§13. Correlation between Mode Structures of Toroidal Alfvén Eigenmodes and Induced Fast Ion Losses in LHD

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Alfvén instabilities induced fast-ion losses have been directly observed for the first time by a newly developed scintillator lost ion probe (SLIP) in the Large Helical Device (LHD). Neutral beam driven Alfvén Eigenmodes (AEs) are excited under the reactor relevant conditions: $v_b/V_A > 0.3 \sim 4.0$, where v_b and V_A are the fast ion and the Alfvén velocities, respectively. The beta value for fast ions β_f is considered roughly to be ~ 10%. The global plasma confinement is degraded by repetitive Toroidal Alfvén Eigenmode (TAE) bursts. It is found that this degradation is well correlated with the increase of fast ion loss signals of SLIP. From the information on the pitch angle and energy of fast ions measured by SLIP, fast-ion orbit is calculated numerically to understand the interaction between fast ions and TAE instabilities at the locations of TAE gaps. The orbit analysis found that the observed fast ions pass through TAE gaps. Bursting TAE activities with low toroidal mode numbers enhance fast-ion losses. This result becomes the experimental evidence of radial transport of fast ions predicted in Ref. [1].

In the similar discharge (shot #69494), perturbed fast ion loss δI_{SLIP} is plotted in Fig. 2 at two time windows between the weak TAE bursts(t = 1.009 ~ 1.262 s) and the clear TAE bursts(t = 1.309 ~ 1.492 s). Higher fast ion losses are observed, even though the magnetic fluctuation level with red circles is lower than that of blue ones. This result would be related to the redistribution of fast ions (the radial transport is pointed out in Ref. [1]), and to the locations and structures of TAEs.

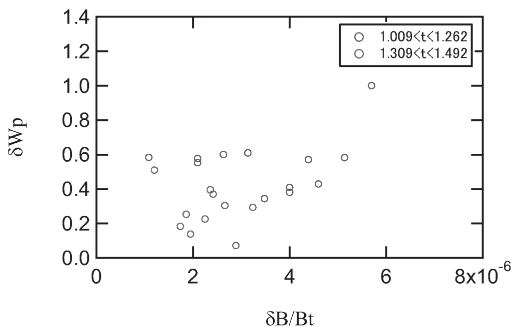

Fig. 1. Fast ion loss signal and magnetic probe signal. The fast ion loss corresponds to the pitch angle of around 130 degrees.

For further understandings of fast-ion transports, we have experimental plans to prepare a reflectmeter, q-profile measurements, and a heavy ion beam probe (HIBP), as well as theoretical analysis and modeling of TAE mode structures.

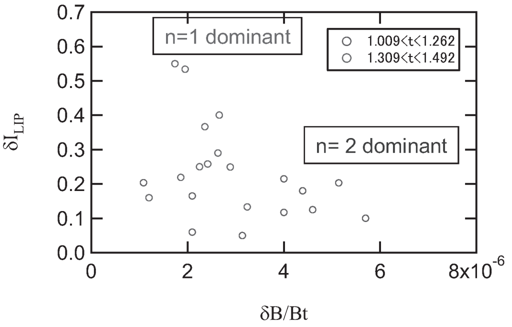

Fig.2 Dependence of perturbed fast ion losses on the magnetic fluctuation level at two time windows.

The development of SLIP has been carried out continuously. The head of SLIP is heated up during the plasma experiments at the temperature of more than 100 °C. Under such high temperature environment usage, new polycrystalline ceramics is fabricated and mounted on the SLIP. The polycrystalline scintillator is also prepared for the demonstration of ITER relevant diagnostics. The dynamical fast ion loss signal is obtained successfully by the polycrystalline scintillator with the sufficient light emission and time response. Three images in a plasma shot indicate the variation of fast particle deposition and their loss in different time windows. Further systematic analyses are required to explain the phenomena reasonably.

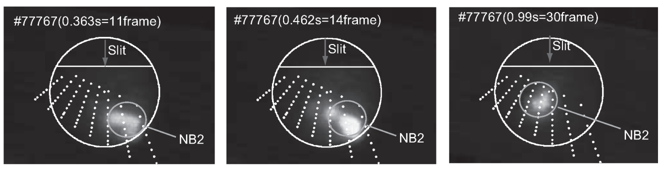

Fig. 3. Changes in pitch angle and energy of fast ion loss signals during a discharge.

1) Y. Todo *et al.*, submitted to Plasma Fusion Res. (2008).
2) Nishiura, M., Isobe, M., Yamamoto, S., Mutoh, T., Tokuzawa, T., Murakami, S., Osakabe, M., Saito, K., Seki, T., Watanabe, F., Toi, K., Ido, T., Nagasaka, T., Nishimura, H., Hirouchi, T., Sasao, M., LHD experimental group, Proceedings of 10th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems, 8-10 October 2007, Seeon, Germany.