§38. Electron Bemstein Wave Emission Measurement in Consideration of Finite Beam Width

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For the measurement of waves originated from the electron Bernstein wave (EBW) and emitted via the EBW-extraordinary-ordinary (B-X-O) mode conversion process, we developed a heterodyne filter-bank radiometer system for a frequency band of 26-42GHz in Heliotron J. Since in high β operation in the LHD the electron density in the main confinement region is higher than $2.0\times10^{19}m^{-3}$, and the magnetic field strength at the plasma center is around 1 T, the measurement of the emissions originated from EBW (EBE) in this frequency range is also expected.

We examined to install this radiometer into one of the transmission lines connected to an antenna in a horizontal port for electron cyclotron resonance heating (ECRH) in the LHD. A waveguide switch for measurements is already installed in the line. As shown in Fig. 1, the power attenuation of 26-42GHz is small enough for 3.5 inch corrugated waveguide used in the transmission line. However, as shown in Fig .2, a perfect transmission of the Gaussian beam cannot be expected with use of the quasi-optical mirrors originally designed to transmit 168GHz waves. The coupling factor of the emitted waves into the transmission line will be reduced to some extent.

Fig.3 shows contours of the O-X(X-O) mode conversion rate calculated with use of the parameters at the reflection point of the ordinary mode obtained by the single ray-tracing calculation for the beam center. For this frequency band, wider "O-X (X-O) mode conversion window" can be expected compared to the cases of frequency bands around 77GHz and 154GHz used for ECRH in the LHD.

Propagation and absorption of the waves are examined by multi-ray tracing calculations as the reversed process of the B-X-O emission process with taking into account a finite beam width. Although the power deposition region of a single ray is localized, the total absorption region is widely distributed as shown in Fig.4 and Fig.5 with taking into account the beam width. Optimization of the beam parameter may be required for detection of the locally emitted EBWs.

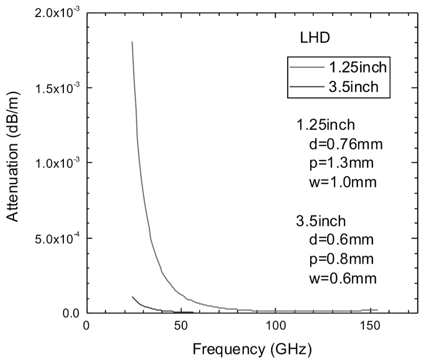

Fig. 1: Power attenuation of the 1.25 inches and 3.5 inches corrugated waveguides use in the LHD ECRH transmission lines.

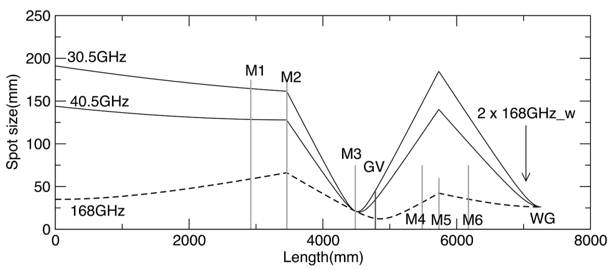

Fig. 2: effective diameters of the quasi optical mirrors (M1-M6) and the beam spot sizes calculated based on the geometrical optics with the use of curvature radii of each mirror

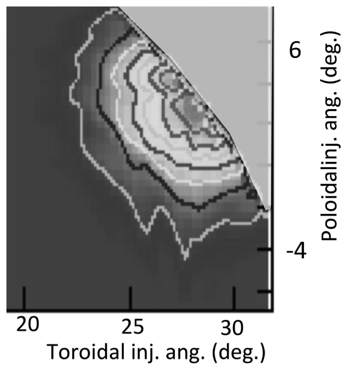

Fig.3: Contours of the X-O(O-X) mode conversion rate of 34.5GHz plotted by10% as functions of the toroidal and poloidal injection (detection) angles.

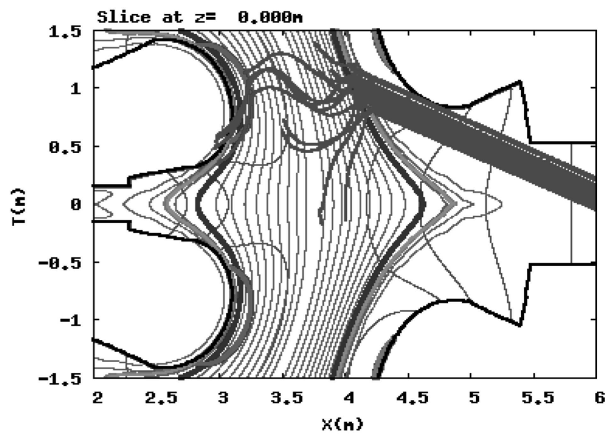

Fig.4: Trajectories of the 34.5GHz waves projected to the equatorial plane.

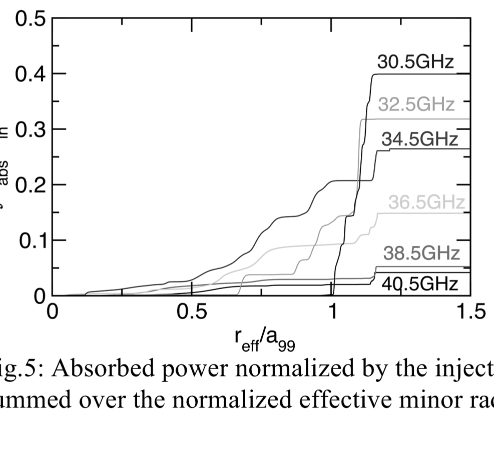

Fig.5: Absorbed power normalized by the injected power summed over the normalized effective minor radius