§1. Studies of Plasma Potential Formation and Confinement and Effects of Radial Electric Field Structure on Transport

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Studies of effects of radial electric field structure on transport are important for fusion plasma researches. In the GAMMA 10 tandem mirror, the plasma confinement is achieved by not only a magnetic mirror configuration but also positive and negative potentials at the plug/barrier region by electron cyclotron heating (ECH). The main plasma confined in the central cell of GAMMA 10 is produced and heated by ion cyclotron range of frequency (ICRF) waves. The typical electron density, electron and ion temperatures are about 2×10^{18} m^{-3}, 0.1 keV and 5 keV, respectively. Suppression of density and potential fluctuations by applying ECH is observed in GAMMA 10.

In order to study the improvement of plasma confinement due to the potential formation, a multi-channel microwave interferometer and an ultra-short pulse reflectometry have been developed. The radial profiles of the electron density and its fluctuations can be measured in a single plasma shot. Moreover, the potential and its fluctuations are measured by using a gold neutral beam probe system (GNBP) in the central cell.

The potential in the central cell is also raised when the plug potential is formed in the plug regions. The progress of high potential formation will give bases for the formation of a strong shear of the radial electric field E_r. In the absence of plug-ECH (P-ECH), a weaker E_r shear is observed. Figure 1 shows the amplitude of the potential fluctuation and the potential in the central cell. Integrated values of the fluctuation due to low frequency turbulence are plotted. It is found that the potential increases suddenly and the potential fluctuations are significantly reduced during the application of P-ECH. The time evolution of Fast-Fourier-Transformed (FFT) fluctuation powers of the line-integrated densities at each line of sight in the multi-channel interferometer is measured. The radial potential profile is measured by using GNBP, and the radial profile of electric field shear during the application of P-ECH is estimated. The fluctuation suppression due to strong radial electric field shear is observed during P-ECH. Moreover, the local density fluctuation (r ~ 12 cm) is measured by using the ultra-short pulse reflectometry system. The suppression of the local density fluctuation is also observed due to the formation of the confinement potential with the application of P-ECH. These are the clear results for the fluctuation suppression by the potential formation.

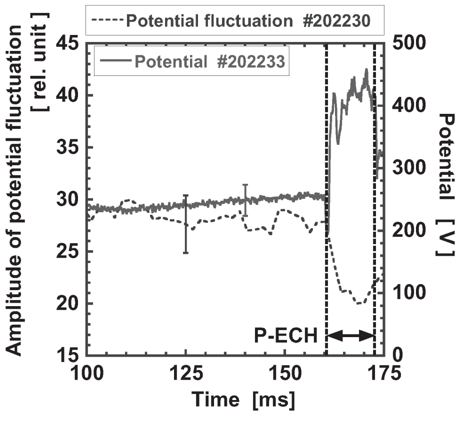

FIG. 1. The time evolution of the amplitude of the potential fluctuation (Solid line) and potential (Dotted line) in the central cell

The particle flux can be evaluated from the phase differences between the potential and density fluctuations by GNBP. Figure 2 shows the time evolution of diamagnetism (solid line) and radial particle flux near the plasma center (dotted line). The changes of the diamagnetism and the particle flux correlate with each other and are in the frequency of around 100 Hz. For example, the particle flux starts to increase at 135 ms and the diamagnetism changes to a decreasing phase from 138 ms. Next, the particle flux changes to the decreasing phase at 139 ms, then the diamagnetism changes to the increasing phase at 141 ms. It is found that the radial particle transport due to the fluctuations measured by GNBP affects the decrease in the plasma stored energy.

High power gyrotrons with TE4,2 cavity at 28 GHz and efficient microwave transmission systems have been developed for such high potential formation and efficient electron heating experiments. The maximum outputs of 570 kW at 28 GHz from the gyrotron were obtained. It is found that the reduction of the stray RF (diffraction loss) is effective to improve gyrotron performance. Installation of the polarizer in the transmission line enhanced the performance of the ECH system in GAMMA 10, which is the first result which clearly showed ~100% X-mode excitation is a key to design the efficient fundamental ECH system in mirror devices.

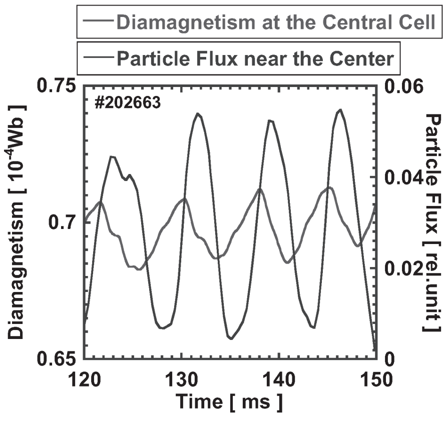

FIG. 2. Time evolution of diamagnetism and radial particle flux evaluated from the phase difference between potential and density fluctuations.