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LHDで観測される外部印加摂動磁場に対する磁気島の履歴応答
Hysteretic magnetic island response to externally applied resonant magnetic perturbation field in LHD

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Understanding of the magnetic island behavior is an important issue from the view point of MHD stability and/or plasma confinement in magnetic confinement plasmas. In tokamak plasmas, a disruptive phenomenon is triggered by a growth of magnetic island. On the other hand, in the Large Helical Device (LHD) plasmas, serious disruption never occurs even if the magnetic island grows. The island growth merely triggers a minor collapse when the magnetic shear becomes low [1]. Furthermore, the growth of magnetic island at the peripheral region brings the detached state [2], which implies an advantage of the magnetic island. 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 are affected by plasma parameters of plasma beta β, collisionality ν, and poloidal flow ω_{pol} [3-4]. Through those studies, the plasma parameter 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. The resonant magnetic perturbation (RMP) field with m/n=1/1 Fourier mode is imposed to produce the magnetic island. Typical waveforms of plasma response field ($\Delta\Phi_{m=1}$), RMP field ($\Delta\Phi_{RMP}$), phase shift ($\Delta\theta_{m=1}$),

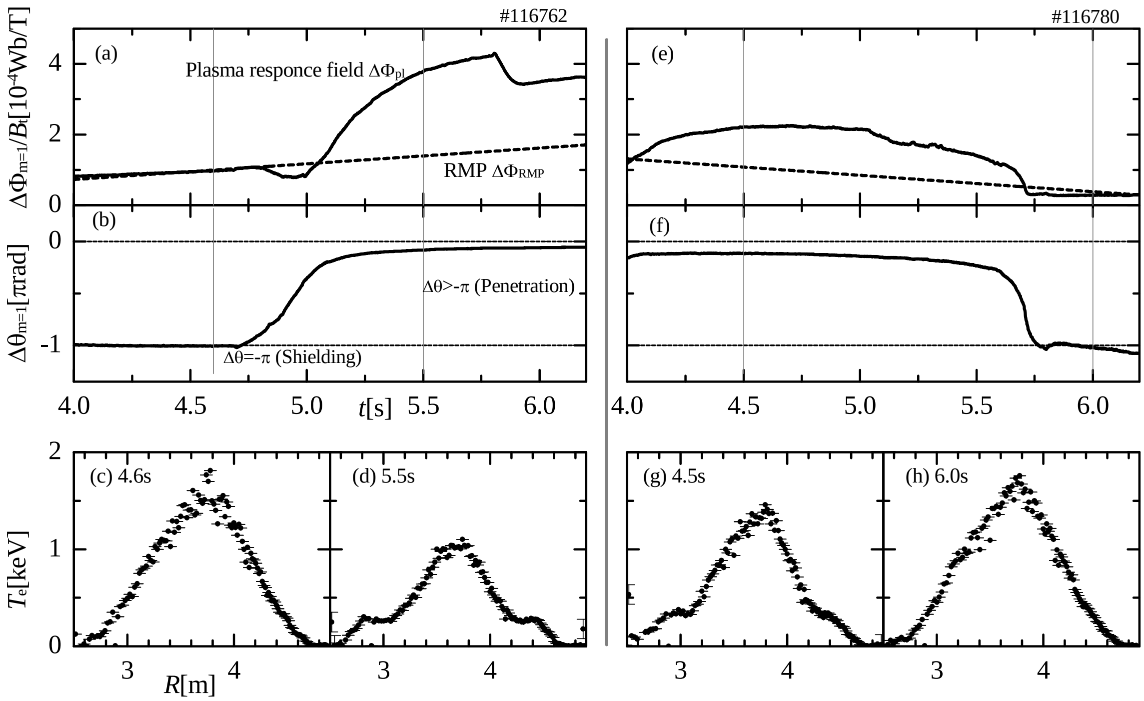

Fig.1 Time evolution of (a, e) Plasma response field (solid) and RMP (dashed), (b, f) phase shift $\Delta\theta$, (c, d, g, h) electron temperature. (Left) Case of RMP ramp up (Right) Case of RMP ramp down.

and radial profiles of electron temperature T_e are shown in Fig.1. Here, $\Delta\theta_{m=1}$ indicates the behavior of the RMP; the RMP is penetrated (shielded) when $\Delta\theta_{m=1}<|\pi|$ ($\Delta\theta_{m=1}=\pm\pi$). In case of the ramp up of the RMP during the discharge (Fig.1(a)-(d)), the RMP is shielded until t=4.7s. The plasma response field $\Delta\Phi_{pl}$ is same as $\Delta\Phi_{RMP}$, which means the plasma resonance field compensates the RMP field. When the RMP reaches $\Delta\Phi_{RMP}/B_t$ = 1.0[10^{-4}Wb/T], the RMP penetrates the plasma. The finite $\Delta\Phi_{pl}$ for $\Delta\theta_{m=1}$ = 0 means the growth of the magnetic island. Before the penetration (t<4.7s), the T_e profile does not show the local flattening region (Fig.1(c)) whereas the local flattening appears after the penetration (Fig.1(d)). In the ramping-down RMP case (Fig.1 (e)-(h)), the RMP field penetrates until t=5.75s. The RMP is shielded when the RMP falls below $\Delta\Phi_{RMP}/B_t$ = 0.5[10^{-4}Wb/T]. It should be noted that the thresholds of RMP field $\Delta\Phi_{RMP}$ in each transition are different, which shows the hysteretic magnetic island response to externally applied resonant magnetic perturbation field. Figure.2 shows the relationship between $\Delta\theta_{m=1}$ and $\Delta\Phi_{RMP}$, which indicates that the threshold for the penetration is larger than that for shielding. This implies that once the magnetic island is produced by an increasing RMP, attenuation of the RMP is required for the magnetic island suppression. Theoretical studies based on the balance between electromagnetic and viscous torque have reported that the existence of the hysteresis of magnetic island transition [5-8]. Experimental observation shown above qualitatively corresponds to the

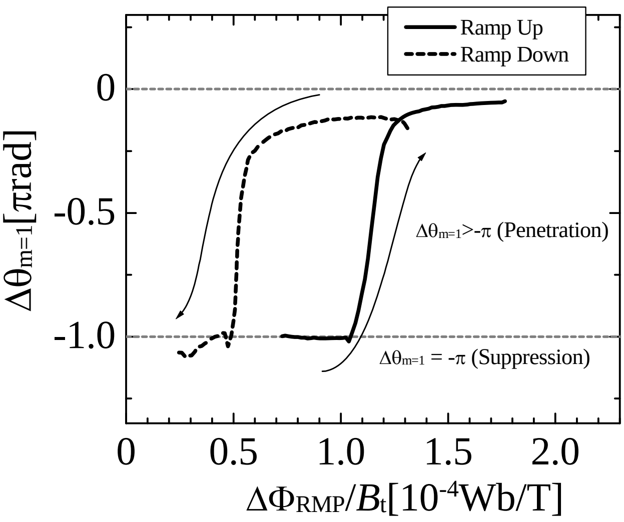

Fig.2 Relationship between phase shift and RMP. Solid and dashed lines indicate increasing and decreasing RMP cases respectively. Arrows mean time evolution.

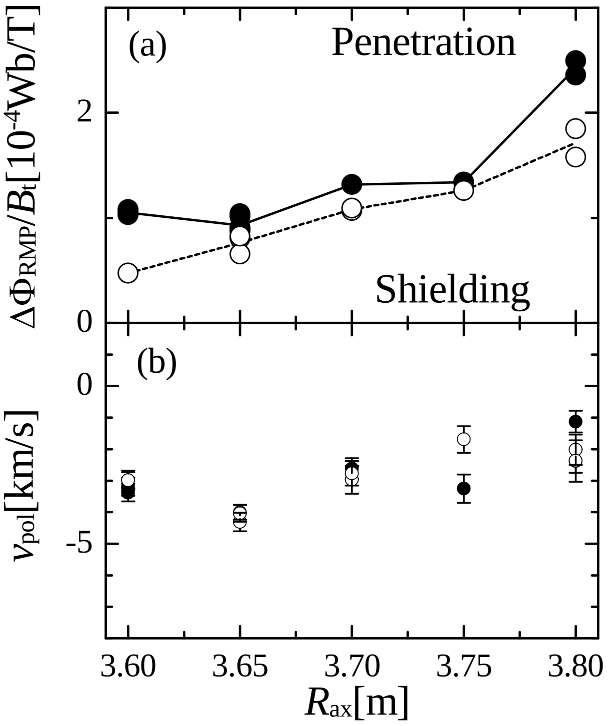

Fig.3 Magnetic axis R_{ax} dependence of (a) RMP threshold and (b) poloidal rotation. Closed and open circles indicate case of ramping-up and down respectively.

result of nonlinear simulation (Fig.3 in Ref.5). To clarify the effect of a parameter originated from the magnetic configuration, the behavior of the RMP penetration / shielding was observed in the different magnetic configuration (the position of the magnetic axis R_{ax}) under the condition of constant poloidal rotation (v_{pol}=~2.5[km/s]). The critical $\Delta\Phi_{RMP}$ increases with R_{ax} showing the hysteresis. It is under study to determine what parameter affects the RMP threshold. This study was supported by NIFS (Contract No. ULPP014).

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