§48. Re-entering Fast Ion Measurement Using Hybrid Directional Langmuir Probe

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A hybrid directional Langmuir probe (HDLP) was installed in LHD for fast ion measurements. There are mainly two purposes of the HDLP, one is an experimental estimation of fast ion population / power density outside of the last closed flux surface (LCFS), which is very important for accurate reconstruction of MHD equilibrium in particularly in low field discharge such as high β discharges because of existence of re-entering fast ions. The other is an observation of anomalous fast ion loss due to fast-ion-driven MHD instabilities such as toroidicity-induced Alfven eigenmodes (TAEs) and energetic particle modes (EPMs).

The co-directed passing particle orbit was calculated and the probe position was determined (see Fig. 1(a)). The directional probe was inserted by a remotely controlled linear drive system installed at the 2.5U port on LHD. Four pairs of directional probe tips (total 8ch) were mounted in the probe head, and schematics of the probe head structure are shown in Fig. 1 (b) and (c). Each probe collector has a thermocouple to estimate heat flux. Therefore this directional probe can measure local heat flux and fast ion current simultaneously at the same position. This method was developed and applied for fast ion measurement in CHS [1-2] for the first time and is also applied to Heliotron J experiment. The calibration of the heat flux measurement was performed using YAG Thomson laser. The pulsed laser of which power was calibrated was injected on the collector surface and the temperature increase was measured.

The heat flux measurement was performed in low field discharges in LHD (B_t=0.75T). The temperature of the co-channel (sensitive to co-directed flux) collector was increased just after the start of co-NB injection, while no response was observed in the ctr-channel, which are shown in Fig. 2 (a). Thus the heat flux observed by the HDLP is attributable to the co-directed fast ions. The spatial profile of the fast ion heat flux at the HDLP position was measured and the co-directed passing fast ions spread at the outside of the plasma up to 8.5cm far from the LCFS, which is shown in Fig. 2 (b). The systematic measurement of fast ion heat flux at outside of the LCFS and the comparison of orbit calculation are left for future study.

[1] K. Nagaoka, et al., Plasma and Fusion Res., 1 (2006) 005.
[2] K. Nagaoka, et al., Phys. Rev. Lett. 100 (2008) 065005.

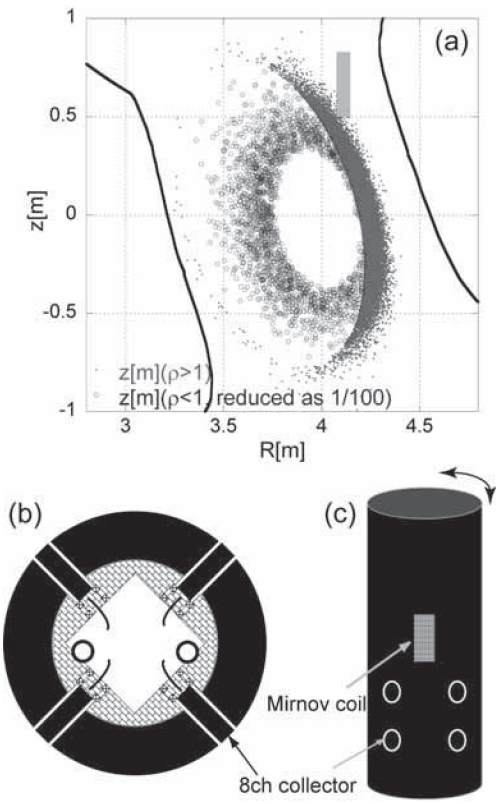

Fig. 1 (a) Poincare plots of co-going fast ions with Rax=3.6m and Bt=0.5T. The Schematics cross section of DLP (b) and DLP head (c).

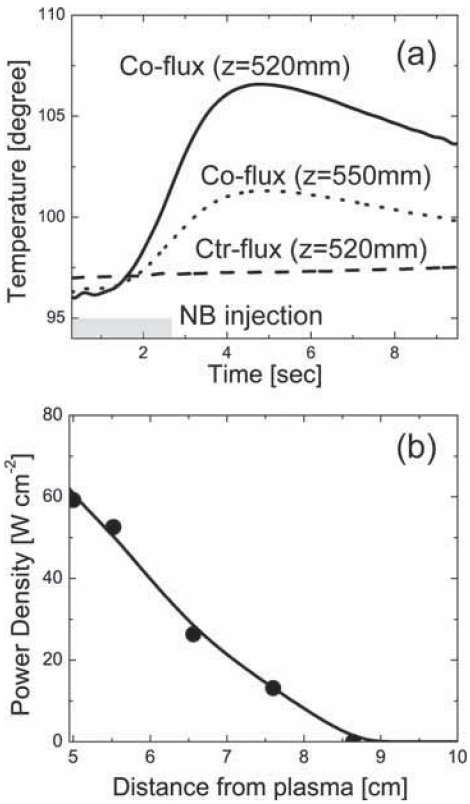

Fig.2 (a) The temperature increase just after co-NB injection. (b) The profile of fast ion power density with the magnetic configuration of R_{ax}=3.75m, B_t=-0.75T.