§33. Measurement of Electron Bernstein Wave Emission from Ultra High Beta Plasmas

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Plasma current-drive technique to enable steady state operation of a low-q plasma discharge proposed by Hassam [1] utilizes the Nernst effect. If a plasma has a steep radial temperature gradient, the cross-field thermoelectric force is in the opposite direction to the usual resistive friction, thus maintaining the plasma current. In low-q plasmas such as a field reversed configuration (FRC), however, maintaining the electron temperature profile is difficult because of its high beta property. Although electron cyclotron resonance heating (ECRH) is a very powerful method to heat magnetically confined plasmas, the accessible plasma density is limited by a critical density. Electron Bernstein wave (EBW) is considered as a possibility for overcoming the density limit. In order to investigate the possibility of heating an extremely high-beta plasma by EBW, we have developed a diagnostic system of electron Bernstein wave emission (EBE), which is an inverse process of mode conversion of EBW heating.

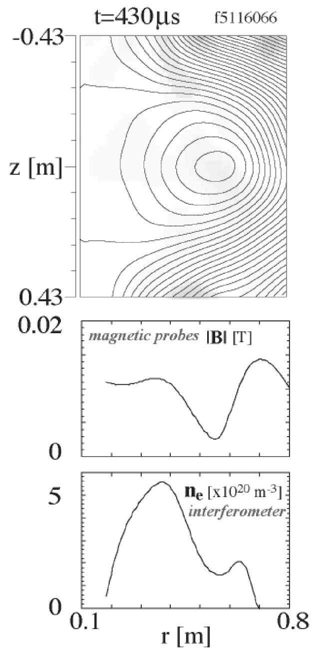

Fig. 1. Poloidal flux contour (top), radial profiles of magnetic field strength (middle) and electron density (bottom).

Figure 1 shows poloidal flux contour (top), radial profiles of magnetic field strength (middle) and electron density (bottom) of the TS-4 FRC plasma. Magnetic field of 0.01 T confines a plasma with density in the order of 10^{20} m^{-3}, indicating extremely overdense medium $\omega_{pe}/\omega_{ce} \geq 100$. Because the density gradient at edge of TS-4 FRC is sufficiently steep at the location of the UHR layer, the UHR layer can come close enough to the right-hand cutoff, so that some of the power trapped in the plasma can tunnel through to electromagnetic, X-mode branch. This is the mode conversion process we expect. Figure 2 is schematic of the EBE measurement system we had developed in this year for TS-4 plasmas. Frequency which can be measured by our system is resonant with the sixth or seventh electron cyclotron layer near the plasma edge. The electromagnetic wave emitted from TS-4 plasmas is received by a waveguide antenna and transmitted to a detector module through a waveguide-coaxial cable converter, coaxial cable, attenuators and amplifiers. The detector module surrounded in a bold line frame in Fig. 2 was fabricated using microwave integrated circuit (MIC) technology by Mase laboratory Kyushu University [2]. Employment of the MIC technique had downsizing of the system and cost reduction of development enabled. Figure 3 shows transmission performances of the band-pass filters. The frequency range is 2-5.1 GHz and 500 MHz of bandwidth is achieved in each channel.

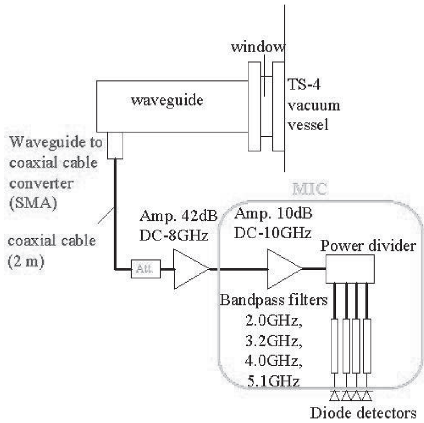

Fig. 2. Schematic of the EBWE measurement system. Microwave integrated circuit (MIC)technology was utilized for the detector module.

According to a numerical calculation based on the cold plasma resonance absorption model, in an optimal condition of receiving angle and polarization, conversion efficiencies of 30 % for 2.45 GHz and 50 % for 5.0 GHz are expected in TS-4 FRC. We are to initiate the measurement of EBE from TS-4 FRC and compare the experimental results with the calculation.

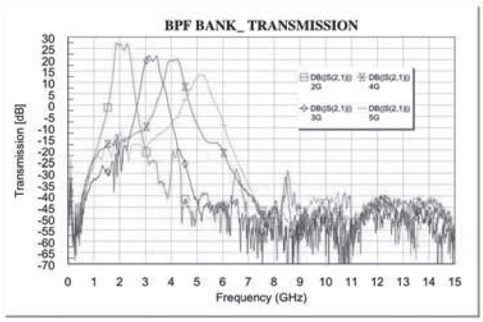

Fig. 3 Transmittance of the band-pass filter bank

[1] Hassam, et.al., Phys. Rev. Lett, **83**, (1999) 2969.
[2] Y. Kogi, et al., "Development of IF system for ECE radiometer on KSTAR tokamak", in Proceedings of the 13th International Symposium on LASER-AIDED PLASMA DIAGNOSTICS, 18-21 September, 2007 Hida Hotel Plaza, Takayama, Japan (NIFS-Proc-68)