§1. Three-Dimensional MHD Analysis of Heliotron Plasma with RMP

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We numerically analyze the interaction between the pressure driven modes and the magnetic islands in the LHD plasma with a resonant magnetic perturbation (RMP) by utilizing three-dimensional magnetohydrodynamics (MHD) codes[1]. To obtain an equilibrium with a pressure profile consistent with the magnetic islands, we utilize the HINT2 code[2]. We impose a uniformly perturbed magnetic field in the horizontal direction as an RMP in a high aspect ratio and magnetic hill configuration. In the case without the RMP, nested flux surfaces are obtained in the whole region of the plasma in the $\beta_0 = 2\%$ equilibrium. On the other hand, in the case with the RMP, an $m = 1/n = 1$ magnetic island appears around the position of the $\iota = 1$ surface in the case without the RMP as shown in Fig.1, where m and n denote the poloidal and the toroidal mode numbers and ι is the rotational transform. The equilibrium pressure gradient is reduced at the O-point as shown in Fig.2.

The dynamics of the plasma is examined with the MIPS code[3]. This code solves the full MHD equations by following the time evolution. In the case without the RMP, the mode pattern is distributed almost uniformly around the $\iota = 1$ surface. This structure shows that the mode is a typical interchange mode. On the other hand, in the case with the RMP, the mode is localized around the X-point like a ballooning mode as shown in Fig.1. This localization is attributed to the fact that the pressure gradient is much larger at the X-point than at the O-point as shown in Fig.2. Therefore, the mode can utilize the driving force more effectively by being localized around the X-point rather than being distributed uniformly around the resonant surface.

The nonlinear evolution is also examined for the perturbation shown in Fig.1. In the case with the RMP, the total pressure evolves as shown in Fig.3. Since the linear mode is localized around the X-point, the pressure starts to collapse around the point, and then, the collapse spreads to the core region. Therefore, the mode phase is fixed to the RMP phase. It is also obtained that the magnetic surfaces are destroyed from the X-point to the whole plasma region. The pressure collapses also in the case without the RMP. Since the deformation structure corresponds to the linear mode, there is no special spatial phase in the mode structure in poloidal and toroidal directions.

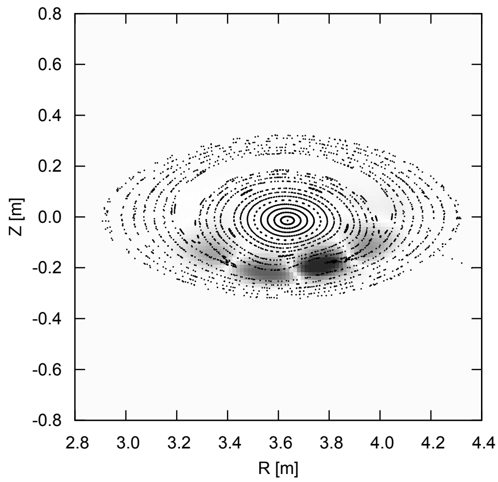

Fig.1 Puncture plots of the equilibrium magnetic field lines and the mode pattern of the perturbed plasma pressure in the linear phase.

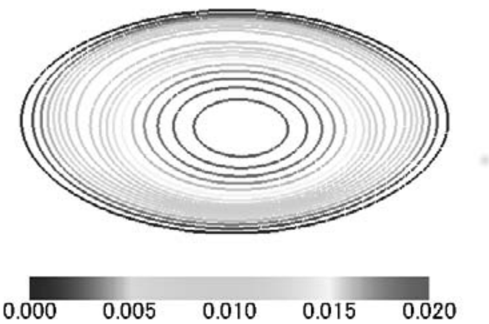

Fig.2 Contours of equilibrium pressure with the RMP.

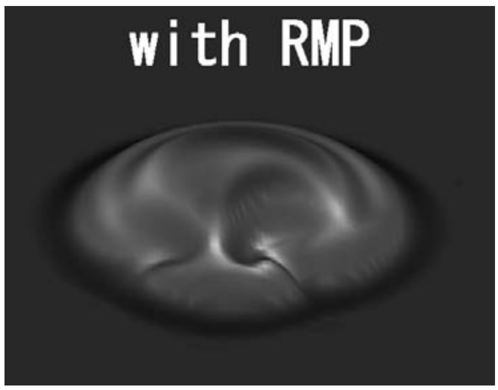

Fig.3 Bird's eye view of total pressure in the nonlinear saturation phase with the RMP.

1) K. Ichiguchi, et al., submitted to Plasma and Fusion Res. (2014).
2) Y. Suzuki, et al, Nucl. Fusion **46** (2006) L19.
3) Y. Todo, et al, Plasma and Fusion Res. **5** (2010) S2062.