§20. Observation of Doppler Shifted Cyclotron Damping of Electron Bernstein Wave in a Toroidal Plasma

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Recently, there arises considerable interest in electron Bernstein (EB) waves in toroidal plasmas in relationship to heating and diagnostics of overdense plasmas in stellarators 1) and spherical tokamaks 2). Although EB waves have no density limit for propagation and, therefore, have potential ability to heat high density plasmas, they have to be excited in plasmas via mode conversion process from the electromagnetic waves injected from outside. Another interest is their propagation and absorption characteristics in toroidal plasmas. Ray tracing study indicates that the parallel refractive index N// of EB waves becomes large depending on their ray path 3). With a large N//, EB waves may be damped away apart from the ECR layer via Doppler-shifted cyclotron resonance. In toroidal plasmas with the toroidal magnetic field Bt and the poloidal field Bp, the parallel index is given by N//=(NpBp +NtBt)/B=Np(Bp/Bt) +Nt, where Np and Nt are poloidal and toroidal refractive indices, respectively. Since the EB wave is an electrostatic mode and has a large refractive index N, the poloidal contribution Np(Bp/Bt) may become large in contrast to the cases of the electromagnetic modes, where Np(Bp/Bt) is negligible and N//=Nt.

In order to investigate the above points, experiments were carried out in the WT-3 tokamak. The mm wave power for EB wave heating is generated by a gyrotron (48 GHz, 100 kW) and transmitted via corrugated wave guides in the HE11 mode to the vacuum window attached on the top of a top port as shown in Fig.1. The mm wave comes through the window and is injected by a couple of mirrors fabricated inside the top port toward the corrugated polalizer attached on the inboard vessel wall. The polarization of electric field of the injected wave is parallel to the toroidal field (O-mode), and the wave is mode-converted into X mode by the polarizer and reflected toward the plasma perpendicularly to the toroidal field (N//=0).

We inject the EC power into OH plasmas with Ip=60 kA and ne(0)=2.1x10^{13}cm^{-3}. The loop voltage decreases and the soft X-ray (SX) intensity increases, suggesting that the bulk electron heating takes place. The power deposition profile on the plasma cross section is investigated by SX computerized tomography. The difference of the SX emissivity just after and before the ECH turned on or off is found to make an annular ring on the cross section as shown in Fig.2. The ray trajectories are calculated by using the present plasma parameters and plotted in this figure, which shows that N// of the EB waves increases along the ray from N//=0 at the UHR layer to 1 ~ 2 on the ring and EB waves are damped away there via Doppler shifted cyclotron damping before arriving at the ECR layer. These results show that upshift of N// affects significant effect on the power deposition profile of EB waves in the toroidal plasmas.

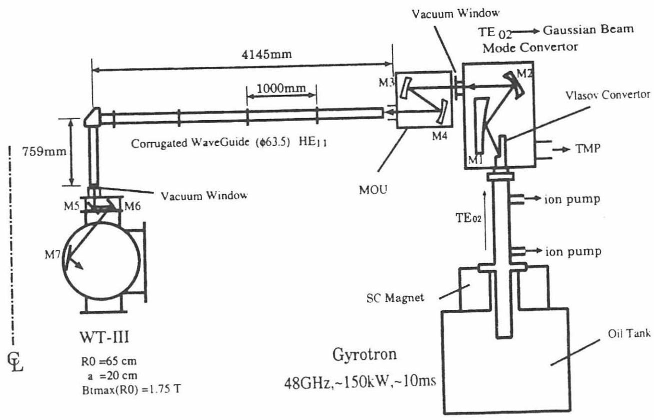

Fig.1. EB wave ECH system on WT-3

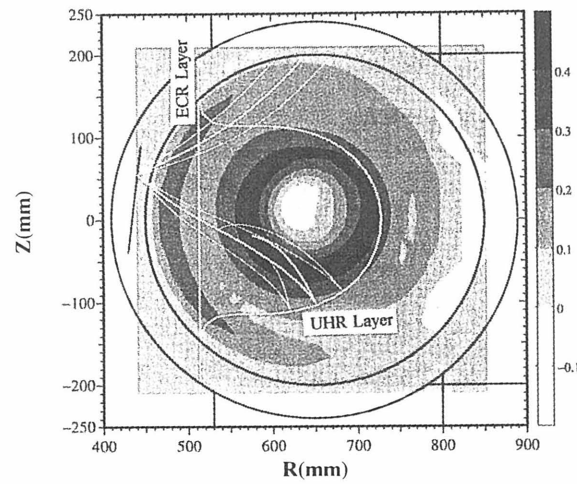

Fig.2. Decrement of SX emissivity at ECH turned off

References

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