Development of magnetic island detector by magnetic measurement in helical plasmas

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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 the profile measurement of electron temperature in Large Helical Device (LHD) plasmas. High performance plasmas are achieved by the shrinkage of low-n magnetic islands using a resonant magnetic perturbation (RMP) produced by a local island diverter (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 order to optimize the location and shape of magnetics, and the RMP coil to externally control m=2/n=1 magnetic island, we have developed a numerical scheme combined with HINT2 [1] MHD equilibrium solver and JDIA [2] external magnetic field solver where three-dimensional magnetic configuration, finite beta effect and plasma current can be taken into account. We have experimentally investigated magnetic field by the RMP coil using a toroidal array of magnetic probe. The magnetic field strength in the experimental result agrees well with that of calculated one. This result indicates that the perturbation magnetic field with m=2/n=1 is successfully produced in vacuum chamber of Heliotron J. Moreover, the penetration time of magnetic field τ~5 (ms), is short enough in comparison with Heliotron J plasma discharge duration τ > 100 (ms). We have applied the m=2/n=1 RMP to plasma experiment in the configuration with rotational transform of 0.5. The amplitude of observed magnetic field obtained from magnetic probe depends on the RPM coil. However, it is difficult to investigate island width and location from magnetic probe measurement because the existing toroidal array of magnetic probe is not optimized for our study. We designed new flux loops using the numerical scheme mentioned above and RMP experimental result. 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 current caused by existence of m=2/n=1 magnetic island. We will show the measurement result of magnetic island obtained from new flux loops in the RPM experiment of Heliotron J.

[1] Y. Suzuki, et al., Nucl. Fusion, **46** (2006) L19.
[2] T. Yamaguchi, et al., Plasma Fusion Res., **1** (2006) 011.