§51. Electron Bernstein Wave Heating in Super Dense Core Plasmas on LHD

Tanaka, H., Maekawa, T., Uchida, M., Nishi, S.
(Grad. School of Energy Science, Kyoto Univ.),
Igami, H., Kubo, S., Shimozuma, T., Yoshimura, Y., Takahashi, H.

Since the central electron density in the super dense core (SDC) plasma exceeds more than ten times of the cutoff density of the microwaves launched for electron cyclotron heating (ECH) in LHD, study on ECH by the electron Bernstein wave (EBW) which has no density limit in propagation is required to expand the applicable region of ECH to higher density region. It is important to know whether the launched wave reaches the upper hybrid resonance (UHR) layer as the extraordinary (X-) mode where the mode conversion process from the X-mode to the EBW occurs. It is well known that non-linear three wave coupling process occurs in the UHR layer when the X-mode is mode converted to the EBW, and parametrically-decayed waves in the lower hybrid (LH) range of frequency are excited. In this study, we observe this parametrically-decayed waves and investigate the mode conversion process for optimal wave injection.

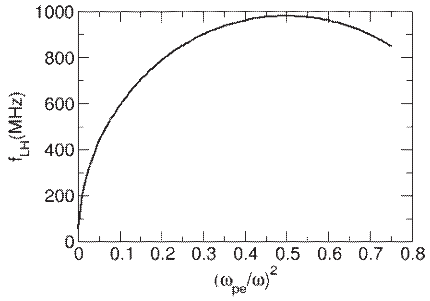

Fig. 1 : Lower hybrid wave frequency plotted as a function of $(\omega/\omega_{pe})^2$ at the UHR layer.

Figure 1 shows the frequency of the LH wave excited at the UHR layer in the hydrogen plasma when the 84 GHz microwave is used. Measurement in wide range of frequency from 100 MHz to ~2000 MHz is required to detect the LH waves and its harmonics and to examine the location of the UHR layer. In the 12th experimental campaign, a discone and a loop antennas were newly installed in the 9.5-L port. Figure 2 shows a schematic view of the installation of those antennas.

Frequency spectrums in LH wave frequency range were measured in the experiment where the 84 GHz microwave was launched obliquely to access the electron cyclotron resonance (ECR) layer and the UHR layer from the high field side (HFS). The magnetic field configuration was (R_{ax}, B_{ax}) = (3.6 m, 2.75 T). Figure 3 shows the frequency spectrums measured by the loop antenna in a discharge where the central electron density n_{e0} was 2 x 10^{19} m^{-3}. For both

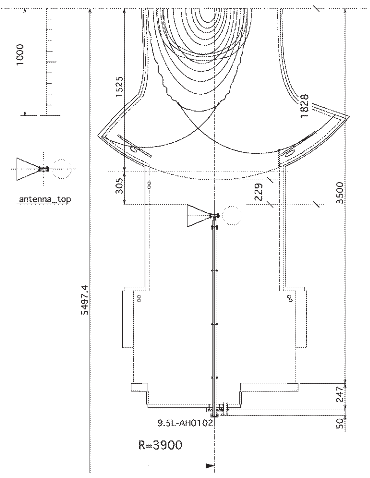

Fig. 2 : Schematic view of the installation of the discone and the loop antennas in 9.5L port.

cases of the X- and the O-mode launching, waves are detected in the wide range up to 500 MHz and the spectrums are similar to each other. However the intensity at 400 MHz is larger for the case of the X-mode launching than the case of the O-mode launching. The numerical investigation with the ray-tracing calculation assuming n_{e0} = 2 x 10^{19} m^{-3} suggests that about 70% of the launched power can reach the UHR layer where $(\omega/\omega_{pe})^2$ ~ 0.2 and is mode converted to the EBW by optimization of the launching direction. However, around 800 MHz that corresponds to $(\omega/\omega_{pe})^2$ ~ 0.2 at the UHR layer, no significant intensity were observed. In discharges of similar density and the same launching condition, significant intensity was not observed in the spectrum measured by the discone antenna. Three wave coupling process can occur outside the last closed flux surface (LCFS) where the density is very low before the launched wave reach the HFS of LCFS. This may be why waves are observed in low frequency range. For the case of the O-mode launching, the residual power of the waves that suffered multiple reflections might excite the decay waves of low frequency range outside the LCFS. Numerical investigations for excitation of the EBW via the O-X-B mode conversion process in over dense plasmas where the density profile resembles that of SDC plasma in the peripheral region, suggests that the $(\omega/\omega_{pe})^2$ ~ 0.5 in the UHR layer. Sensitivity in high frequency range should be improved for measurement of the decay waves excited inside the LCFS in over dense plasmas like a SDC plasma.

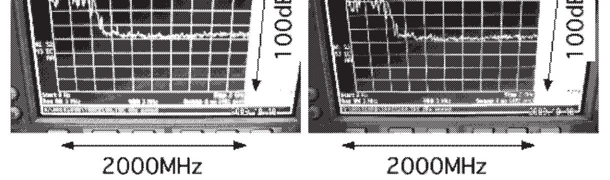

Fig. 3 : Spectrums measured by the loop antenna.