§13. Development of Spectrum-calculation Code for Collective Thomson Scattering

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Collective Thomson scattering (CTS) diagnostic has been proposed for the bulk and tail ion temperature measurements in the LHD using the existing electron cyclotron resonance heating (ECRH) by gyrotron with the frequency of 77 GHz. The CTS is also assessed numerically using the injector and receiver geometry of the LHD with accessible plasma parameters$^{1)}$.

The CTS diagnostic requires the spectrum analysis of the fluctuation wave vector $\boldsymbol{k}^{\delta}$ to obtain the thermal and fast ion distribution functions with the relation $\boldsymbol{k}^{\delta} = \boldsymbol{k}^{s} - \boldsymbol{k}^{i}$. Here $\boldsymbol{k}^{s}$ and $\boldsymbol{k}^{i}$ are the wave numbers for incident and the scattered radiations, respectively. Since the existing ECRH system is utilized as an initial trial, the port locations for probing and receiving beams are limited to the backscattering and near perpendicular to the toroidal magnetic field. Figure 1 shows the collective scattering region. The Salpeter parameter $\alpha = 1/|\boldsymbol{k}^{\delta}|\lambda_D = 1/(2\ |\boldsymbol{k}^{i}|\ \lambda_D \sin(\theta/2))$ as a function of scattering angle for 77 GHz probing radiation at different plasma parameters. Here λ_D is the Debye length. The Salpeter parameter should be larger than a unity. In any case, we found that α is more than a unity for the scattering angle from 0 to π radians in LHD discharges with the electron temperature of 1~10 keV and the density of $5\text{x}10^{18}$~10^{20} m^{-3}.

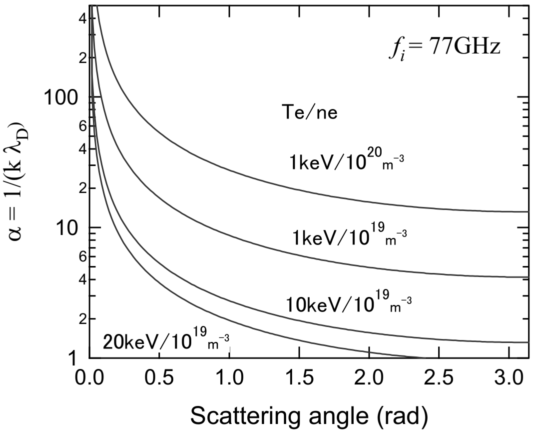

Fig. 1. The Salpeter parameter α as a function of scattering angle for CTS diagnostics in LHD. Gyrotron frequency of 77 GHz is used.

We compared CTS spectra with the same plasma parameters calculated by two codes, which have been developed at RISØ DTU$^{2)}$ and NIFS. Our code is based on the electrostatic-fluctuation model$^{3\text{-}4)}$. Electron, hydrogen ion, and fast hydrogen ion obey Maxwellian distribution functions with the electron temperature T_e, the hydrogen temperature T_i, the fast hydrogen temperature T_{fast}. These densities are given by n_e, n_i, and n_{fast}, respectively. Figs. 2 show the calculated CTS spectra with $T_e = T_i = 1$ keV, $T_{\text{fast}} = 40$ keV, $n_e = 1.1\text{x}10^{19}\ \text{m}^{-3}$, $n_i = 1\text{x}10^{19}\ \text{m}^{-3}$, $n_{\text{fast}} = 0.1\text{x}10^{19}\ \text{m}^{-3}$. The probing and receiving beam are located at the plasma center (R=3.6m, and Z=0). The CTS spectrum within the frequency of ± 0.7 GHz corresponds to the bulk ion, and it is dominated by the fast ions at more than ± 0.7 GHz, as is shown in Fig. 2 (a). Fig. 2 (b) shows the CTS spectra calculated by both codes. These are in good agreement within 10% at most. We have investigated the cause of the difference.

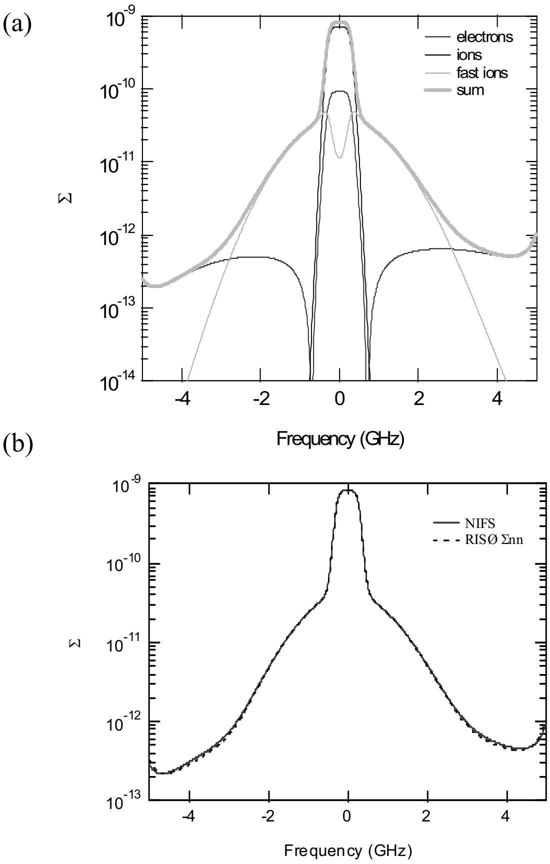

Fig. 2. (a) CTS spectrum and the composition for electron, hydrogen ion, and fast ions. (b) CTS spectra calculated by two codes for comparison.

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