§49. Correlation between Detached Plasmas and Magnetic Island Dynamics

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In the recent LHD experiment, the resonant magnetic perturbation (RMP) has been utilized to establish the detached plasma [(1)] which is one of candidates to prevent the divertor heat load. The behavior of plasma response field has been investigated from the view point of the magnetic island dynamics [(2)]. The purpose of this study is to investigate the detailed behavior of plasma response field and its dependence of plasma parameters for detached plasmas. Here, an important parameter, the phase shift ($\Delta\theta_{m=1}$), should be noted that the $\Delta\theta_{m=1}$ is defined as the phase difference between the plasma response field and RMP. When the phase shift is in-phase ($\Delta\theta_{m=1} = 0$), the magnetic island grows whereas the magnetic island is suppressed when that is anti-phase ($\Delta\theta_{m=1} = \pi$). Figure 1 shows the time evolution of the $\Delta\theta_{m=1}$ acquired from multiple discharges. In case plasmas are not detached, the $\Delta\theta_{m=1}$ is less than -0.3πrad (Fig.1 (a)) whereas the $\Delta\theta_{m=1}$ lies at around $\Delta\theta_{m=1} \sim -0.3\pi$rad when the detached plasmas are established through the whole term of discharges (Fig.1 (b)). Furthermore, when the plasma transits from attached to detached state, the $\Delta\theta_{m=1}$ shows dynamical behavior in which the $\Delta\theta_{m=1}$ gradually moves to positive direction corresponding to ion-diamagnetic direction. And finally, the $\Delta\theta_{m=1}$ reaches -0.3πrad (Fig.1 (c)). It should be noted that each times for detachment are discrete but the threshold of $\Delta\theta_{m=1} = -0.3\pi$rad seems to be a robust value for that. To compare the dispersion of $\Delta\theta_{m=1}$ and other parameters (plasma β and collisionality ν), we summarize them as shown in Fig. 2. The β and ν are widely dispersed when the detached plasma is produced (closed circles in Fig.2). Both states (detach/attach) coexist in the same wide region of β from 0.08% to 0.17%, (Fig. 2 (a)) and ν from 2 to 5. This means that the necessary condition for detachment can be determined not by β and/or ν but by $\Delta\theta_{m=1}$. From the viewpoint of magnetic island dynamics, the growth of magnetic island is required to produce detached plasmas.

1) M. Kobayashi, et al. (2010) Phys. Plasmas **17** 056111
2) Y. Narushima, et al., (2011) Nucl. Fusion **51** 083030

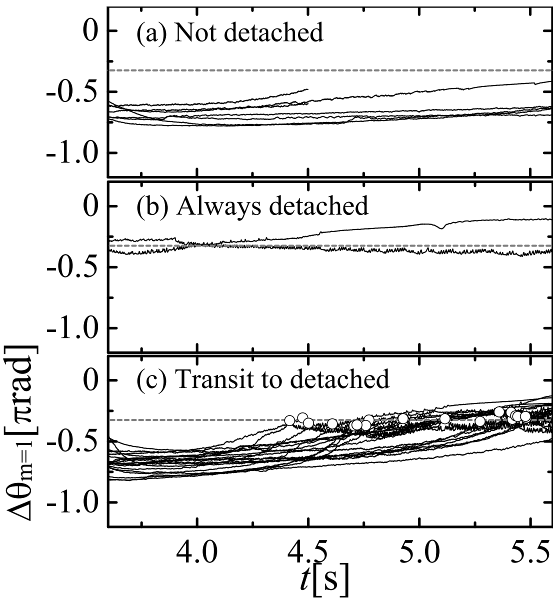

Fig.1 Time evolution of phase shift $\Delta\theta_{m=1}$ (solid lines) for the cases of (a) always attached, (b) always detached and (c) transition from attached to detached state. White circles indicate the point when the detached plasmas are established. Their averaged value of $\Delta\theta_{m=1}$ is represented by the grey dashed line indicating the threshold of $\Delta\theta_{m=1}$ for detachment.

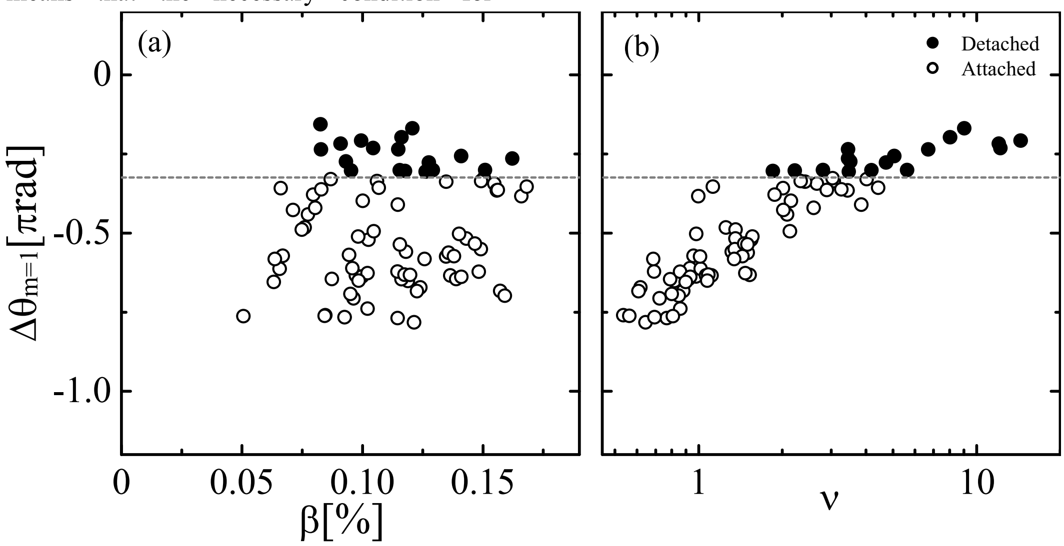

Fig.2 Relationship between phase shift and (a) beta and (b) collisionality. Filled and open circles indicate detached and attached state respectively. Dashed grey line indicates the threshold of $\Delta\theta_{m=1}$ for detachment.