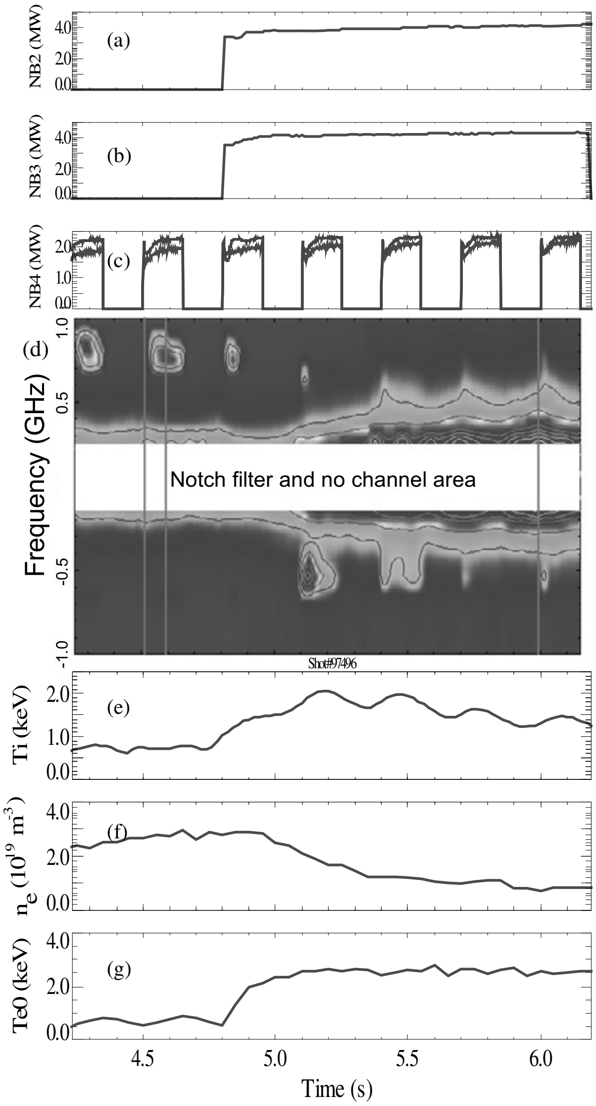

Fig. 1. Time evolution of CTS spectrum for LHD#97496. The injection powers of (a) Co-NB2, (b) Ctr-NB3, (c) Perp.-NB4. (d) Spectrogram of scattered radiation measured by CTS. (e) Ion temperature T_i from Ar line spectroscopy. (f) Electron density and (g) Electron temperature are measured by the incoherent Thomson scattering at the plasma center.

1) Kubo, S., *et al.*, J. Plasma Fusion Res. **5** (2010) S1038.
2) Nishiura, M., *et al.*, Journal of Physics: conference series **227** (2010) 012014.
3) Nishiura, M. , *et al.*, Plasma and Fusion Res. in press.