§5. Calculation of Microwave Power Absorption Distribution and Study of Launching Method for the GAMMA 10 Central Cell ECRH

Tatematsu, Y., Saito, T. (FIR, Univ. Fukui),
Imai, T., Minami, R. (PRC, Univ. Tsukuba),
Kubo, S., Shimozuma, T.,
Sakagoshi, Y., Harigae, M., Nakamura, M. (Graduate School of Pure and Appl. Sci., Univ. Tsukuba)

The role of electron cyclotron resonance heating (ECRH) in the central cell of GAMMA 10 is increasing the electron temperature. A new 28GHz, 500 kW gyrotron has been installed in the central-cell ECRH system.[1] Improvement of the launcher with newly designed reflection mirrors has achieved efficient power transmission to the resonance layer.[2-4] In the first stage of the experiments with the newly designed launcher, plasma collapsed after the injection of heating powerful microwave. Before the plasma collapsed, light-emission from top-side wall of the GAMMA 10 was observed. Moreover, asymmetry of electron temperature distribution against the GAMMA 10 axis was observed. They show that something asymmetry causes the plasma-collapse against the microwave injection.

When the microwave with linear polarization is injected from the waveguide in the central ECRH system, the X-mode purity is 69 %. Since O-mode component of the microwave is little absorbed by electrons under the present central-cell plasma density and temperature, it penetrates the fundamental resonance layer, reaches the top-side wall of the vacuum vessel and is finally absorbed to plasma at unexpected positions. To increase microwave power deposition on the resonance layer and to reduce the power transmitting through the resonance layer to reach the wall, a polarizer has been designed and installed on the way of the transmission line to control the incident wave mode.[1,5]

The launcher was designed to make the beam cross section circular on the plane perpendicular to the GAMMA 10 axis at the position where the magnetic field strength is a little larger than exact resonance magnetic field strength 1T for 28 GHz frequency, taking account of Doppler shifted resonance. Since the microwave is obliquely injected from the bottom-side of the GAMMA 10, the profile of the power deposition is not circular, even if the beam cross section is circular around the GAMMA 10 axis in vacuum. To calculate actual spatial distribution of power absorbed to plasma, wave dispersion equation is solved.

Figure 1 shows the calculation results. On-axis electron density n is assumed as $2x10^{12}$ cm^{-3}. Power deposition was calculated for two cases of electron temperature Te= 100 and 500 eV. In Fig.1, imaginary part of wave index k_i, magnetic field strength B, beam intensity I and power deposition P are plotted for the center ray of the heating beam. For Te = 100 eV plasma, power absorption starts around Z = -246 cm and ends at Z = -244 cm. For Te = 500 eV, it starts around Z = -248 cm and ends at Z = -245 cm. Thus, the absorbed region is a little apart to high field side for the exact resonance point (B = 1 T) Z = -243 cm, even if for low temperature (Te = 100 eV) case. Figure 2 shows calculated spatial power deposition in vertical axis, X, along some rays. The attached numbers show the vertical radiuses of the rays from the beam center. It shows that power absorption is larger in X < 0 and the spatial distribution becomes non-axisymmetry against the GAMMA 10 axis for high Te case.

When Te is low just after ECRH-on, plasma is heated almost axisymmetry. However, after increase of Te, the resonance position shifts downward from the GAMMA 10 axis and asymmetric heating occurs. Thus, to keep the heating area symmetry, one way is heading up the beam direction and another way is to change the heating configuration to inject the beam almost parallel to the GAMMA 10 axis.[3]

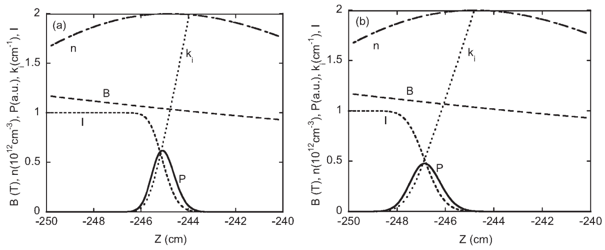

Fig. 1. Calculation results of solving plasma dispersion equation with the density $n = 2x10^{12}$ cm^{-3}. (a) Te = 100 eV, (b) Te = 500 eV.

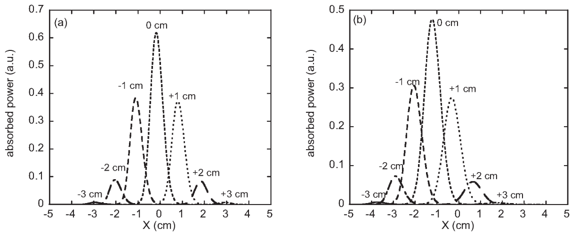

Fig. 2. Spatial distribution of power deposition along some rays with different radius of the beam in the vertical plane. (a) Te = 100 eV, (b) Te = 500 eV.

1) Y. Tatematsu, T. Saito, O. Watanabe et al., Transaction of Fusion Science and Technology **51** (2007) 400.
2) Y. Tatematsu, T. Cho, H. Higaki et al., Journal of the Korean Physical Society **49I** (2006) S406.
3) Y. Tatematsu, N. Machida, T Saito et al., Japanese Journal of Applied Physics **45** (2006) 7911.
4) N. Machida, Y. Tatematsu, T. Saito et al., Transaction of Fusion Science and Technology **51** (2007) 406.
5) R. Minami, Y. Tatematsu, T. Imai et al., Transaction of Fusion Science and Technology **51** (2007) 403.