§23. 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-frequency-range gyrotrons have been developed, and a 400 GHz high-power pulse gyrotron is now being developed.[1-2] 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.[3]

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. Ray tracing calculations are carried out. Results are shown in Fig. 1. An incident probe wave with frequency of 400 GHz propagates through the high density plasma and reaches the center of plasma without refraction and reflection. Microwave of 300 GHz also almost straightly propagates. However, the wave with 168 GHz, which is the highest frequency among existing NIFS gyrotrons for electron heating, does not straightly propagate, and it is reflected due to upper-hybrid cut-off for X-mode injection in the high density plasma.

When beam waist of the probe beam is converged at the scattering point to improve spatial resolution, the beam radius at the injection point increases and antenna size becomes large. Figure 2 indicates the beam radius relation between incident and scattering points, where Gaussian beam is assumed. When beam radius is converged as $w_0 = 1$ cm at the scattering point, the incident radius w is 5 cm for 400 GHz. This value is not so large that the antenna size is reasonable to be installed.

1) T. Saito et al., The Joint 33rd International Conference on Infrared and Millimeter and Terahertz Waves, 1209 (2008).
2) T. Notake et al., Plasma Fusion Res. **4**, 011 (2009).
3) Y. Tatematsu et al., The Joint 33rd International Conference on Infrared and Millimeter and Terahertz Waves, 1281 (2008).

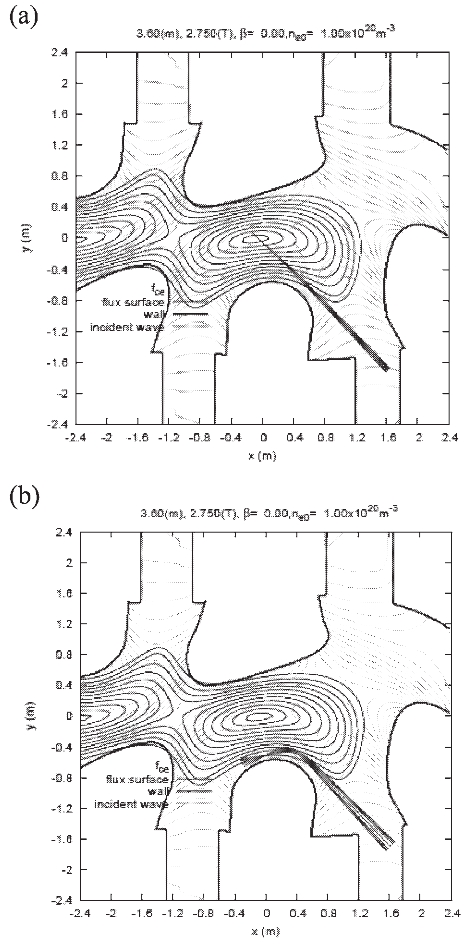

Figure 1: Calculation of ray tracing in LHD. Maximum density is 10^{20} m^{-3} and ray frequency is (a) 400 GHz and (b) 168 GHz.

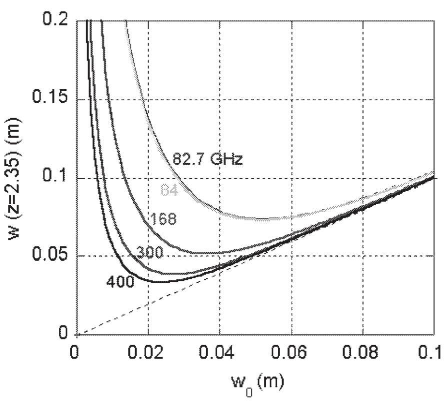

Figure 2: Relations between incident radius (w) and scattering radius (w_0) for incident beam with some different frequencies. Attached numbers represent wave frequencies in GHz.