§35. Study of Application of THz Gyrotrons to Collective Thomson Scattering on LHD High Density Plasmas

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In FIR center, Univ. of Fukui, THz-fequency-range gyrotrons have been developed[1)], and a 400 GHz high-power pulse gyrotron is now being developed.[2)] In the experiments of high-density plasma operation in LHD, plasma density reaches more than 10^{20} m^{-3}. To obtain the ion temperature in such high-density plasmas, collective Thomson scattering (CTS) is one of strong diagnostics. To overcome the CTS problems such as signal-to-noise ratio and spatial resolution, a low-frequency beam is favorable for CTS probe beam. However, a lower limit of frequency is set because of wave refraction in the high-density plasmas, wave reflection due to upper hybrid cut-off and background noise due to cyclotron emission in magnetic field. From the points of view, wave length of the probe beam must be less than 1 mm, which is in THz-frequency range. Thus, a feasibility study of the Fukui 400 GHz gyrotron as a CTS source for LHD experiments is tried. Ray tracing calculations and scattering spectra calculations are carried out.

For the feasibility study of LHD-CTS to be concrete, positions of injection and detection should be determined. Two available ports on the LHD vacuum vessel are chosen as injection and receiving antennas. In Fig. 1, the plane, constructed by the injection point (I), scattering points (S) and receiving point (R), is shown. Scattering angle is large enough to obtain high spatial resolution for this configuration.

As a target of the feasibility study of CTS, high density plasma with the density 10^{20} m^{-3} and temperature 1 keV is chosen. At first, ray tracing calculations are carried out. A probe beam with frequency of 400 GHz propagates through high density plasma of 10^{20} m^{-3} and reaches the center of plasma without refraction and reflection. Next, scattering power spectra received at the receiving antenna are calculated. An example of power spectra is show in Fig. 2, where gyrotron output power is assumed as 100 kW and beam radius is 1cm at the scattering point. The power spectra indicated by the solid and dashed lines indicate electron motion collective with ions and thermal motion of electrons, respectively. Thus, collective scattering is dominant enough to give ion information. The calculated power per unit band width is about 1eV. From the value, a signal to noise ratio is estimated as about 3, which is large enough to measure ion temperature. Thus, 400 GHz gyrotron is one of strong candidates of power source for LHD-CTS.

1) T. Idehara et al., Conf. Digest "The Joint 32nd International Conference on Infrared and Millimeter Waves and 15th International Conference on Terahertz Electronics" 339. (2007).
2) T. Saito et al., Conf. Digest "The Joint 32nd International Conference on Infrared and Millimeter Waves and 15th International Conference on Terahertz Electronics" 164. (2007).

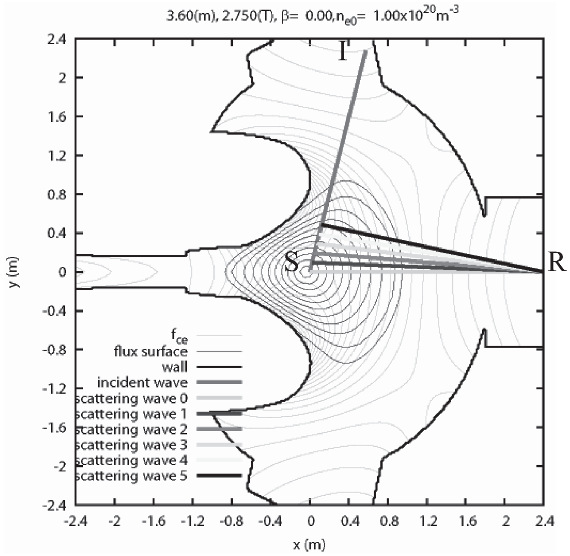

Figure 1: Configuration of injection and scattering beams chosen for feasibility study of LHD-CTS.

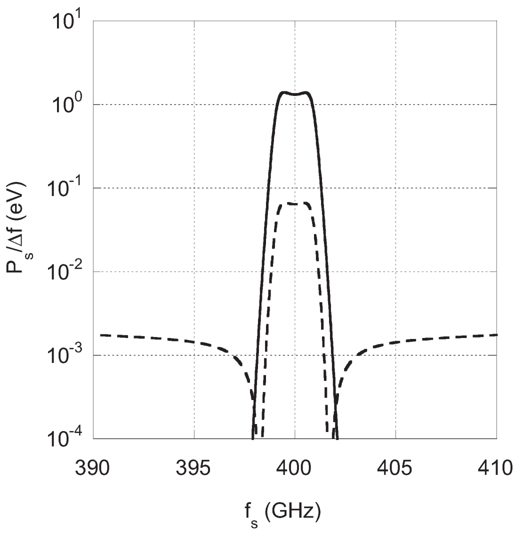

Figure 2: CTS scattering power spectrum in unit frequency. Solid and dashed lines indicate power spectrum scattered from coherent and incoherent electrons.