§10. Dependence of Penetration and Shielding of Resonant Magnetic Perturbation on Magnetic Configuration

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Dynamics of magnetic islands in helical plasmas has been studied to clarify its effect on the MHD stability and/or confinement. It was reported that the magnetic islands show a spontaneous behavior of growth/healing during the discharge, in which the saturated island states can be clearly divided in to two regions in the space of plasma beta β and collisionality ν (1). Furthermore, it was found that the change of the poloidal flow ω_{pol} causes the magnetic island transition (2). Through those studies, the plasma parameter (β, ν, ω_{pol}) effect on the magnetic island has been clarified under a same magnetic configuration. Subsequently, it is interested in the dependence of the island behavior on magnetic configurations. To clarify the configuration effect, we carried out the experiment with various magnetic configurations (range of magnetic axis position is R_{ax} = 3.55 - 3.80m). Shown in Fig.1 are typical waveforms and radial profiles of electron temperature in the configuration with R_{ax} = 3.7m. In case the resonant magnetic perturbation (RMP) is increased during the discharge (Fig.1 left), the phase shift indicates $\Delta\theta = -\pi$ (rad) (which means the RMP is shielded) until t = 5.35s (Fig.1 left (b)). At that term, the T_e profile does not have the local flattening region (Fig.1 left (d)). After t = 5.3s, the phase shift leaves from $\Delta\theta = -\pi$ (rad) which means the RMP penetrated into the plasma and the local flattening appears in the T_e profile at R = 3m (Fig.1 left (e)). In the case of decreasing RMP (Fig.1 right), the penetration is observed until t = 5.2s (Fig.1 right (b)) and local flattening of T_e appears (Fig.1 right (d)). The RMP is shielded after t = 5.2s and local flattening disappears (Fig.1 right (e)). It should be noted that the poloidal flow is almost constant (~15krad/s) during the plasma discharge in both cases. We summarized the critical RMP coil current I_{RMP} which is determined as the current when the transition of the RMP penetration / shielding occurs. The clear dependence of the critical I_{RMP} on the magnetic configuration can be seen as shown in Fig.2, in which the region upper (lower) than solid line corresponds to the penetration (shielding). In the case of increasing RMP (Fig.2 (a)), the finite critical I_{RMP} increases with R_{ax}. Qualitatively similar dependence is seen in the case of the decreasing RMP (Fig.2 (b)). However, interestingly, the penetrated field never be shielded even in the RMP becomes zero in the case of R_{ax} = 3.6m and 3.55m. These experimental observations show the strong hysteresis. Some theories based on the balance between an electromagnetic torque and a viscous torque follow the experimental observation (3,4,5). They propose that the island dynamics can be explained by the balance of those torques. The penetration (shielding) occurs when the electromagnetic torque overcomes (succumbs to) the viscous torque. The electromagnetic torque T_{EM} is the function of the plasma response field, RMP field, and the phase shift. The viscous torque T_V is the function of the poloidal flow and poloidal viscosity. In the LHD, the poloidal viscosity increases with R_{ax}, which implies that the T_V becomes large with R_{ax}. Assuming that the T_{EM} does not have the dependency on the magnetic configuration, it might be thought that the tendency of the critical I_{RMP} comes from the dependence of T_V on the configuration. The strong viscous torque overcoming the electromagnetic torque is likely to shield the RMP. This study was supported by a Grant-in-Aid for Young Scientists (B) (No.22760661) from the Ministry of Education, Culture, Sports, Science and Technology of Japan. This work was supported by NIFS under Contract No.NIFS12ULPP014.

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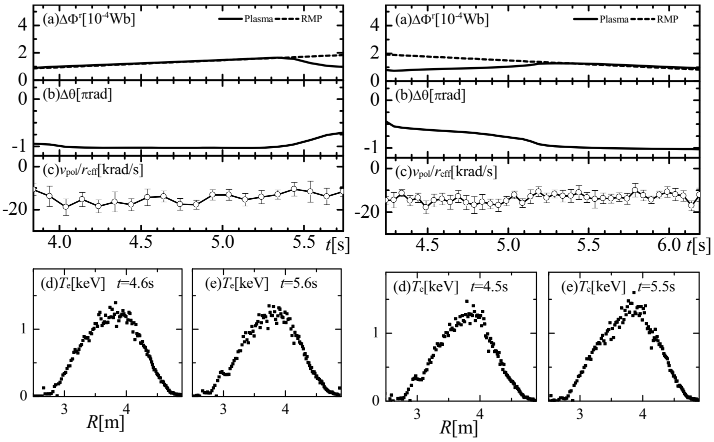

Fig.1 Time evolution of (a) Plasma response field (solid) and RMP (dashed), (b) phase shift, (c) poloidal flow, (d, e) electron temperature. (Left) Case of RMP increases (Right)Case of RMP decreases .

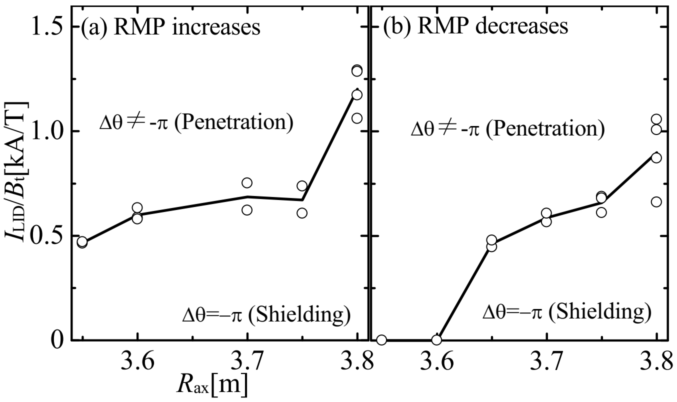

Fig.2 Dependence of threshold for penetration / shielding of resonant magnetic perturbation on magnetic configuration. (a) Case of RMP increases and (b) RMP decreases.