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

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The Electron Bernstein Emission (EBE) radiometry was proposed to measure the time evolution of the electron temperature profile in the over-dense high-beta plasma. The Electron Cyclotron Emission (ECE) radiometry is widely used to measure the electron temperature time evolutions, but the ECE cannot propagate outside the plasma due to the cut-off in the over-dense plasma. The EBE wave cannot propagate in the vacuum due to the electrostatic mode. The electrostatic EBE wave should be converted to the electromagnetic ECE wave to be measured. Some mode conversion processes are 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 converted O-mode wave can be detected as the EBE signal. The mode conversion efficiency depends on the density gradient at the B-X and X-O mode conversions, and also the parallel refractive index $N_{//}$ to the magnetic field at the X-O mode conversion. The oblique viewing beam should be prepared for the EBE radiometry with the B-X-O mode conversion.

In order to detect a pure O-mode in the oblique viewing with $N_{//}$, the elliptical polarization should be measured. In the EBE radiometry with the B-X-O mode conversion, the advanced antenna system with good directionality and polarization controllability has been required. A square-waveguide Phased-Array Antenna (PAA) system, which enables us to control the receiving polarization and angle, was proposed. Figure 1 shows the radiated intensity profile in the steering x direction at various numbers of 1 dimensional waveguide elements and waveguide sizes. The radiation fields were evaluated with the developed Kirchhoff integral code. The side-lobe part became small if the number of waveguide element was significant and the waveguide size was reduced. A 2 dimensional 9 [3x3] element PAA system was selected and fabricated as a receiving antenna for the EBW radiometry. A waveguide side of the antenna was 0.79 inch. Figures 2 show a contour plot of the measured intensity pattern, and the calculated and measured intensity / phase profiles in the steering x direction. The measured profiles were in good agreement with those calculated with the Kirchhoff integral code. The quad-ridged broadband orthomode transducer was also designed to measure the elliptical O-mode with two orthogonal electric field components. Figure 3 shows the VSWR of two electric field components at the orthomode transducer. The low VSWR less than 2 was obtained in the frequency range of 8-14.5 GHz at the two electric field comnponents. The density profile is essential in mode conversion phenomena. The density profile should be measured in detail to identify the EBE position. The developed PAA system will be co-operated as a receiving antenna for the EBE radiometry, and as a launching antenna of the probe beam for the reflectometry to measure the density profile simultaneously.

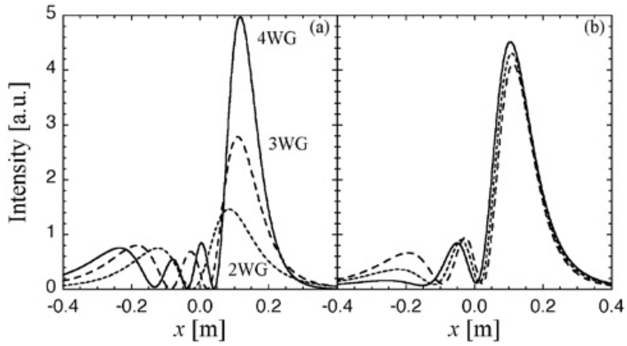
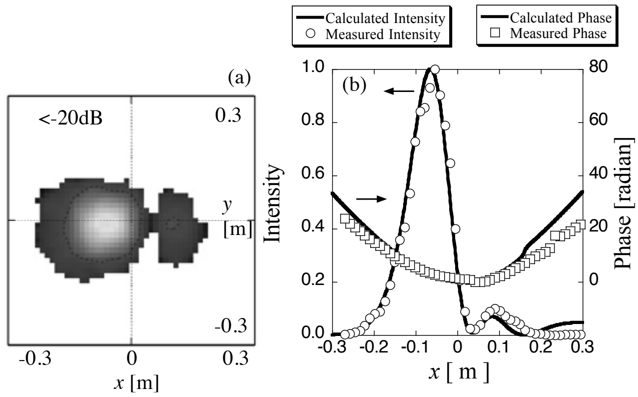


Fig.1: Radiated intensity profile in the steering x direction at various numbers of 1 dimensional waveguide elements and waveguide sizes.



Figs.2 (a): Contour plot of radiated intensity pattern. (b): Calculated and measured intensity and phase profiles in the steering x direction.

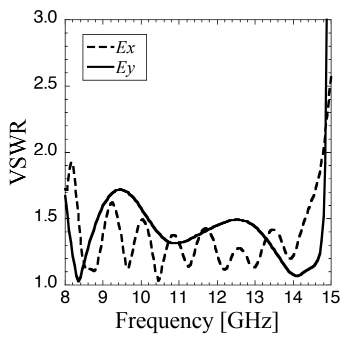


Fig. 3: VSWR of two orthogonal electric field components at the quad-ridged broadband orthomode transducer.