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Studies of GAMMA 10 Central ECRH Heating Characteristics by X-ray Measurement

X線計測によるGAMMA 10 セントラル部ECRH加熱特性の研究

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The new ECRH antenna system is installed and the improvement of c-ECRH is expected. But in some cases, the plasma collapse is caused by the c-ECRH. The one reason of the plasma collapse might be the degradation of the plasma stability by non-axisymmetric heating. There may be many other causes. The ECRH in the mirror plasma has to be careful to heating position and heating electron energy range and more for the plasma confinement.

1. Introduction

The tandem mirror plasma confinement device GAMMA 10 studies the plasma physics utilizing the simplicity of linear device for the physics understanding. Figure 1 shows the schematic view of the GAMMA 10. The main plasma is confined in the central cell by the mirror magnetic field and the confining electric potential. The GAMMA 10 is ordinarily operated in the high ion temperature mode [1] for aiming the higher plasma performance by the Ion Cyclotron Resonance Heating (ICRH), which produces and sustains the plasma. Since, the electron temperature is far lower than the ion, the rise of ion temperature is limited by the electron drag. It is necessary to confine the high temperature ions for achieving the nuclear fusion. Furthermore, the high temperature ions are needed to obtain high heat flux for the recent GAMMA 10 PWI studies. It is very important to suppress the electron drag. So, the Electron Cyclotron Resonance Heating (ECRH) is employed for raising the electron temperature and suppressing the electron drag in the central cell [2].

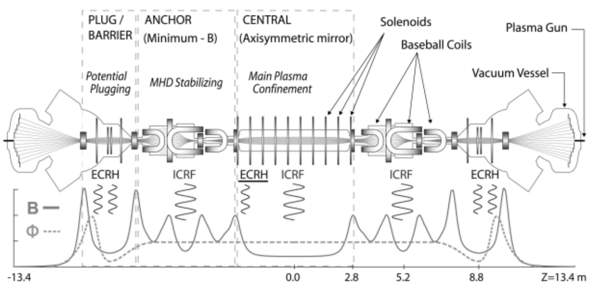

Fig.1. The schematic view of the GAMMA 10

The soft X-rays are radiated from EC heated electrons by the bremsstrahlung. The soft X-ray intensity has the information of electron temperature and density. The effects of ECRH can be clarified by measuring the soft X-ray intensity.

In case of some experimental settings, by the central cell (c-) ECRH, the plasma collapse is caused by degrading the plasma comfinement in spite of raising the electron temperature. For solving the issue, this study aims to clarify the heating characteristics and optimize the c-ECRH by the X-ray measurement.

2. Experimental Apparatus

For c-ECRH, The 28GHz wave propagates the corrugated waveguide as HE_{11} mode from gyrotron. The wave polarization is controlled by the miter bend polarizers before the EC wave reaches vacuum vessel. The EC wave is polarized to 100% X-mode in the section 3. Figure 2 shows side view of the c-ECRH antenna system. The EC wave which is polarized to X-mode propagates to the axis of cylindrical plasma at B=1T from strong field for fundamental resonance heating.

The soft X-ray measurement is employed for investigating the effect of ECRH by the Micro Channel Plate (MCP) in the central cell. The MCP is composed of a lot of channels that is the secondary electron multiplier and installed at the upper side of the central cell. The MCP investigates the time evolution of the integrated soft X-ray intensity and has radial resolution of about 1.8 cm because it employs the separated MCP and the collimator.

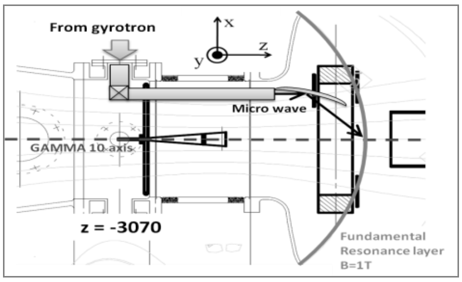

Fig.2. The side view of the c-ECRH antenna system.

3. Experimental Results

The new direct injection antenna system (Fig. 2) is installed in this year because the wave polarization changed due to the wave pass problem and could not be controlled in the previous antenna system. In addition, the O-mode micro wave generates the hot electrons and degrades the plasma comfinement [3]. The improvement of c-ECRH by the new antenna system is expected.

The experimental results where the c-ECRH injects the two similar plasmas are examined. Figure 3(a) shows the time evolution of the diamagnetism and the line density. In Fig. 3, the c-ECRH is injected during the shaded region. By the c-ECRH, the diamagnetism increases in #219359. On the other hand, in #219410, the plasma collapse is caused in spite the similar plasma. Figure 3(b) shows the time evolution of Line Intensity of Soft X-ray (IsxL). In #219410, the IsxL increases immediately after the injection and then decreases by the plasma collapse. So, the c-ECRH raises the electron temperature but the plasma confinement degrades.

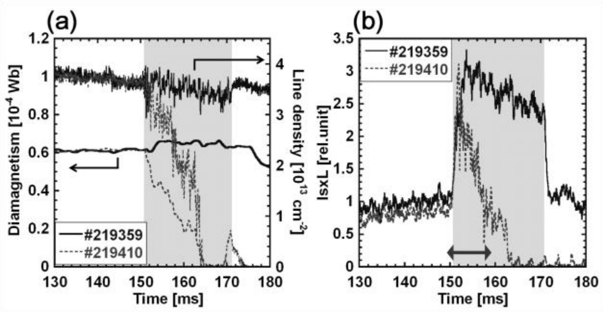

Fig.3. The time evolution of (a) Diamagnetism, Line density and (b) IsxL. The c-ECRH is injected at shaded region.

Figure 4 shows the time evolution of radial IsxL distribution in the range of arrow interval in Fig. 3(b). In #219410, the radial IsxL distribution is oscillated spatially in contrast to #219359 as shown in Fig. 4. The plasma stability degrades and then the plasma collapse is caused by the c-ECRH. The one reason of the plasma collapse might be non-axisymmetric heating because the IsxL profile increases symmetrically by the c-ECRH in #219359 but the negative side IsxL increase more than the positive side in #219410 as shown in Fig. 5.

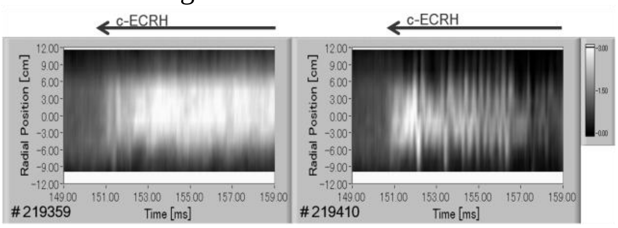

Fig.4. The time evolution of radial IsxL distribution seems to be oscillated spatially in #219410.

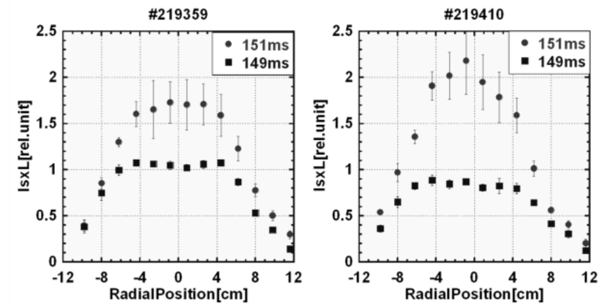

Fig.5. The radial IsxL distribution at immediately before (149ms) and after (151ms) the c-ECRH.

4. Summary

The improvement of c-ECRH by the new antenna system is expected. In some cases, the diamagnetism increases but in other cases, the plasma collapse is caused by the c-ECRH in spite of the injection into similar plasmas. The one reason of the plasma collapse might be the degradation of the plasma stability by non-axisymmetric heating. There may be many other causes like the plasma confinement degradation by the difference of heated electron energy range and/or enhancement of the ion transport due to the non-axisymmetric potential formation. The ECRH in the mirror plasma has to be careful to heating position and heating electron energy range and more for the plasma confinement. It would be required to analyze data in more detail to see these physics and to optimize the ECRH.

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References

[1] Y. Kiwamoto et al.: Plasma phys. Control. Fusion **39** 5A (1997) 381.
[2] T. Imai et al.: Trans Fus. Sci Tech. **51** 2T (2007) 208.
[3] H. Iizumi et al.: 27th JSPF Annual Meeting 30P29.