§20. Fast Ion Analysis on Compact Helical System

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In heliotron/torsatron configurations orbit loss of first ion due to the helical ripple is an important issue, because it gives a prospect for the efficiency of α-heating in future.

Fast ions with small pitch angle ($v_\perp < v_\parallel$) have a orbit "passing" through the torus, while fast ions with large pitch angle ($v_\perp > v_\parallel$) are "trapped" in helical ripple. There are "transition" particles that change the states between "passing" and "trapped". Here $v_\perp$ ($v_\parallel$) is velocity of fast ion perpendicular (parallel) to the magnetic field line. In order to study the behavior of fast ion, diagnostic neutral beam (DNB), which can scan the injection angle θ_1 from 52 to 97°, is installed in CHS. The fast ion injected will be detected by neutral particle analyzer (NPA), which will be also scanned the detection angle θ_2 from 68 to 133°.[Fig.1(a)]

To investigate the characteristics of orbit (passing, trapped or transition) detected with NPA, orbit calculations were performed in the magnetic field configurations of R_{ax}=92.1 cm and B_t=1.76 T with energy of fast ion of 36 keV. Fig.1(b)-(d) show the top view of the diagnostic system arrangement and the fast ion orbit injected from DNB and detected by NPA located at 180° degree apart from DNB. The fast ions that are created near the plasma edge become trapped or transition particle, while the fast ions created in the plasma core become passing particle. (Fig.2(a)) The pitch angle of the fast ions detected with NPA is larger than that injected. The change of pitch angle is due to the difference in magnetic field strength between birth location of fast ion and charge exchange loss location. (Fig.2(b)) The trapped ions detected have a pitch angle close to 90°. It is interesting that the trapped ions are detected in counter traveling direction (θ_2>90°) while the transition ions are detected in co-traveling (θ_2<90°) direction.

By measuring the pitch angle of fast ion detected with NPA, one could know the characteristics of orbit (passing, trapped or transition). The influence of electric field on fast ion trapped in helical ripple will be studied.

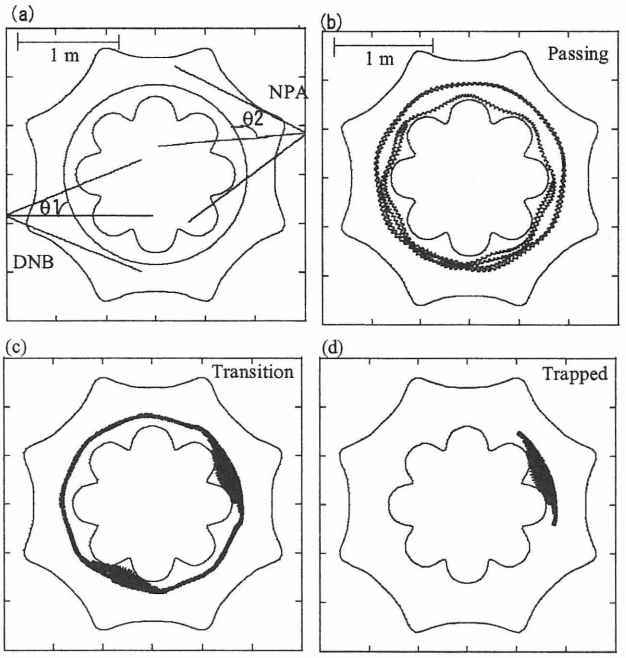

Fig.1 Top view of (a) DNB,NPA arrangement (b) passing particle orbit (c) transition particle orbit (d) trapped particle orbit

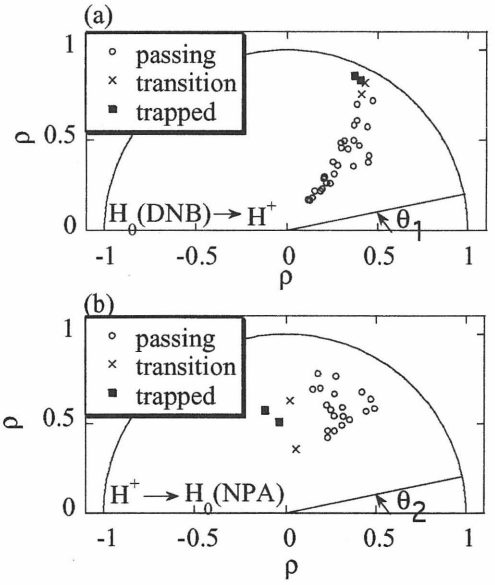

Fig.2 Polar plot of normalize minor radius and pitch angle (ρ, θ), where θ=arctan($V_\perp/V_\parallel$) of fast ion at (a) birth location on the beam line and (b) charge exchange loss location at NPA line of sight.