§10. Study on Collisional Ripple Transport of Neutral Beam-Injected Energetic Ions in CHS

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Losses of partially thermalized, pitch angle-scattered neutral beam (NB) ions have been experimentally observed by use of a lost fast ion probe (LIP) at the small R side of CHS [1]. Localized bright spot of scintillation light appears on the scintillator screen in NB-heated plasmas with B_t/R_{ax}=1.76T/0.921m (see Figure 1). The LIP indicates that the energy of escaping fast ions at the probe position ranges from 10 to 20 keV and their pitch angle (χ=arccos($v_{//}/v$)) is around 75~80 degrees although the NB (E_b=38keV) is tangentially coinjected in CHS. Judging from this, collisional ripple transport looks important to understand beam ion behavior and confinement in CHS. In order to verify whether the experimental observation can be explained by classical drift orbit phenomena, particle simulation in the presence of collisions is performed by the DELTA5D code [2]. In this code, the guiding center beam ion orbits are followed in the equilibrium magnetic field on Boozer coordinates obtained from the VMEC code. The beam ions slowed down to 3/2•T_i are counted as part of thermal ions. The plasma parameters used here are $n_e(0)$=3.0×10^{19} m^{-3} with a profile of $n=n(0)$•(1-(r/a)^2), and $T_e(0)=T_i(0)$=0.5 keV with a profile of T = $T(0)$•(1-(r/a)^2)^2. T_e and n_e profiles are obtained from Thomson scattering diagnostic. T_i profile is assumed to be the same as T_e profile and n_i (hydrogen) is given as 0.91•n_e and one impurity component is considered. The plasma potential is set to be zero. Energetic ions of 2,000 are launched in the co-direction in this analysis. Figure 2 shows location of beam ion losses on last closed flux surface (LCFS) and the LIP in 3D real space coordinate. It is seen that escaping beam ions cross the LCFS at the inboard side because trapped ion orbits deviate there from magnetic flux surfaces in CHS [3] and some of them can reach the vicinity of probe position. Figure 3 shows energy and pitch angle spectrum of beam ions coming to the vicinity of the LIP. Energy of escaping beam ions ranges from 18 keV down to 3/2•T_i. The LIP does not detect ions less than 10keV because of the limitation due to the aperture's structure. Therefore, it seems reasonable to conclude that the energy of escaping beam ions predicted by the DELTA5D is consistent with that observed by the LIP. On the other hand, there is a small discrepancy between the results from experiment and simulation in the pitch angle of escaping ions. One of possible reasons to explain this is that the DELTA5D provides location of lost beam ions on the LCFS but the probe tip is actually ~1.5cm away from the LCFS. Further analysis to explain the small discrepancy in the pitch angle is now in process.

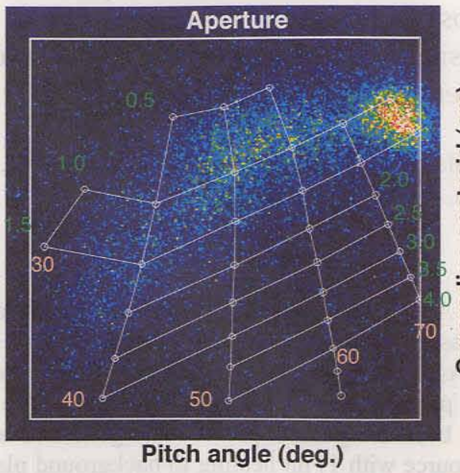

Fig. 1. Scintillation light due to impact of escaping beam ions in B_t/R_{ax}= 1.76T/0.921m. The magnetic field strength |B| at the probe position is 1.56T.

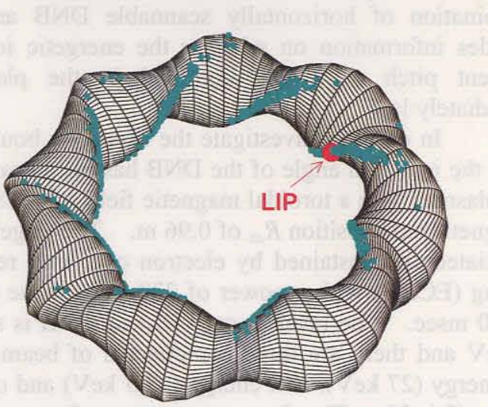

Fig. 2. Location of escaping beam ions on the last closed flux surface of R_{ax}=0.921m.

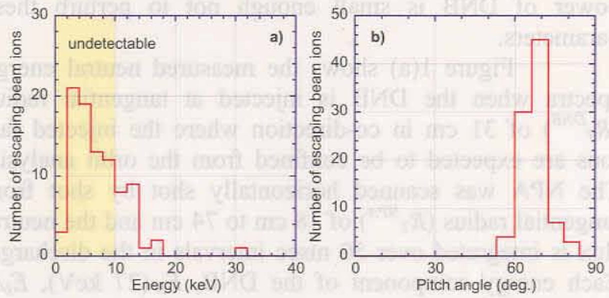

Figure 3 a) Energy spectrum of escaping ions in B_t/R_{ax}=1.76T/0.921m, b) Distribution of pitch angle of escaping ions.

References
1) Isobe, M. *et al.*, Rev. Sci. Instrum. 74(2003)1739.
2) Kugel, H, Spong, D.A., *et al.*, to be published in Fusion Science and Technology.
3) Isobe, M. *et al.*, Nuclear Fusion **41**(2001)1273.