§10. Three-Dimensional Analysis of the Propagation of ICRF Waves in the GAMMA 10 Central Cell

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One of the main concerns for the GAMMA 10 experiments is the production of higher density plasmas more than 10^{19} m^{-3}. Although high ion-temperature above 10 keV has been realized, the density is relatively low ($\sim 10^{18}$ m^{-3}) on such a high-temperature discharge. In the axisymmetric central cell, Ion-Cyclotron Range of Frequency (ICRF) antenna is coupled to the fast Alfvén wave for the plasma production. However, saturation in the plasma density has been observed when Nagoya Type-III antenna (~10 MHz: $\omega/\omega_{ci} \sim 1.6$) is used for plasma production. In the present operating conditions, plasmas are in the order of the wave length in size. So, the wave excitation is strongly affected by the boundary condition, such as the dimension of the plasmas and the antenna configuration. To investigate the optimum antenna configuration, Double Half-Turn (DHT) antenna was additionally used for plasma production[1)]. The experiment was performed to control the phase difference of a pair of DHT and adjacent Type-III antennas. With the optimum phase difference of $\Delta\phi \sim 0$, the density considerably increases ($\sim 5 \times 10^{18}$ m^{-3}) with the applied RF power. Even if DHT and Type-III antennas are driven with different frequency (DHT: 10.0 MHz, Type-III: 10.3 MHz), the density saturation is also released.

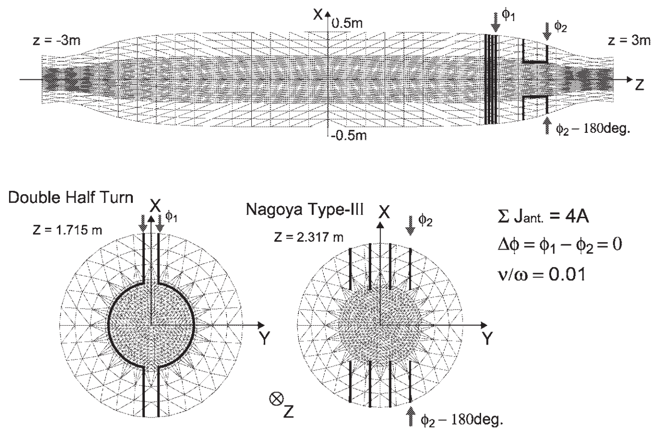

Fig. 1. Finite element mesh of the central cell. Configuration of Nagoya Type-III and Double Half-Turn antennas are shown.

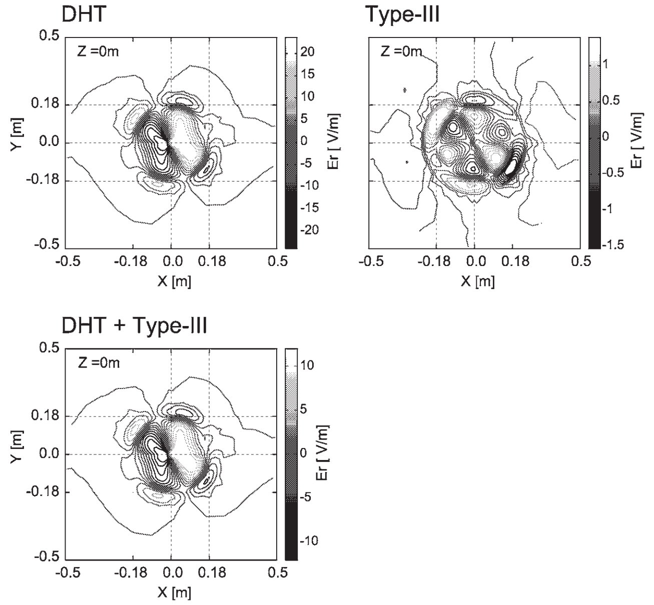

Fig. 2. The calculated profile of the radial component of the wave electric field. It is clearly shown that DHT antenna excites m=1 mode, and Type-III antenna excites m=3 mode at the core plasma region. In the case of DHT + Type-III (the phase difference between two antennas is $\Delta\phi = 0$), m=1 mode is dominantly excited.

In this study, the effect of the antenna structure to the wave excitation is numerically evaluated by use of a three-dimensional full wave code (PAF/WF3). This code solves the Maxwell's equations as a boundary-value problem using the finite element method. In the calculations, it is assumed that the cold and inhomogeneous plasmas surrounded by the conducting walls. The effect of the collisions is taken into account in the dielectric tensor. Figure 1 shows the generated finite element mesh. The profiles of the magnetic field and the plasma density, and the structure of ICRF antennas are precisely included. The results of the calculations are shown in Fig. 2. The radial electric field profile is plotted on the x-y plane. It is found that DHT and DHT + Type-III (with the phase difference of $\Delta\phi = 0$) antennas strongly couple to m = +1 mode at the core plasma region. Type-III antenna couples to m = + 3 mode. The profile of the absorbed power is also evaluated. When the DHT antenna is used, the waves are excited with large amplitude and absorbed in the core plasma region. On the other hand, the power absorption concentrates near the antenna in case of Type-III antenna. It is suggested that the strong excitation of the waves in the core plasma region is effective for high density plasma production.

1) Yamaguchi, Y., Transactions of Fusion Science and Technology **55** (2009) 2T 106