§1. Studies of the Divertor-simulating Boundary Plasma and Transport Control in Making Use of Open End Magnetic Field and Effects of Electric Potential and Field

Imai, T., GAMMA 10/PDX Group (Univ. Tsukuba)

Many progresses of novel research activities in Plasma Research Center have been obtained in FY 2012. As the magnetic field of the Scrap Off Layer (SOL) plasma in torus system crosses the first wall, the mirror configuration resembles the edge (SOL) plasmas. The control of both core and edge plasma transport is a key to achieve both good confinement and practical wall heat load on the fusion reactor. Since the electric field structure/profile affects the plasma flow in both radial and axial directions, studies of effects of electric field structure on the core and edge transport are crucial issues for fusion plasma researches. The GAMMA 10 is the world largest tandem mirror. The mirror system having open magnetic-field provides advantages for the control of radial and axial potential structures by ECH and high heat flux by strong ICRF, EC and NBI heating schemes. Therefore, mirror-based systems enable both core and edge plasma experimental studies with these remarkable characteristics. In addition to these main subjects of the GAMMA 10, the development of high power gyrotron for the ECH, main tool for these experiment, is one of the major research topics, too.

The most recent emphasis is on the divertor plasma simulating experiments, which is a new major objective of the second medium research plan. For this purpose, the divertor simulating module (D-module) has been installed on the west end section of the GAMMA 10, as shown in Fig. 1 and the modified device is called GAMMA 10/PDX. This module has closed divetor structure with V shaped plates (Fig. 2), which can change the plate angle. It also enables to feed gasses to the divertor region and to control the pumping speed of the compressed region. We have started the studies of the divertor plasma experiments with this module. The stable plasma similar to that without D-module has been formed with D-module. The expected plasma flow was observed and the first characterization experiment was done with active control of the various parameters. In parallel, the characterization of the high heat flux at the mirror throat for simulating divertor plasma. The ITER level heat flux density (10 MW/m^2) at the 30 cm from the mirror throat was obtained. Using the modulated ECH power, intermittent heat pulse simulating the ELM like heat pulse was produced. The energy density is 0.05 MJ/m^2 was obtained.[1), 2)]

The studies of the radial electric field and drift type fluctuations had been done for radial transport physics. It is clearly seen that the Plug (P)-ECH changed the potential profile and successive suppression of the fluctuations and hence the radial transport were observed. To study these phenomena more, multi-channel detector of the Gold Neutral Beam Probe (GNBP) has been developed.[3)] It is found that the radial electric field profile increases with the application of the P-ECH and it changes from negative to positive in the core region and fluctuations of the drift type wave is also suppressed by ECH formed E-field. The correlation between the potential fluctuations from GNBP and End Plate fluctuations has been examined and we found the strong correlation between them, which suggest the importance of the End Plate signal for the transport studies.[4)] Multi-channel and multi-path Thomson scattering measurements have also progressed for the transport study.

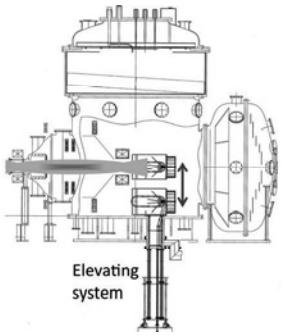

FIG. 1 The schematics of the D-module installed on the west end section of the GAMMA 10 (PDX). The D-module is movable and the ordinary experiment without the D-module is also possible.

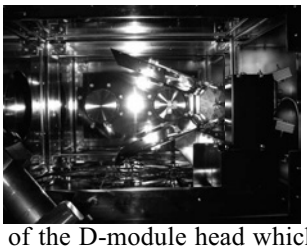

FIG. 2 Picture of the D-module head which is installed on the west end section of the GAMMA 10/PDX.

In gyrotron development, the output of 1.8 MW for 1 s., the world record, was achieved in collaboration with NIFS. Based on this, we have been developing 154 GHz 1 MW tube for LHD high density plasma [5)] and obtained the more than 1 MW for 1 s. In the development of 1MW-28 GHz gyrotron for GAMMA 10, the design of the electron gun and window was improved for higher power and dual frequency operation. As a result, 1.25 MW operation has been successfully obtained. In long pulse operation, 0.6 MW x 2 s has been also obtained with the modified tube. The collaboration with Kyushu Univ. has been progressed for the QUEST EBW and ECH/ECCD studies. The Tsukuba 28 GHz gyrotron has been installed on the QUEST site and the collaborative experiments will be done in the next FY.

1) T. Imai, et. al., Joint Int. Conf. OS2012&PMIF2012. Tsukuba, Japan, 20 -31, Aug., 2012, IP-2.
2) Y. Nakashima, et al., IAEA FEC2012, San Diego FTP/.P1-11.
3) Y. Miyata, et al., PFR, 6, 1202090 (2011).
4) M. Yoshikawa, et al., IAEA FEC2012, San Diego (2012), EX/P3-03.
5) R. Minami et. al., IAEA FEC2012, San Diego (2012) FTP/P1-20.