§17. Wave Excitation in the Anchor Cell of GAMMA 10 with Nonaxisymmetric Configuration

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To control high performance plasmas with ion cyclotron range of frequency (ICRF) waves is one of the main subjects in GAMMA 10. The high end-loss particle and heat fluxes are required for the boundary plasma research, such as divertor simulation experiments. The study of wave excitation and propagation in the nonaxisymmetric mirror configuration is important because the formation of high-pressure plasmas in the anchor cell is required for Magneto-Hydro-Dynamic (MHD) stabilization. In the standard discharge, ICRF waves excited by Nagoya Type-III antennas in the central cell propagate to anchor region and heat ions at the ion cyclotron resonance layer. Three sets of Double Arc Type antennas are installed in the central side of the east and the west anchor cells, and in the end side of the west anchor cells; EAI-DAT, WAI-DAT, WAO-DAT antennas, respectively. The direct-anchor-heating experiments with phase-controlled antennas in the central and anchor cells have been performed.[1)]

By use of a three-dimensional full wave code (TASK/WF3), the wave excitation in the central cell and the anchor cell have been studied to analyze the experimental observations in GAMMA 10. This code solves the Maxwell's equation for the wave electric-field as a boundary-value problem using the finite element method. In the model, it is assumed that a cold and inhomogeneous plasma is surrounded by conducting walls. The power absorption through the collisional damping is described by introducing effective collisions in the dielectric tensor.[2)]

In Figure 1, as an example, the phase-difference dependence of the normalized line-integrated density in the central cell and the SED signal in the anchor cell using the WAI-DAT antennas are shown. Increase of the central line-density and effective anchor heating is observed near the phase-difference of $\pi/2$ in the case of EAI-DAT and WAI-DAT antennas. For WAO-DAT antennas, the phase-difference of 0 indicates high density and effective heating. On the other hand, using the ICRF wave excitation obtained by TASK/WF3, the absorbed ICRF powers are calculated by dividing into three regions. The phase-difference dependence of the absorbed power in each region using WAI-DAT antennas is shown in Fig. 2. In the Right side, which means the anchor cell including ICRF resonance layer, the absorbed power becomes large near the phase difference of $\pi/2$; it is consistent with the observed results in the experiments. In the case of EAI-DAT, the magnetic configuration is geometrically same with WAI-DAT, so that result is same as WAI-DAT one. For WAO-DAT antennas, ICRF resonance layer is exist between antennas, and the largest absorbed power is obtained near the phase difference of 0, as the same as experiments.

Experiments and calculations demonstrate that, more effective anchor heating is expected owing to interactions between excited waves by antennas in the central and anchor cells. The optimization with the wave analysis for the high-density plasma production experiments is continuing.

1) T. Yokoyama, M. Ichimura, A. Fukuyama, et al., “Analysis of wave excitation of the phase-control ICRF antennas with theree dimensional full wave code on GAMMA 10”, 10th International Conference on Open Magnetic Systems for Plasma Confinement, Daejeon, Korea, Aug. 26-29, 2014, OS4-12.
2) T. Yokoyama, M. Ichimura, A. Fukuyama, et al., “ICRF wave analysis in the minimum-B configuration on GAMMA 10 with three-dimensional full wave code” Plasma Conference 2014, Toki, Nov. 18-21, 2014, 20PA-052.

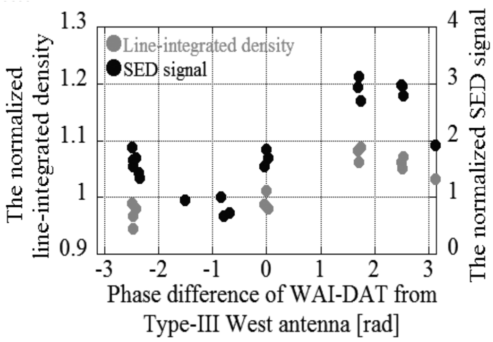

Fig.1 Phase-difference dependence of the normalized line-integrated density in the central cell and the SED signal in the anchor cell in cases of WAI-DAT antennas are used.

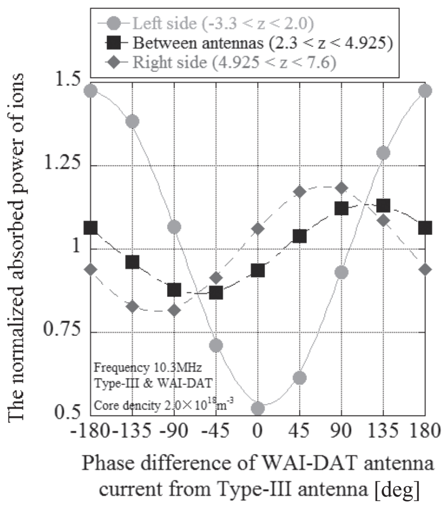

Fig.2 Phase-difference dependence of the calculated ICRF absorbed-power in cases of WAI-DAT antennas are used. The absorbed powers are calculated in three region; Left side of antennas, Between antennas, and Right side of antennas.