§16. Observation of MHD-induced Beam Ion Losses on CHS

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In fusion devices, fast ions are required to be well confined until they transfer their energy to plasmas. A scintillator based lost fast ion probe (LFIP) is installed to study tangentially injected neutral beam (NB) ion losses on the Compact Helical System (CHS) [1]. The probe has an advantage that it is possible to measure the time evolution of escaping beam ions on the pitch angle and the energy resolution with the time resolution of 50 μs. The fast time response makes it possible to study fast phenomena in plasmas such as magnetohydrodynamic (MHD)-induced beam ion losses [2]. Measurements of MHD-induced losses of co-going and counter (ctr.)-going ions were performed to study characteristics of these losses. To investigate orbits of these fast ions, an orbit following code was used.

LFIP was applied to NB-heated plasmas with fishbone-like burst instability. In CHS, two types of fishbone-like burst mode are observed during NB injection. One is the m/n=3/2 fishbone-like instability, which is often observed in a shot with an outward-shifted plasma (magnetic axis position, Rax ≥ 0.974 m). The other is the m/n=2/1 fishbone-like instability, which is often observed in a shot with an inward-shifted plasma (Rax = 0.921 m). Low magnetic field (toroidal magnetic field, B_T~0.9 T), co-injection of a neutral beam and low electron density, ~ 1.0×10^{19} m^{-3}, are characteristics of these burst modes.

MHD-induced beam ion losses were only seen in the m/n=3/2 fishbone-like instability. Time traces of MHD-induced beam ion losses of two cases with different pitch angle χ and energy E are shown in Fig. 1 together with those of the magnetic perturbation on a Mirnov coil when the m/n=3/2 burst mode was observed. Figure 1 (a) shows the time evolution of co-going ion losses with χ ~43 degrees and E ~18 keV at the probe position. The orbit calculation was performed to see the orbit of these ions and showed a transition orbit. Figure 1 (b) shows the time evolution of ctr.-going ion losses with χ ~95 degrees and E ~20 keV at the probe position. Here, ctr.-going ions mean ions that co-injected NB ions are reflected by the magnetic mirror. The orbit calculation showed these ions are trapped ions. MHD-induced losses in other ranges of χ and E are not observed, clearly. The correlation between MHD-induced losses and the mode amplitude of the m/n=3/2 fishbone-like instability is presented in Fig.2. The enhancement ratio of MHD-induced losses of ctr-going trapped ions to base loss level was up to a factor of 30 and was increased as the mode amplitude increased. On the other hand, that of co-going transition ions was a factor of 2 at most and was saturated with increase in the mode amplitude. The threshold of the mode amplitude was $\delta B/B \sim 3\times10^{-5}$ for both kinds of ions. Further works to interpret the mechanism of MHD-induced beam ion losses are in progress.

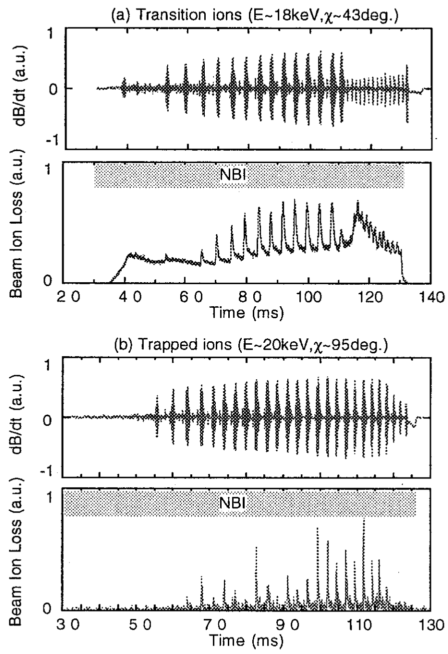

Fig.1. Time traces of MHD-induced beam losses.

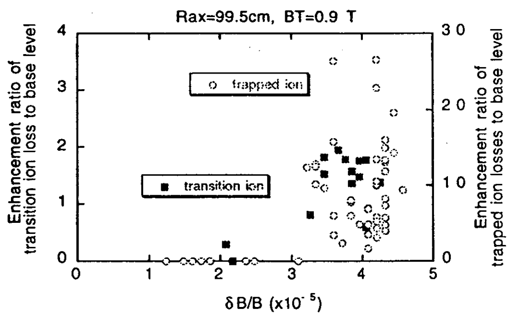

Fig.2. Correlation between MHD-induced losses and the mode amplitude of instability.

References
[1] D. S. Darrow et al., J. of Plasma Fusion Res. SERIES, Vol. 1, (1998) 362.
[2] T. Kondo et. al., in Proc. 1998 ICPP & 25 th EPS CCFPP F072PR (1998) 1462.