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

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Ion-Cyclotron Range of Frequency (ICRF) waves play important rolls in the production, heating, and stabilization of the plasmas in the GAMMA 10 tandem mirror. For optimum application of ICRF waves, the process of the wave excitation, propagation, and absorption should be investigated. In this study, a new full-wave code (PAF/WF3) is introduced for the precise analysis of ICRF waves in the minimum-B anchor cell of GAMMA10. PAF/WF3 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. It is applicable to the configurations which have three-dimensional inhomogeneity.

In the anchor cell, high pressure plasmas are produced by the ion-cyclotron resonance heating to stabilize the interchange mode. The fast wave is excited with the Nagoya Type-III antenna in the axisymmetric central cell and propagates to the anchor cell. A part of the fast wave is mode-converted to the slow wave in the non-axisymmetric transition region between the central and the anchor cells. The slow wave is absorbed at the ion-cyclotron resonance layer and heats ions in the anchor cell. In order to see the mode conversion of the propagating waves, the right-handed and the left-handed circularly polarized components of the wave electric field are calculated.

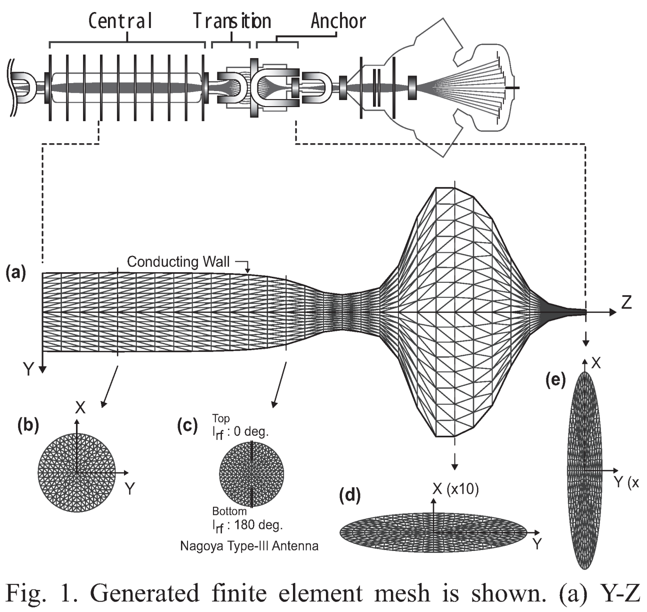

Fig. 1. Generated finite element mesh is shown. (a) Y-Z cross section (b) X-Y cross section at Z=0. (c) The shape of the Nagoya Type-III antenna. (d), (e) X-Y cross section of the non-axisymmetric transition region.

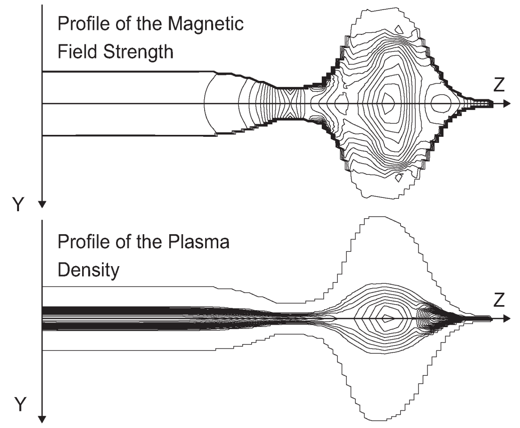

Fig. 2. The profiles of the magnetic field and the plasma density used in the calculation.

Figure 1 shows the generated finite element mesh. The magnetic field and the density profiles are given in Fig. 2. The results of the calculations are shown in Fig. 3. It is clearly shown that the wave propagates from the central to the anchor cell, and absorbed at the ion-cyclotron resonance layer. The polarization reversal from the right handed one to the left handed one occurs in the region which have a magnetic flux tube with the elliptical cross-section. The efficiency of the mode-conversion is estimated for the first time in the present experimental condition.

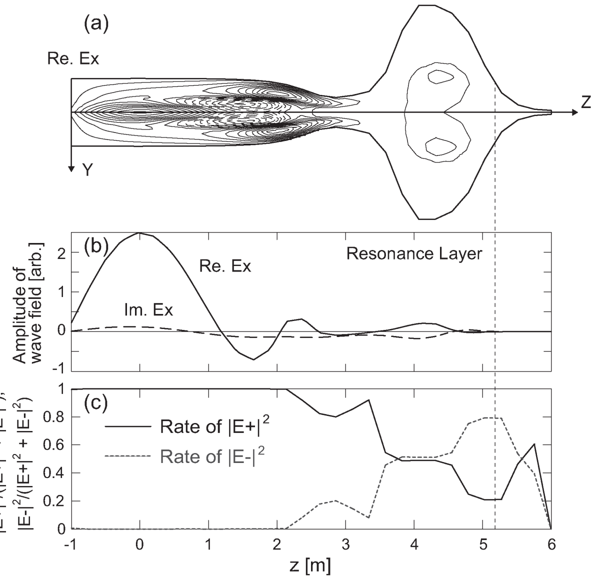

Fig. 3. Results of the calculations. (a) Contour plot shows the profile of the excited wave electric field. (b) It is clearly shown that the wave propagates from the central to the anchor cell, and absorbed at the resonance layer. (c) The right-handed (|E+|) and left-handed (|E-|) polarized components are estimated. The efficiency of the mode-conversion is 0.8 at the resonance layer.