§6. Measurement of Fast Ion Velocity Distribution Function by Collective Thomson Scattering Diagnostic in the Large Helical Device

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Fast ion confinement is major concern in fusion plasmas as well as bulk ion one. One of possible methods for diagnosing confined bulk and fast ions is to use a collective Thomson scattering (CTS) technique with a millimeter wave and mega-watt power. As other options, the fuel ratio of D/H, the ion temperature, and the flow velocity have also reported in TEXTOR and ASDEX-Upgrade using this method. We have recently reported major progresses on the data analysis[1] of the CTS diagnostic in the Large Helical Device (LHD).

Figure 1 shows a time trace of discharge for CTS measurements. The hydrogen plasma was sustained by 77GHz ECRH and five NBs. Three negative ion based NBs (N-NB1-3) and two positive ion based NBs (P-NB4,5) were injected. During the discharge, total injected NB power was 9-14 MW, while modulated ECRH were 800 kW. The ECRH power was sufficiently low not to change plasma parameter at the scattering volume. The averaged electron density was almost constant at 1.5×10^{19} m^{-3}. The central electron temperature was 3 keV and also almost constant during discharge. The central ion temperature reduced from 3 to 2 keV after the turning off of the N-NB1.

The probe beam of 77 GHz electromagnetic wave was injected from 2O-R port, and the scattered radiation was detected from 2O-LL port in LHD. Figure 2 shows two cases for (a)NB1-ON and (b)NB1-OFF. NB1 is injected as co directional beam. The CTS spectra is calculated using the electron and ion temperatures measured by the Thomson scattering and charge exchange recombination spectroscopy. The calculated CTS spectrum is plotted as the solid line. The center frequency of CTS spectrum shifts to the negative direction. This shift agrees with the co moving ions produced by NB3, and is no discrepancy between the observation and the NB3 direction. The anisotropy of the CTS spectrum in the frequency of more than –0.5 GHz is observed during NB3 injection. This anisotropy is considered to be the tail component originated from co moving fast ions qualitatively. The quantitative analysis is the next step to measure the fast ion distribution function.

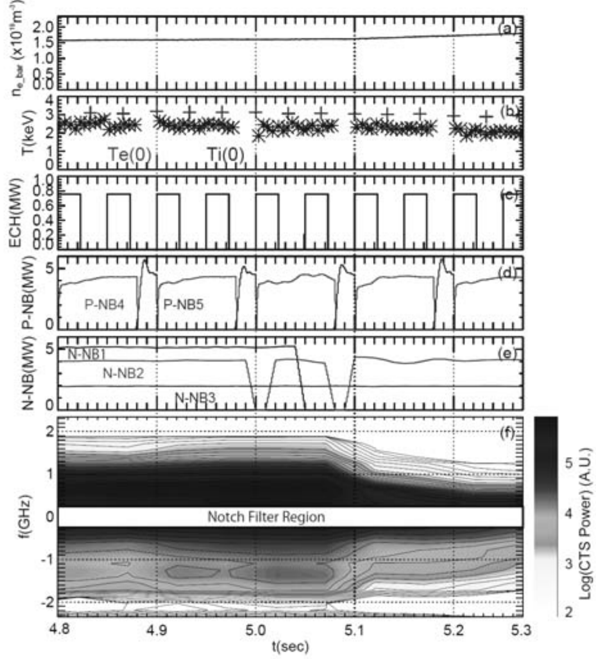

Fig. 1 Time evolution of CTS spectrum. From the top graph, line averaged density, ion and electron temperatures, ECH power, perpendicular injected NBs, and parallel NBs are plotted.

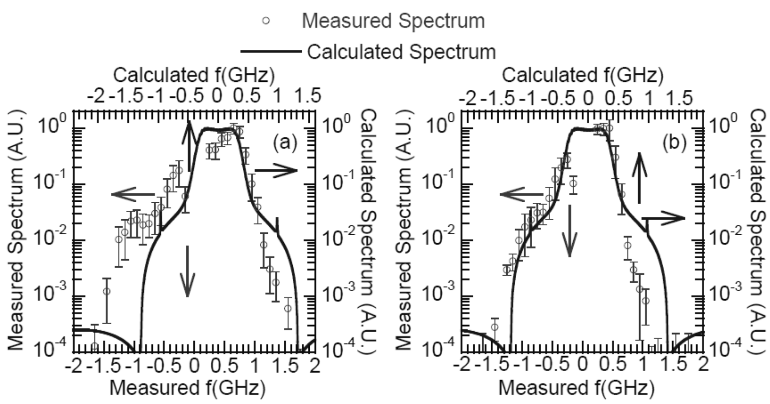

Fig. 2 Comparison of the measured CTS spectrum and calculated CTS spectrum using bulk ion and electron temperature and density at (a) t=4.92s and (b) t=5.22s. Horizontal axes of the calculated spectra are shifted in order to compare spectrum shape.

1) Tanaka, K., Nishiura, M., Kubo, S., Shimozuma, T., Saito, T. : Journal of Instrumentation, Vol 10 (2015) C12001, 1-8.