Numerical Simulation of Pressure Driven Modes in Heliotron Plasmas with Resonant Magnetic Perturbations

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In the recent study of magnetically confined fusion plasmas, resonant magnetic perturbations (RMPs) are focused from the viewpoint of the magnetohydrodynamics (MHD) stability against pressure driven modes not only in tokamaks but also heliotrons, because RMPs can locally change the pressure gradient around the resonant surfaces. In Particular, in the Large Helical Device (LHD), which is a typical heliotron device, since the pressure driven modes are the most dangerous, the change of the pressure gradient can directly influence the global stability. Therefore, the behavior of the plasma with RMPs is extensively studied in the LHD experiments []].Thus, in this study, the interaction between pressure driven modes and magnetic islands generated by an RMP is numerically analyzed in the LHD configuration.

The RMPs changes the topology of the magnetic field lines, which locally deforms the pressure profile. Therefore, it is essential to obtain an equilibrium with such a pressure profile consistent with the field geometry. For this purpose, we utilized the HINT2 code [2]. This code finds a three-dimensional (3D) equilibrium without any assumption of existence of nested surfaces. Then, we analyze the MHD dynamics of the plasma by means of the MIPS code [3]. This code solves the full 3D MHD equations by following the time evolution. Here, we analyze a plasma with a horizontally uniform RMP in the LHD configuration with a high aspect ratio and a magnetic hill by comparing with the plasma without the RMP. In this case, an m=1/n=1 magnetic island is generated in the equilibrium with the RMP. The pressure profile is deformed so that the gradient is smaller at the O-point than at the X-point. In the equilibrium without the RMP, the interchange mode is the most unstable. On the other hand, in the equilibrium with the RMP, a ballooning type mode becomes the most unstable. The mode structure is localized around the X-point. This is attributed to the deformation of the equilibrium pressure profile. The mode can utilize the driving force most effectively by being localized around the steepest pressure gradient point. In the nonlinear evolution of the mode, the pressure starts to collapse around the X-point, and then, the collapse spreads out to the core region. Therefore, the phase of the mode structure in the poloidal and the toroidal directions is fixed to that of the island. In LHD, the error field works as an m=1/n=1 RMP. In the experiments, collapses in the electron temperature are observed in both existence and reduction cases of the error field in the present configuration [1]. The spatial phase in the toroidal direction of the observed mode is fixed in the existence of the error field. This property agrees with the present result.

[1] S. Sakakibara, et al., *Nucl. Fusion*, **53** 043010 (2013).
[2] Y. Suzuki, et al, *Nucl. Fusion* **46** L19 (2006).
[3] Y. Todo, et al, *Plasma and Fusion Res.* **5** S2062 (2010).