§6. Detachment Stabilization with RMP Application in LHD: Input Power Dependence and Correlation between Detachment Transition and Plasma Response Field

Kobayashi, M., Narushima, Y., LHD Experiment Group

It has been found that the detachment can be stabilized by application of resonant magnetic perturbation (RMP) in LHD [1)]. The RMP (m/n=1/1) creates the remnant magnetic island in the edge stochastic layer and the radiation distribution is modified by the structural change as confirmed in the numerical simulations as well as in experiments [2,3)]. Without the RMP, the enhanced radiation with increasing density can not be stabilized and leads to radiation collapse.

In the present experiment, an input power dependence of detachment transition has been conducted by changing the timing of neutral beam (NB) injections. Figure 1 shows temporal evolutions of plasma parameters. The startup phase is sustained by NBI#2 only (4 MW) and plasma goes to detachment phase at t=4.4 sec as density increases (deep detachment), as shown in the radiated power increase and the reduction of divertor particle flux. Afterwards, when the NBI #1 and 3 are added (total power = 13 MW), the plasma re-attaches around t=5.0 sec, which is confirmed with the increase of divertor particle flux and the decrease in the radiated power. At t=5.4 sec, the NBI#2 is terminated (total power = 8 MW), then the plasma detaches again. But the reduction of divertor particle flux is small compared to the initial phase of detachment sustained with only the NBI#2 (shallow detachment). Finally, at t=6.5 sec, the NBI#3 is also terminated and the plasma sustained with the NBI#1 only (5 MW). In this case, the radiated power increases and the divertor particle flux decreases further, which is similar behavior as the detachment at the initial phase (deep detachment).

Figure 2 shows a plasma response magnetic field against the RMP. Interestingly, it is found that the plasma response is well correlated with the divertor particle flux as follows:

1. At the initial phase of the discharge, t=3.4 sec, the phase of plasma response θ starts to shift to direction of ion diamagnetic drift, i.e. towards an enhancement of RMP. → the attach phase.
2. At t=4.3 sec, the phase θ reaches 0.95 π rad, then stay constant up to t=4.9 sec. The duration corresponds to the (deep) detachment phase.
3. At t=4.9 sec, the phase θ starts to shift to direction of electron diamagnetic drift, and reaches 0.47 π rad at t=5.3 sec. This duration corresponds to the re-attached phase.
4. After that, the phase θ again shifts to the ion diamagnetic direction and reaches 0.85 π rad at t=5.5 sec, and stays there until t=6.5 sec, the duration of which corresponds to the shallow detachment phase.
5. At t=6.5 sec, the phase shifts further towards the ion diamagnetic direction and keeps θ ~ 1 π rad until the end of discharge, which corresponds to the deep detachment phase.

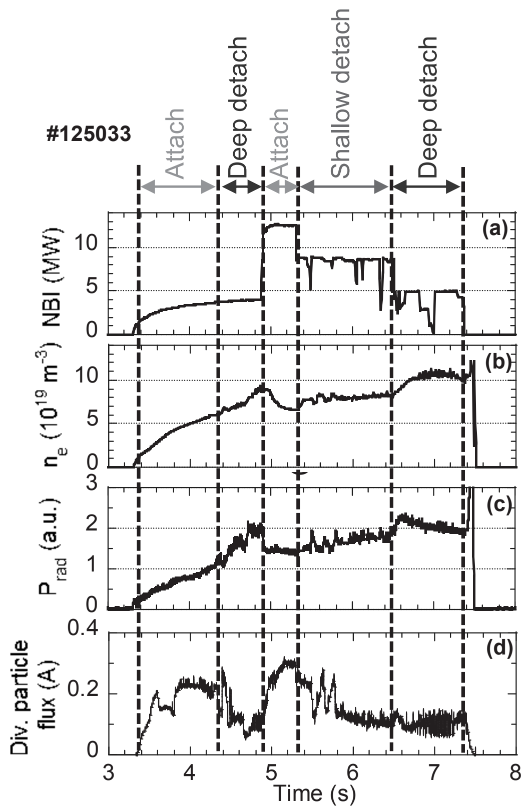

Fig.1. Temporal evolutions of (a) NBI power, (b) line averaged density, (c) radiated power, (d) divertor particle flux.

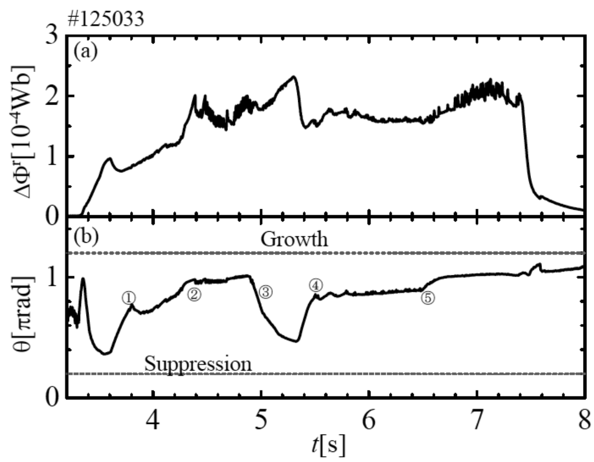

Fig.2. Temporal evolutions of plasma response against RMP. (a) amplitude, (b) poloidal phase of the plasma response.

1) Kobayashi, M. et al.: Nucl. Fusion **53** (2013) 093032.
2) Drapiko, E.A. et al.: Nucl. Fusion **51** (2011) 073005.
3) Peterson, B.J. et al.: Plasma and Fusion Research **8** (2013) 2402037.