§3. Development of Magnetic Island Detector by Magnetic Measurement

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In magnetically confined plasmas, a magnetic island, which disturbs the structure of nested magnetic flux surface, would lead to degradation of plasma confinement. The m=2/n=1 and m=1/n=1 (n and m are toroidal and poloidal mode number) magnetic islands generated by misalignment of helical coil winding are observed in LHD plasmas. High performance plasmas are achieved by the shrinkage of low-n magnetic islands using a resonant magnetic perturbation (RMP) produced by LID coil. However, the physics of magnetic islands and its effect on plasma confinement is little understood. The aim of our study is to develop a magnetic island detector using flux loops with high spatial and time resolution and to clarify the physics and effect of magnetic island in helical plasmas. We are developing the island detector in Heliotron J of Kyoto University. The magnetic island in Heliotron J is expected to be large because of low magnetic shear in whole plasma region, if the rational surface exists.

In order to optimize the location and shape of magnetics, and the RMP coil to externally control m=2/n=1 magnetic island, we developed a numerical scheme combined with HINT2 MHD equilibrium solver and JDIA external magnetic field solver where three-dimensional magnetic configuration, finite beta effect and plasma current can be taken into account. We designed new saddle loops and RMP coils based on numerical scheme mentioned above and installed those systems into Heliotron J. Optimized new magnetics consist of two coil sets locating a different toroidal section in order to measure the asymmetry of magnetic field by Pfirsch-Schlüter (PS) current caused by existence of m=2/n=1 magnetic island. Figure 1 shows calculated differential signal between each saddle loops for the plasma with m=2/n=1 magnetic island. PS current without toroidal field period N_p=4 caused by magnetic island produces the difference in the saddle loops signals.

We applied the m=2/n=1 RMP field into a plasma experiment in the configuration with $\iota/2\pi$=0.5 which can resonate with RMP field. Figure 2 shows the time evolution of saddle loop signals and differential signal (green solid line with negative value). The differential signal is proportional to plasma stored energy corresponding with plasma beta. Incidentally, differential signal has zero amplitude in the plasma without magnetic island. Observed poloidal distribution of differential signals of saddle loops shown in Fig. 3 qualitatively corresponds with numerically estimated distribution shown in Fig. 1. We observed finite magnetic island width in the case of RMP coil current I_{RMP}=0 in Fig.4. Moreover, we suppressed the degradation of plasma stored energy by the shrinkage of magnetic island using RMP coil.

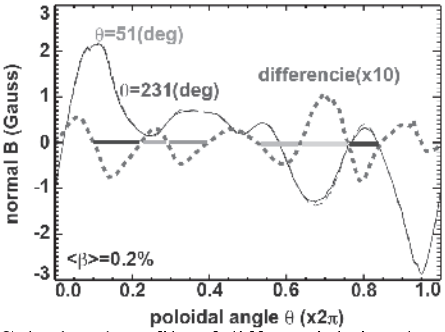

Fig. 1. Calculated profile of differential signals of loops in the plasma with m=2/n=1 magnetic island.

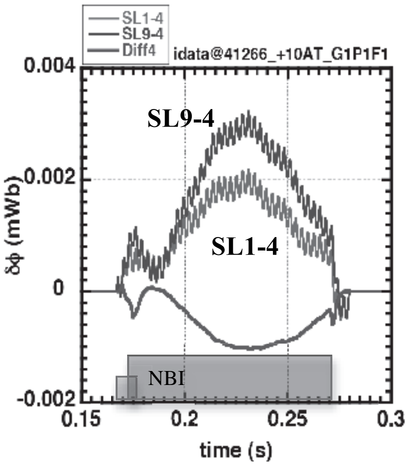

Fig.2. Time evolution of differential signals of loops.

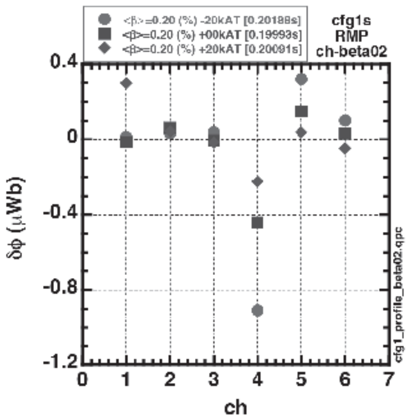

Fig. 3. Poloidal distribution of differential signals.

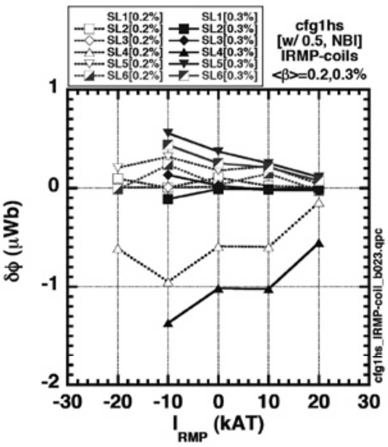

Fig. 4. Dependence of differential signals on I_{RMP}