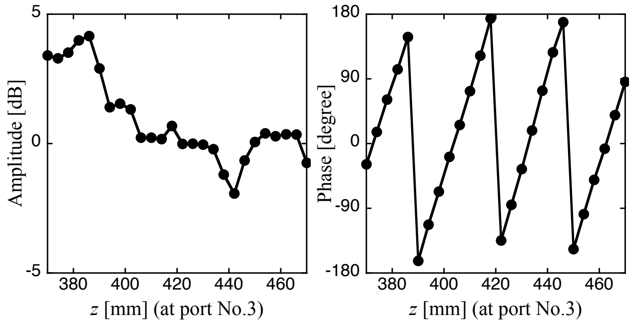
§5. Development of Electron Bernstein Emission Diagnostics for Electron Temperature Measurement in High Beta Plasmas

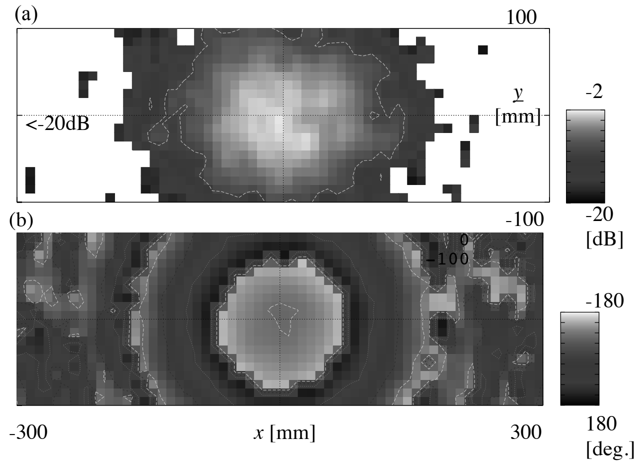
Idei, H., Inagaki, S. (Kyushu Univ.),
Ohdachi, S., Kawahata, K., Nagayama, Y., Igami, H., Shimozuma, T.

Electron Bernstein Emission (EBE) radiometry was proposed to measure time evolutions of the electron temperature profile in the over-dense high-beta plasma. Electron Cyclotron Emission (ECE) radiometry is widely used to measure electron temperature time evolutions, but the ECE cannot propagate outside the plasma due to the cut-off in the over-dense plasma, while the electrostatic EBE wave cannot propagate in the vacuum. The EBE wave should be converted to the electromagnetic ECE wave to be measured. The mode conversion processes were requested in the EBE radiometry. In the B-X-O mode conversion, the Bernstein mode first converted to the eXtraordinary (X) mode at the upper hybrid resonance, and then the X-mode converted to the Ordinary (O) mode at the O-mode cutoff. The EBE wave can be detected as the converted O-mode wave with the parallel refractive index $N_{//}$ to the magnetic field. The oblique viewing should be prepared for the EBE radiometry with the B-X-O mode conversion.

In the EBE radiometry with the B-X-O mode conversion, the advanced antenna system with good directionality has been required for the oblique viewing. A [3x3] square-waveguide Phased-Array Antenna (PAA) system has been developed in Kyushu University. The PAA performance is one of main issues in this subject. The antenna performance was tested at the low power test facilities. The system included orthomode transduces and some components. The phase was delayed at the RF cables from the antenna system in vacuum, depending the measuring frequency. The system performance was tested in the QUEST device after installed there. The QUEST vacuum vessel may work as a large oversized cavity if the RF was injected to the device. Major and minor (plasma) radii of the QUEST device are 0.68 m and 0.16 m, respectively. The vacuum vessel was quite oversized for the wavelength (~ 30 mm). The standing wave components were sometimes dominant in the cavity condition, preventing us to take the phase array. First the field radiated from the PAA was measured along the propagating z direction to check if the propagating wave-field component was properly measured or not. Figures 1 show amplitude and phase profiles along the propagating z direction when one of the [3x3] waveguide ports was excited. The proper kz phase evolution was measured along the propagation, where k was the operating 10 GHz wavenumber. The intensity profile had complicated fine structures by phase interferences along the kz evolution, including a global interference effect in the oversized cavity condition. The phase array among the waveguide ports was adjusted from measured phases of the propagating waves. Figures 2 show amplitude and phase contour plots in the x-y plane in perpendicular to the propagating z direction for the perpendicular injection. Although the amplitude profiles were complicated due to the interference effect, the beam was focused to the center of the antenna The parabolic phase profile showed a focused beam was expanding along the propagation. Good focusing property of the developed PAA were confirmed in the test conducted with the QUEST device.



Figs.1: Amplitude and phase profiles along the propagating z direction in the operating frequency of 10 GHz.



Figs.2: (a) Amplitude and (b) phase contour plots in the x-y plane in perpendicular to the propagating z direction for the perpendicular injection.

The heterodyne detection system was developed to measure the emission from the plasma. The plasma was produced and its current was started up with the RF injection of 8.2 GHz. The band rejection filter (rejection band: 8.1-8.3 GHz) was prepared to protect the heterodyne mixer. Figure 3 shows the emission frequency spectra successfully measured with the heterodyne system.

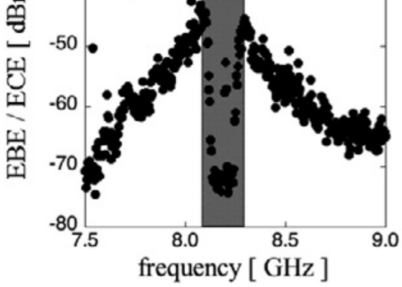


Fig.3: Emission frequency spectra successfully measured by the heterodyne system with a band rejection filter.