§8. Three-Dimensional Analysis of ICRF Wave Excitation on GAMMA 10

Fukuyama, A. (Kyoto Univ.), Ichimura, M. (Univ. Tsukuba), Yamaguchi, Y. (Fukui Univ.)

In GAMMA 10, the formation of high pressure plasmas in the anchor cell is required for Magneto-Hydro-Dynamic (MHD) stabilization. In standard discharges, ion cyclotron range of frequency (ICRF) waves excited by Nagoya Type-III antennas (east and west) in the central cell propagate to both anchor regions with the minimum-B field configuration and heat ions at ion-cyclotron resonance layer. In future, replacement of the west anchor cell to axisymmetric mirror cell with a diverter configuration is planned. To keep MHD stabilization with only east anchor cell, more effective anchor heating is needed. A bar-type antenna has been installed in the minimum-B well region, where magnetic flux tube has a vertically long elliptical cross section. By use of a three-dimensional full wave code (TASK/WF3), the wave excitation with the present bar-type antenna is studied. In Fig.1, loading resistances of the present antenna are plotted as a function of applied frequency. The frequency around 10 MHz is needed for the ion heating near the midplane of the minimum-B field configuration. The direct anchor heating with the frequency of 9.7 MHz (RF3) has been tested and improvements of plasma parameters have been observed in last year [1,2]. As shown in the figure, the loading resistance at the frequency of 9.7 MHz is very small under the present experimental conditions. Because it is difficult to measure profiles of the magnetic field strength and plasma parameters on the minimum-B field in axial and radial directions, the optimization of antenna configuration (location, shape and so on) is not so easy. The design of a new ICRF antenna with the three-dimensional wave code is started.

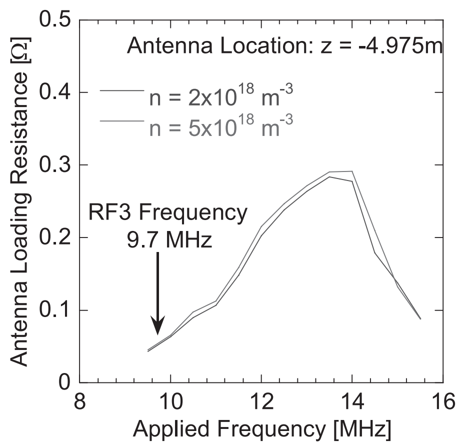

Fig. 1. Loading resistances of the present anchor antenna as a function of applied frequency. In the experiments, the frequency of 9.7MHz is used.

In 2010, experiments with phase-controlled antennas in the central and anchor cells have been performed. It will be expected to obtain more effective anchor heating owing to interactions between excited waves by Nagoya Type-III and bar-type antennas. Figure 2 shows effects of the phase differences on plasma parameters during a discharge. The line density and diamagnetic signal are plotted in Fig. 2(a) and detected phase differences are shown in Fig. 2(b). When phase differences are in positive region, significant increase of the line density is clearly observed. When the differences are in negative region, the increase of the diamagnetic signal is observed. In the positive case, excited waves are estimated to propagate in the direction outward of both antennas (to the midplane of the anchor and central cells). Waves are localized between both antennas when differences are in the negative region. The electron heating is also observed in this region. At present, the mechanism of the electron heating is unknown. Analysis with the three-dimensional wave code and more precise experiments are needed.

[1] Y. YAMAGUCHI, M. ICHIMURA, A. FUKUYAMA, et al., J. Plasma Fusion Res. SERIES, Vol. 9, 23-28 (2010)

[2] Y.Yamaguchi, M.Ichimura, T.Yokoyama, A.Fukuyama, et al., Fusion Science and Technology, 59, No.1T (2011) 253-255.

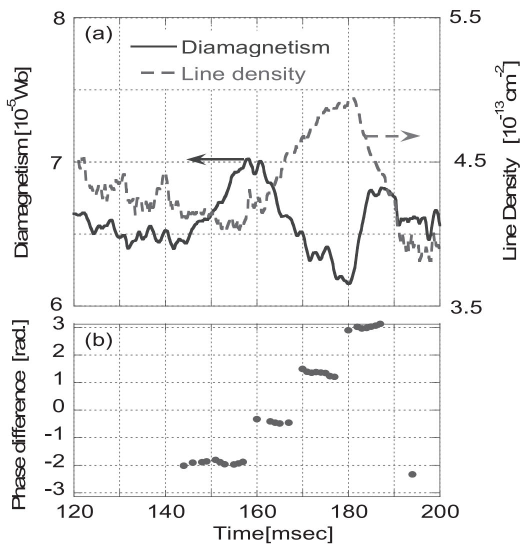

Fig.2. (a) Effects of the phase difference on line density and diamagnetic signals during a discharge, (b) detected phase differences.