§8. Measurement of Core Stochastization on High Ti Plasma Using Heat Pulse Propagation

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It is widely recognized that the magnetic topology is one of the most basic factor of plasma confinement in magnetized plasma including tokamak and helical devices. Since the formation of internal transport barrier associated with the transition from the stochastic state to helical state was demonstrated in RFP [1], the understanding of core magnetic topology grows increasingly important even in helical system. In helical system, the magnetic topology in the core region is originally nesting state. However core temperature flattening is often observed in the plasma with internal transport barrier. This flattening prevents the achievement of high central ion temperature [2].

We measured the formation of core stochastic field by using the heat pulse propagation analysis when the core flattening temperature profile is appeared [3]. In this article, the further analysis is reported. The heat pulse is generated by power modulation electron cyclotron heating (MECH) in the NBI sustained plasma. The modulation frequency of the applied MECH is 30Hz. The power deposition point of 77GHz ECH is located at $r_{\mathrm{eff}} = 0.12\mathrm{m}$.

In Fig.1, the comparing between the 2 discharges is described. The co-direction tangential neutral beam (NB, 2beam, 10.5MW) is injected in both cases, and the ctr-direction NB (2.3MW) is injected in the plasma as shown in the top of the figure. At t= 0 sec, the carbon pellet is injected to achieve the high ion temperature. Figure 1 b) and c) show the ion temperature profile. The increasing of the ion temperature can be clearly seen. However, the core flattening profile is appeared in case of only co-NB injection. With ctr-NB, the peaking profile is realized. The time evolution of mode amplitude of m/n=2/1 measured by magnetic probe are shown in the middle of Fig.1 a). After the carbon injection, the amplitude of w/o ctr-NB discharge decreases. This change is considered to indicate the transition of magnetics. The bottom of the Fig.1.a) is the graph of the plasma currents. Even though the NB are injected continuously, the current is increasing. We can see the effect of the carbon pellet injection in plasma current. It is considered that the current penetrate into the core region at cool plasma, and the amount of the penetration current of this two case is different because the driven current is different. The results of the heat pulse propagation analysis are shown in Fig.2. The bottom of the delay time profile indicates the deposition point of the ECH, and the heat pulses propagate radially outward with finite time scale before pellet injection in Fig.2.a). In Fig.2 b),after carbon pellet injection, we can see the quite fast propagation in case of core temperature flattening. This indicates the formation of stochastic field in the region of $r_{\mathrm{eff}}<0.25\mathrm{m}$. The rotation transform(ι) profile at rational surface is important for the transition of the magnetic topology. It is considered that the weak shear at iota = 0.5 is appeared by large penetrating current, and it leads to the formation of stochastic field. The scenario of higher Ti discharge with ITB can be developed avoiding the stochastization, i.e. the weak shear in core region by control of current using NB.

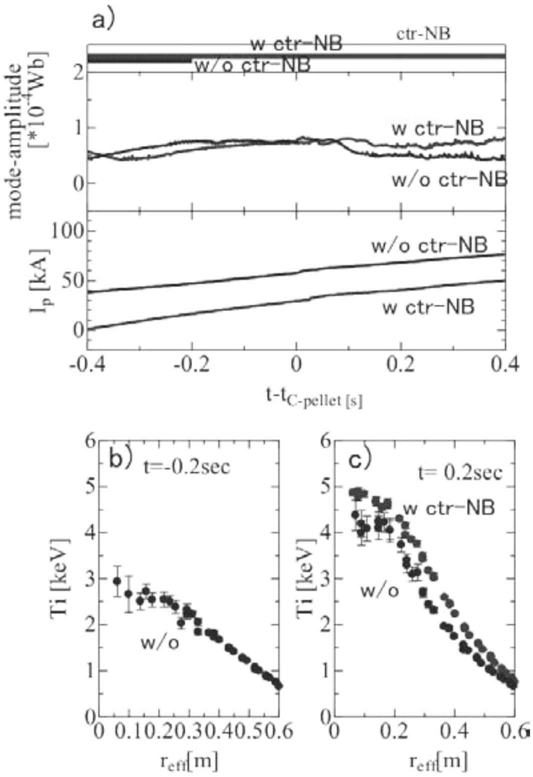

Fig. 1. a) The evolution of mode amplitude of m/n=2/1 and plasma current (I_p), b) ion temperature (T_i) profile at t=-0.2sec, c) ion temperature profile at t=0.2sec.

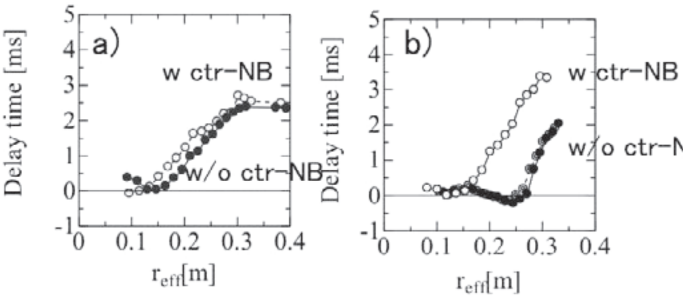

Fig. 2. The delay time profile of heat pulse propagation at a) t=-0.2sec and b) t=0.2sec.

1) R. Lorenzini et al., Nature Phys. 5 (2009) 570.
2) Osakabe, M. et al., Annual Report of NIFS April 2010-March 2011, p14.
3) Tsuchiya, H. et al., Annual Report of NIFS April 2012-March 2013, p95.