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Evaluation of the Non-Axisymmetry of the GAMMA10 Plasma by Using a Segmented Limiter

分割リミターを用いたGAMMA10プラズマの非軸対称性の評価

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Production of high-density and high-temperature plasmas is investigated as one of the main purposes in the GAMA10 tandem mirror. Non-axisymmetry of the plasmas causes radial transport in a mirror configuration. In this study, floating potentials in the vicinity of segmented limiter was measured to evaluate the non-axisymmetry of plasmas. The limiter divided into 8 equal parts in azimuthal direction can measure the azimuthal distribution of the floating potentials on each element installed near the midplane of the GAMMA10 central cell. It becomes clear that non-axisymmetry of the central cell plasma depends strongly on heating systems and their power levels.

1. Introduction

In the GAMMA10 tandem mirror, electromagnetic waves with two different frequencies in the ion-cyclotron range of frequency (ICRF) are used for plasma production and ion heating. For the magneto-hydrodynamic (MHD) stabilization of the whole plasma, ICRF waves are also used at the anchor cells, which are composed of minimum B field and located at both ends of the central cell. Waves in the electron-cyclotron resonance (ECR) frequency are used for the electron heating and the formation of the plasma potential along the magnetic field line. In typical discharges, the formation of non-axisymmetric plasmas has been observed with a medium speed camera placed of the midplane of the central cell though the magnetic field has an axisymmetric configuration[1] Non-axisymmetry of the plasmas causes radial transport of confined particles and deterioration of plasma parameters. In this paper, non-axisymmetry of plasmas in the central cell of GAMMA10 is evaluated from the distribution of the floating potentials on a segmented limiter.

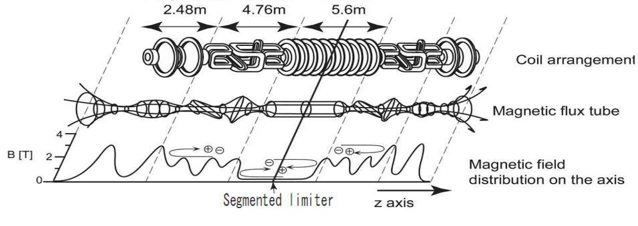

Fig. 1. Magnetic field structure of GAMMA10.

2. Experimental Setup

Figure 1 shows the schematic drawing of the GAMMA10 tandem mirror. A segmented limiter of which diameter is 36cm is installed near the midplane of the central cell. The segmented limiter is divided into 8 equal parts in the azimuthal direction, as shown in Fig. 2. The segmented elements are electrically-insulated from the ground. Thus, the floating potentials and its azimuthal distribution in the peripheral region can be measured. By connecting all segmented elements electrically, we can change the boundary conditions in the peripheral region.

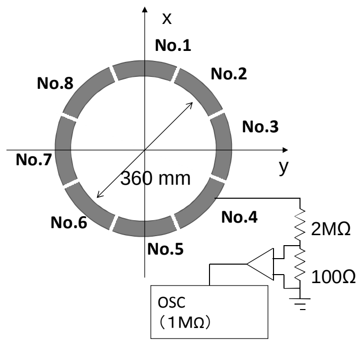

Fig. 2. Configuration of the segmented limiter.

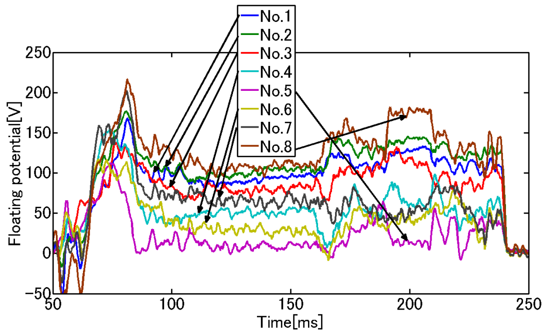

Fig. 3. Temporal evolution of floating potentials on the segmented limiter.

Figure 3 shows the temporal evolution of the floating potentials on each element (from No.1 to No.8). Potential difference more than 100V is observed between No.5 and No.8 elements. We can study the non-axisymmetry of the plasmas from the behavior of these floating potentials.

3. Experimental Results

(a) Reduction of the amplitude of low frequency fluctuations

Two types of low-frequency fluctuations are detected on the floating potential signal. These are drift-type and flute-type fluctuations. Azimuthal mode structure of these fluctuations are analyzed by the phase difference between floating potential signals on segmented elements. The degradation of the plasma parameters due to low-frequency fluctuations is observed in GAMMA10. These fluctuations are also observed with electrostatic probes installed in the central cell. Therefore, we are able to analyze the amplitude and their mode numbers. Drift-type fluctuations of which frequency is around 10 kHz rotate in the direction of the election gyro-motion. As a result, it is clearly observed that the amplitude of the drift-type fluctuation with low-azimuthal mode numbers becomes small, when all segmented elements are connected electrically. The potentials in the peripheral region would become uniform by the connection.

(b) Evaluation of non-axisymmetry of the central cell plasma using standard deviation

The azimuthal distribution of the floating potential is a good indication of non-axisymmetry of the plasmas. Non-axisymmetry of the plasmas in a simple mirror configuration will cause diffusion in the radial direction and degrade plasma parameters. We have evaluated non-axisymmetry of the plasma by calculating the standard deviation of the edge floating potentials from the axisymmetric profile. We have observed the axisymmetry of the plasmas are affected by the heating systems.

(c) Evaluation of mode numbers of the non-axisymmetry in the central cell

In this experiment, non-axisymmetry of the plasmas in the central cell of GAMMA 10 is evaluated with the azimuthal distribution of the floating potentials on each element of the segmented limiter. When ICRF and ECR are used for the experiments, the azimuthal distribution of the floating potentials depends on their injecting powers. We measure the influence of ICRF and ECR on non-axisymmetry of the plasma. The mode numbers of the floating potential in the azimuthal direction are analyzed. We evaluated the non-axisymmetry of plasma by the application of spatial Fourier transformation to 8 floating potentials. Each mode can be represented by 2 variables, which are amplitude and phase, as shown in Fig.4. We can resolve the mode number from m=0 to m=4. Figure 4 shows the temporal evaluation of the amplitude and phase of each mode number.

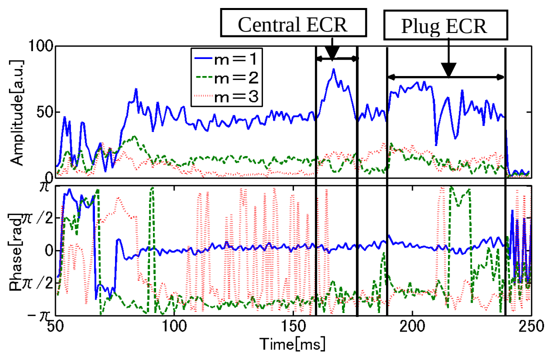

Fig. 4. Temporal evolution of the mode amplitudes and phases.

4. Summary

We have measured the floating potentials on the 8 elements of the segmented limiter, and resolved the non-axisymmetric behavior in azimuthal direction up to m=4 mode by using Spatial Fourier transform. It is found that m=1 mode is the strongest and its phase is shifted with the increase of ICRF power.

Acknowledgement

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References

[1] Y. Nakashima *et al.*, Trans. Fusion Sci. Technol. **55**, No.2T, (2009) 38-45.