§35. Electron Heating Scheme of Ion Cyclotron Heating Experiment in LHD Observed by Code Calculation

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Ion Cyclotron Range of Frequency (ICRF) heating experiment is planned as one of additional heating method in LHD. We are planing to use two types of antenna; a half-turn loop antenna and folded waveguide antenna. We intend to use the loop antenna to launch fast waves and heat the plasma particles mainly.

To study fast wave heating in helical plasma, we introduce ORION code as one of calculation codes from Oak Ridge National laboratory by US-Japan collaboration. This code has been developed by Dr. Jaeger[1,2] and is global wave code and solves reduced-order wave equation. Two dimensional helical symmetric magnetic field is used. Upshift of wave number parallel to line of magnetic force and ion Bernstein wave are not included. Figure 1 shows position of cyclotron resonance layer of minority ion in different frequency of radio frequency (RF) waves. Strength of magnetic field is fixed to 3 T.

From scan of plasma parameters, we found the condition which electron absorption is dominant. Figure 2 shows power absorption dependence on the frequency. In this calculation, plasma parameters are; a magnetic field strength of 3 T, a density of 1×10^{20} m^{-3}, a temperature of ion and electron of 2 keV. Deuterium plasma including the 30 % of hydrogen is assumed. Ion cyclotron resonance layer of minority ion places outside the plasma at the frequency of 34 MHz and 54 MHz in this figure. Electron absorption is dominant in the frequency range lower than 42 MHz and higher than 46 MHz. In this case, ion cyclotron resonance layers is located at the plasma peripheral region.

Electron absorption profile varies in different frequency of RF power. In 38 MHz, wave power is absorbed by electrons at two-ion hybrid resonance layers, which is located slightly away from the plasma center. Peak of the power deposition profile exists at the off-center position. However, in 40 MHz, most of absorption is caused by electrons at the plasma core region. The power deposition profile has a center-peaked shape.

In the CHS experiment[3], good ICRF heating was obtained by electron heating with the 30 % hydrogen in the deuterium plasma. In those experiments, to reduce the minority concentration below 15 % was impossible because of recycling of hydrogen. The code calculation shows that electron heating is apt to occur in large minority fraction. If fraction of minority ion will not be reduced enough, electron heating will occur and this will be good for ICRF heating.

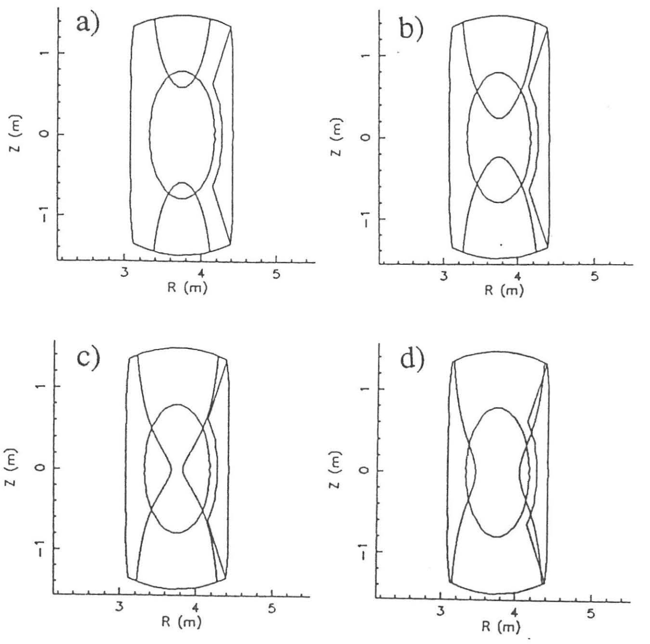

Fig.1. Position of cyclotron resonance layer of minority ion at a magnetic field of 3T. Frequency of RF wave is; a) 38 MHz, b) 44 MHz, c) 46 MHz, d) 50 MHz.

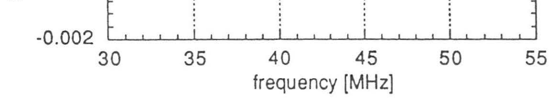

Fig.2. Power absorption dependence on frequency of RF wave.

References
1) Jaeger, E.F., et al : Rep. ORNL/TM-10223 (1987).
2) Jaeger, E.F., et al. : Nucl. Fusion 30(1990)505.
3) Masuda, S., et al. : Nucl. Fusion 37(1997)53.