§2. Improvement of Plasma Performance by Strong ECH with High Power Gyrotron

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An Electron Cyclotron Heating (ECH) has many advantages both in physics and technology on its application to the reactor. It is a key tool for plasma start-up, electron heating, current drive and plasma control. From the technological view point, it has quite flexible launching system and high power density transmission capability. In case of GAMMA 10, tandem mirror device, the ECH is indispensable to get high ion confining potential and high electron temperature. For the purpose of the research of plasma potential physics and high power gyrotron development for LHD, power upgrade of 28GHz gyrotron have been explored on GAMMA 10 ECRH system, based on the power scaling of potential formation[1] and gyrotron technology developed for ITER[2]. The first two years of this program were devoted mainly to the power increase of the central cell ECH and improvement of the antenna and transmission line. The initial experiment there gave the comparatively efficient electron heating of several hundred eV temperature increase. More than 400 kW from the central ECH gyrotron at MOU (Matching Optics Unit) was obtained[3]. This year, the final year, in addition to the further improvement of the ECH gyrotron system, the study of the correlation among the fluctuations, potential and transport during high power ECH.

The stray RF which is generated from diffraction loss in the gyrotron affects the performance of the gyrotron and ECH system. The pressure increase with and without the SiC stray RF absorber in the MOU during the microwave power transmission is shown in Fig. 1. The RF discharge due to the stray RF increases the pressure in the MOU in case of without SiC but it is seen that the discharge is completely suppressed by SiC absorber . As the result, it enabled the high power injection of 350 kW. As for the transmission line improvement, the new polarizer of miter bend type with two grooved mirrors, which has more flexibility, was developed and installed in the central ECH transmission line. The waveguide filter to suppress the higher order mode and stray RF was also inserted to the transmission line and increased the high power capability of the transmission line[3].

It has been observed that the drift type fluctuations are suppressed with the potential/electric field structure change in GAMMA10. Since the ECH is the key tool to control potential structure[4], the further study of the fluctuation and transport in the relation with potential structure in high power central ECH plasma. The radial particle flux Γ_r produced by the *ExB* drift of the fluctuated particles is written as,

$$\Gamma_r = \frac{-2}{B_z}\int k_\theta \gamma \tilde{n}\tilde{\phi}\sin\alpha_{n\phi}d\omega.$$

The k_θ, γ and $\alpha_{n\phi}$ is the wave number, coherency and phase difference. The fluctuations were measured from the gold neutral beam probe in the central cell. The estimated Γ_r is not zero and dW/dt $\propto -\Gamma_r$ is mostly satisfied. In addition, It was observed that the fluctuations were suppressed by the application of the plug ECRH. This suppression of the fluctuation is clearly observed even with high power central ECH as seen in Fig. 2. The application of the plug ECH made the central potential high and the fluctuation became small, while the fluctuation did not decrease without plug ECH. These results indicate the potential structure (e.g. gradient E field) controlled by plug ECRH plays the key role to suppress fluctuation which affects the transport and confinement.

The outcome of this collaboration has been used already in the collaboration on the LHD 1MW 77GHz gyrotron development between NIFS and Univ. of Tsukuba. 1MW power was achieved in short pulse and long pulse operation for 3~5sec. has been done in 500~800 kW level. The obtained results of the fluctuation and potential structure physics is generally important for magnetic confinement system and is expected to contribute greatly to the LHD experiments by the combination of the gyrotron which is now being developed as mentioned.

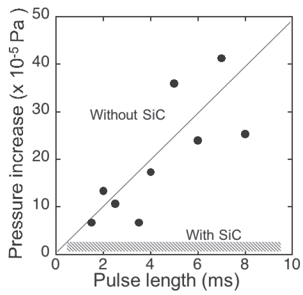

Fig. 1 Pressure increase during the high power transmission in MOU with and without SiC..

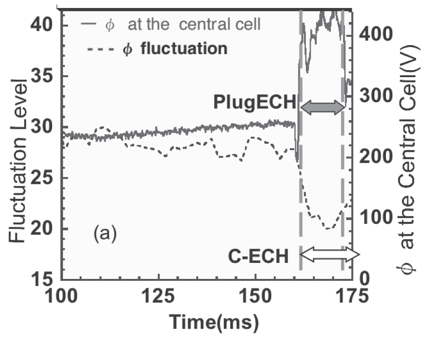

Fig. 2 Time behavior of the potential and fluctuation.

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