§29. Electron Bernstein Wave Emission Measurement in Consideration of Finite Beam Width

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In this collaboration research program, we are developing a radiometer system in Heliotron J to measure emissions originated from the electron Bernstein wave (EBW) and emitted via the EBW-extraordinary-ordinary (B-X-O) mode conversion process for comparison with theoretically predictions about wave propagation, mode conversion and power absorption with taking into account of the finite beam width of the beam.

In Heliotron J, a heterodyne, filter-bank radiometer system is installed to measure emissions originated from electron Bernstein wave (EBE). Emissions of 26-42 *GHz* is collected with a Gaussian optics antenna that is placed in front of a waveguide connected to a waveguide switch installed on the way of the transmission line usually used for electron cyclotron resonance heating (ECRH). In this fiscal year, four frequency channels were newly installed in addition to existing four frequency channels. Fig.1 shows the result of the sensitivity test of each frequency channel. With use of a Voltage Controlled Oscillator (VCO) and frequency doubler, waves of -10 *dBm* ~ -15 *dBm* and 24~40 *GHz* are input into each frequency channels via 40 *dB* attenuator. Waves of about -60 *dBm* can be detected for each channel. However, channels nominally measuring at 26.5 and 28.5 GHz are also sensitive to higher frequencies. Therefore, attention is required in the analysis of the measured data.

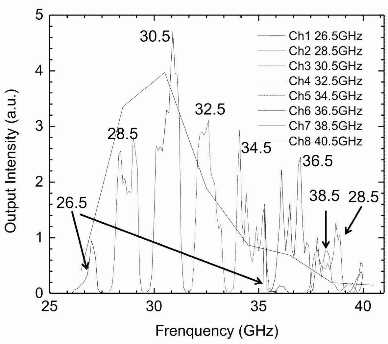

Fig.1: Output signal intensity for each frequency channel of the radiometer normalized by input signal intensity plotted versus input frequency.

K-ray code[1)] expanded from B-ray code was developed to perform the ray-tracing after the O-X mode conversion in Heliotron J configuration. Fig.2 shows a trajectory of 35 *GHz* wave in the "standard configuration". The wave is absorbed around ρ=0.4 where ρ is the normalized minor radius. Fig. 3 shows the positions of the absorption region of each frequency for different center magnetic field strengths. The absorption region can be shifted by changing the magnetic field strength. By selecting Bt=1.2 *T* and 37 *GHz*, the absorption region can be placed ρ=0.1 and it is expected to obtain temperature information in the plasma center region.

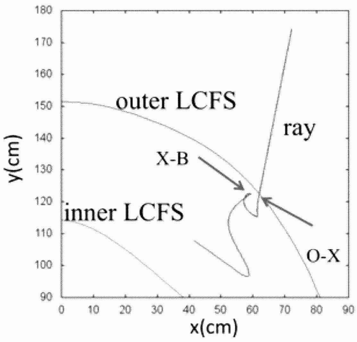

Fig. 2: A trajectory of 35*GHz* wave calculated by K-ray code.

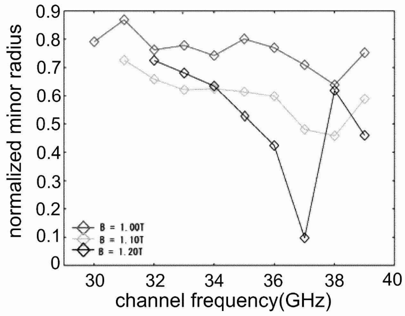

Fig.3: Power absorption region of each channel frequency for magnetic field strength Bt = 1.00T, 1.10T, 1.20T

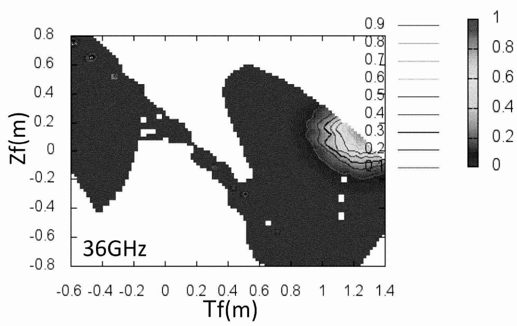

Fig.4: Contours of the calculated O-X mode conversion rate plotted as a function of the toroidal (Tf)-vertical (Zf) target point at fixed Rf=3.9 *m* plane.

Application of this 24~40 *GHz* radiometer into one of the transmission lines for ECRH in the LHD is now under consideration. As shown in Fig.4, calculated O-X mode conversion window for 36 *GHz* can be aimed from a horizontal port antenna in a magnetic configuration (Ra, Bt)=(3.56 *m*, 1.0 *T*) where Ra is the position of the magnetic axis and Bt is the central magnetic field strength. Since this antenna is steerable during a plasma discharge, efficient searching of the O-X mode conversion window is expected. The ray-tracing indicates that power absorption around ρ=0.4 occurs if the target (Rf, Tf, Zf)=(3.9 *m*, 1.05 *m*, 0.20 *m*) is selected.

1) Nagasaki, K., et al, **21PB-063** (poster) PLASMA CONFERENCE 2014, Nov.18-21, 2014 Niigata, Japan