§24. Study of Core Stochastization on High Ti Plasma Using Heat Pulse Propagation

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The magnetic topology (i.e. magnetic structure) is one of the most important basic factor of plasma confinement in magnetized plasma. In torus plasma including helical and tokamak devices, because the magnetic structure is not only determined by the external coil but also plasma current, it transient among the closed surface state, magnetic island state and stochastic state [1]. In LHD, the central flattening ion-temperature profile is often observed in the high ion temperature oriented discharge using Carbon pellet injection [2]. It was found the formation of core stochastic field by using the heat pulse propagation analysis, and the transition to stochastic state prevents the achievement of high central ion temperature [3]. It is assumed that the transition to stochastic state is caused by the formation of weak magnetic shear. In this article, the experiment result of measurement of iota profile at core flattening discharge is reported.

Generally, there are the inductive current at core region when the toroidal current is enhanced by tangential neutral beam (NB) injection. Due to the temporal cooling by the carbon pellet injection, driven current penetrates into core region. This rapid change of current profile provides the change the rotation transform (ι) profile. In LHD experiment, the carbon pellets are injected into the base plasma with plasma current control by NB power as shown in Fig. 1. The arrows in the figure indicate the pellet injection. The flattening ion temperature profile were observed at the marked arrow case (1), (2) and (3). The profiles of (1), (2) and (3) just after the carbon pellet injection are shown in Fig.2. Because we can usually see the flattening shape in electron temperature profile when full-stochastization occurs [4], the magnetic structure would be in closed surface state. The 2nd column figures show the vacuum ι profile and measured ι profile. There are no significant difference among these cases. 3rd and 4th column figures show the analysis result of the heat pulse propagation. The heat pulse propagates outward from r_{eff} ~0.2m. We can see the fast propagation at r_{eff} ~0.3m, which corresponding to the flattening in T_e in fig.2 (A3). In this experiment, the density is higher than one of full-stochastization discharge [4] because of difference of wall condition. It is considered that the current suppressed by the relative high density leads prevents the transition to the full-stochastizaion state.

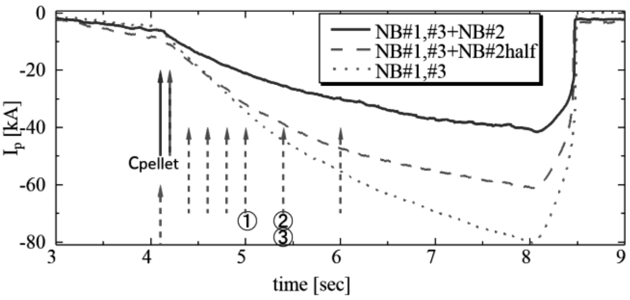

Fig. 1. The typical development of plasma current (I_p) and timing of carbon pellet injection.

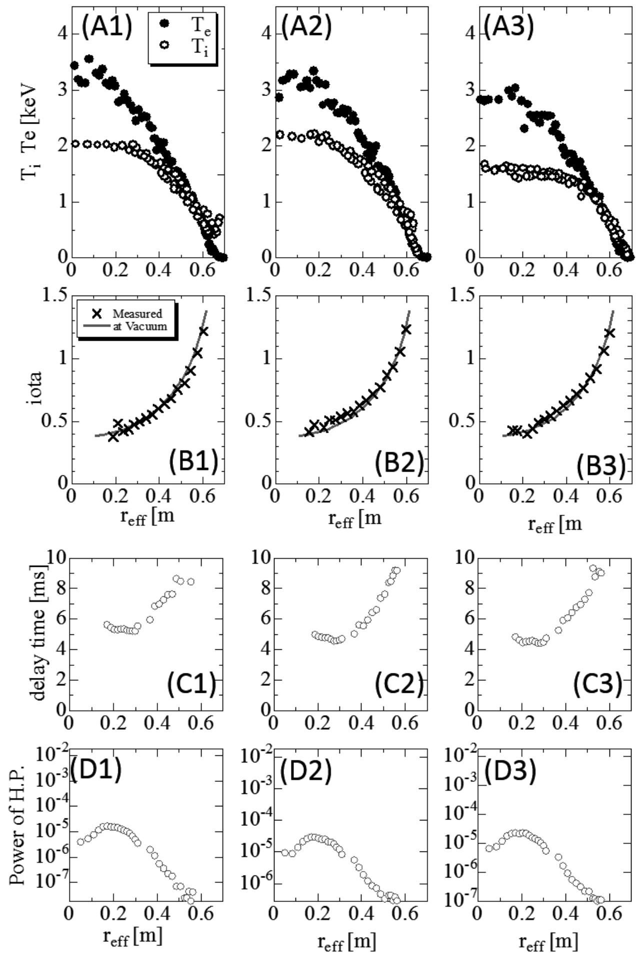

Fig. 2. Summary of the result of (A1-3) the electron temperature (T_e) and ion temperature (T_i), (B1-3) the measured iota profile (cross point) and vacuum iota profile (solid line), (C1-3) delay time profile of heat pulse and (D1-3) the power of heat pulse. The left, center and right columns are corresponding to the data of ①,② and ③in Fig.1, respectively.

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.
4) Tsuchiya, H. et al., Annual Report of NIFS April 2013-March 2014, p63.