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

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The control of an internal and/or edge transport barrier (ITB and ETB) is a key to improve confinement and edge plasma/wall heat load reduction. A radial electric field structure is said to play an important role in this barrier. Therefore, studies of effects of radial electric field structure on transport are crucial issues for fusion plasma researches. The GAMMA 10 is the world largest tandem mirror, and the plasma confinement is achieved by a magnetic mirror configuration as well as positive and negative potentials at the plug/barrier region by electron cyclotron heating (ECH). Mirror devices having open magnetic-field lines provide advantages for the control of radial potential structures through the modification of axial particle-loss balance by end-plate biasing and/or by ECH. Therefore, mirror-based systems enable the experimental study of the influence of the electric field shear or sheared flows on fluctuations and the associated anomalous cross-field transport in magnetized plasmas. This is the main subject of the GAMMA 10 and the development of high power gyrotron for its ECH source, main tool for this experiment, is the associated theme, too. 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.

It was found previously that the plug ECH (P-ECH) suppresses the drift type wave through the formation of the radial electric field [1]. The power dependence of the fluctuation level has been investigated. The radial profiles of the electron density fluctuations, the potential and its fluctuations are measured by using a multi-channel interferometer and a gold neutral beam probe system (GNBP) in the central cell[1]. It is clearly seen that the potential profile changes from concave shape without P-ECH to the convex one with P-ECH, namely, from negative to positive electric field. In the range of 100-350 kW, qualitative profile is similar with P-ECH and the fluctuations are suppressed. The figure 1 shows the dependence of the fluctuation power level on the radial electric field, where the data with various plug ECH power are plotted including those without P-ECH. It is seen that the positive electric field suppress the fluctuations, while the fluctuations survive in the state of the negative electric filed. Since the positive radial electric field is the opposite direction of the diamagnetic direction, it is concluded that the change of the radial structure of the drift velocity and/or the drift velocity reduction by the EXB drift suppresses the drift type fluctuations and hence the anomalous transport[2].

The Thomson scattering system using YAG Laser has been installed to GAMMA 10 for T_e measurements, since it is difficult to get T_e by SX during high power ECH and the increased importance of the T_e for the next GAMMA 10 research of divertor simulation studies. The conditioning of the Thomson system is underway. The preparative divertor simulation studies have been started. In preliminary experiment of the E-Divertor simulator using open end of the mirror, the heat flux of 8 MW/m^2 has been obtained[3].

As for the development of the gyrotron for the potential control tool, 1MW gyrotron program has started after the success in 28 GHz-0.5 MW gyrotrons developement and high ion confining potential formation. In MW program, we do collaborate with NIFS. 77GHz 1MW gyrotron for LHD started from 2006. Up to now, more than 1.5 MW power with more than 1 second, and 1 MW, 5 second operation has been achieved[3]. In the development of 1MW-28 GHz gyrotron for GAMMA 10, the 1 MW has been demonstrated in short pulse and long pulse test will be done soon[3].

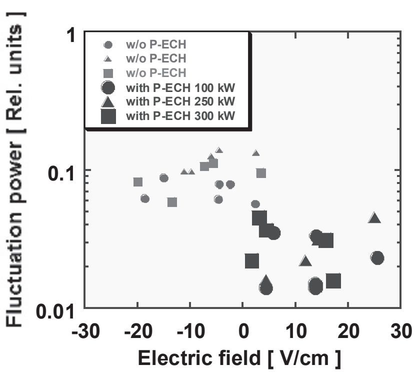

FIG. 1 The dependence of the drift type fluctuations on the radial electric field, where various plug ECRH power discharge are included

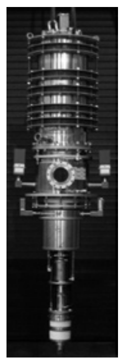

FIG. 2. .The picture of the 28 GHz 1MW gyrotron for GAMMA 10, which demonstrated the 1 MW power.

[1] M. Yoshikawa, et. al ., Trans. of Fusion Sci. and Tech. **55**, 2T, 19 (2009).
[2] M. Yoshikawa, et al., 51st Annual Meeting of the APS DPP, Nov. 2-6, 2009, Atlanta, GA, [Invited].
[3] T. Imai, et al., 51st Annual Meeting of the APS DPP, Nov. 2-6, 2009, Atlanta, GA, [Invited].