§1. ICRF Wave Excitation and Propagation in the Axisymmetrized Tandem Mirror GAMMA 10

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At present, the realization of high-density operation with potential confinement is one of the most important issues on the tandem mirror research. Up to 4 times 10^{12} cm^{-3}, the density increase with the potential formation has been observed in the GAMMA 10 tandem mirror. The plasma production with ion-cyclotron-range of frequency (ICRF) waves is commonly used in both fusion research and plasma applications. In plasmas with a relatively low density (order of 10^{12} cm^{-3}) and a small radius (a few tens cm), the wavelength is in the same order of the plasma size and eigenmodes are formed in both radial and axial directions. Because the wavelength depends strongly on the density, the density is likely to be clamped at the optimum value for the eigenmode formation. The saturation of the density increase is sometimes observed in GAMMA 10. To investigate the eigenmode formation, a two-dimensional wave calculation code has been introduced [1]. The spatial structures of the excited waves are obtained in the axisymmetric mirror field of the GAMMA 10 central cell.

To raise the limit for the density clamping, higher frequency ICRF source (high harmonic fast wave: HHFW), of which frequency is from 6 to 10 times ion cyclotron frequency at the midplane of the central cell, has been used. When HHFW is applied, several eigenmodes with different radial structures will be possibly excited [2] and the restriction of the density clamping will become moderate. The increase of the density from the saturation level has been clearly observed in the experiment [3]. In Fig.1, the amplitude of the wave field measured with a magnetic probe is plotted as a function of the line density. Before applying HHFW, initial plasmas with relatively low density are produced by ICRF waves near the fundamental cyclotron frequency. As shown in the figure, the amplitude of the wave field at 5 times 10^{13} cm^{-2} becomes small. In the experiment, the density clamping is sometimes observed around this value. When the additional HHFW is applied, the density increases continuously above the value and the amplitude of the wave field starts to increase again from the value of 5 times 10^{13} cm^{-2}. A solid line in the figure indicates the calculated amplitude of the wave field in the GAMMA 10 configuration. The eigenmode formation in the axial direction is clearly indicated on both experiment and calculation.

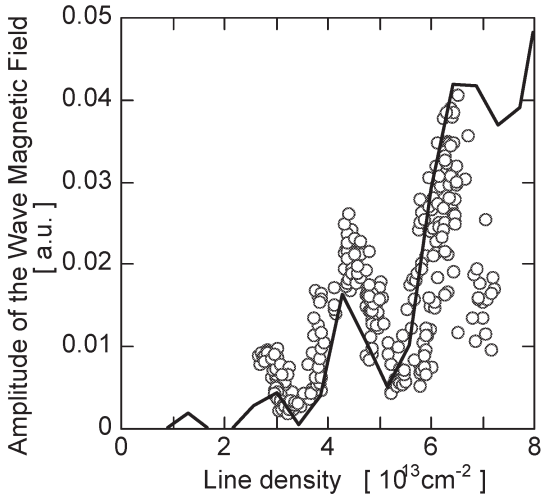

Fig.1 The amplitude of the wave field, measured with a magnetic probe, as a function of the line density. A solid line indicates the calculated amplitude in the GAMMA 10 configuration.

[1] Fukuyama, A. and Ichida, A., Proc. of 1996 Int. Conf. On Plasma Phys., Vol.2, p.1342 (1997).

[2] Yamaguchi, Y.,, et al., Trans. Fusion Sci. and Tech., **47**, 1536 (2005).

[3] Ichimura, M.,, et al., Phys. Plasmas, **8**, 2066 (2001).