§2. 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 transport control. 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. 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), as shown in Fig. 1. 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.

At first, concerning the suppression of the drift type fluctuations, it was reported previously, the ECH likely to suppress the drift type wave. To see more about this physics, 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]. Low Frequency spectra with and without ECH at the several radial points from the measurements of the multi-channel interferometer are shown in Fig. 2. The drift type fluctuation about 9 kHz was clearly suppressed with ECH. Similar results were observed from the measurements of the GNBP. Though we had the indication of the effect of the radial electric field and/or its shear on the suppression, it is assumed the Gaussian profile of the potential in that analysis. The detail comparison between the suppression of the drift-type fluctuations and the electric field and the profile of the electric field determined from the experimental data is necessary and will be done in the coming experiments.

The effect of the drift wave-type fluctuations on the anomalous radial transport was studied further. The drift-wave type fluctuations were measured from the GNBP. The radial particle flux was estimated from the phase differences between the potential and density fluctuations. The time evolution of the diamagnetism and the particle flux clearly correlate with each other, indicating the drift wave type fluctuations cause the anomalous transport [2].

As for the development of the gyrotron for the potential control tool, 0.5 MW gyrotrons with TE4,2 cavity at 28 GHz have been developed and we obtained more than 2 kV of ion confining potential in proportion to the gyrotron power. After this, 1MW gyrotron program has started. In the MW gyrotron development, we do collaborate with NIFS. The collaboration to develop 77GHz 1MW gyrotron for LHD started from 2006. Up to now, more than 1MW power, and 5 second operation with 750 kW has been achieved[3]. 1MW-28 GHz gyrotron for GAMMA 10 has been designed and manufactured. The test of the 28 GHz tube will be done soon.

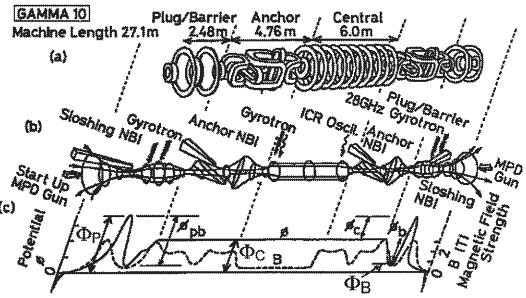

FIG. 1 GAMMA 10 tsndem mirror device.

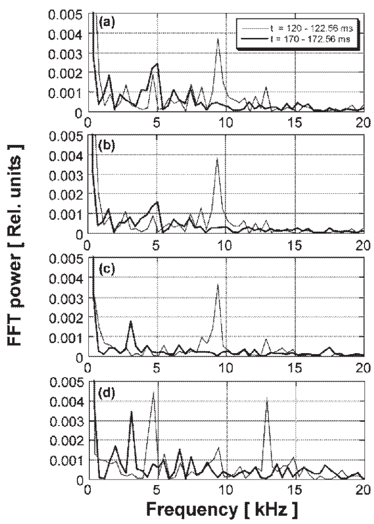

FIG. 2. .The density fluctuation spectra measured from the multi-channel interferometer in the various radial positions. (a) x = 0, (b) 0.03m, (c) 0.06m, (d) 0.09m.

[1] M. Yoshikawa, et. al ., Trans. of Fusion Sci. and Tech. **55**, 2T, 19 (2009).
[2] Y. Miyata, et. al., Trans. of Fusion Sci. and Tech. 55, 2T, 168 (2009).
[3] T. Imai et al., Proc. 22th IAEA Fusion Energy Conf. (Geneva, 2008) , IAEA/FT/P2-25. (2008).