# §17. Direct Observation of Inward Electron Flux Being Blocked in the Large Helical Device

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We analyzed particle transport phenomenon caused by a pellet injection into the Large Helical Device [1].

The plasma (#56112) that we present here was created by ECH in a vacuum magnetic configuration with the magnetic axis at 3.6 m and field intensity 2.75T, heated by 1.3MW NBI, and fueled by a repetitive solid hydrogen pellets. A multi-channel Thomson scattering system measured how the electron temperature ($T_e$) and density ($n_e$) profiles evolve in response to the NBI and pellet injection (PI). Figure 1 shows eight successive snap-shots measured every 0.1s. Before the PI, $T_e$-profile shape was a triangle and $n_e$-profile shape was a shallow hollow. Pellets entered around 2.45s. Just after the PI, $n_e$-profile became a deep hollow shape like a head of a cat. The $T_e$-profile just after the PI shrunk a little but soon restored the initial triangle shape. It seems that the $n_e$-perturbation caused by the PI did not propagate into the core region. To see this more clearly, we over-plot $n_e$-profiles between two PIs in Fig. 2. One can see that particles diffusing into the core region were almost blocked up to the surface intersecting at $R$=3.2m and 4.0m. Only a small amount of particles (<10%) entered the core region just after the PI and resided there for a longer time, thus boosting the background profile as a whole. Except this small increase, the $n_e$-profile resumed almost the same shape as before the PI.

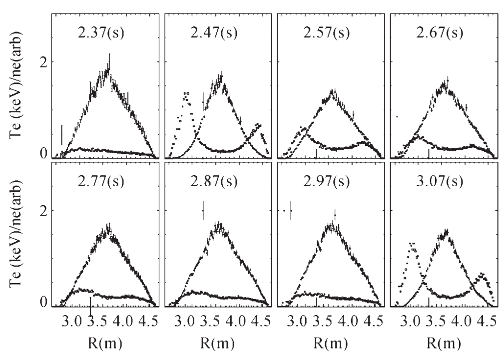


Fig.1 $T_e$ (triangle) and $n_e$ (hollow) profiles every 0.1s. Pellet entered at 2.45s. The $n_e$ lies in $10^{19}m^3$ range.

We examine the above blocking phenomenon somewhat quantitatively. Assuming the usual form of the particle flux $\Gamma = -D\nabla n_e + Vn_e$ with assumed diffusion coefficient $D$ and convection velocity $V$, we follow the left-side $n_e$-profile after 2.47s (2nd frame) by solving $A\partial n_e/\partial t = \partial(A\Gamma)/\partial\rho$, where ρ is a minor radius and $A(\rho)$ is the area of the flux surface. Here we drop the source term, since at 2.47s, 20 ms after PI, the injected hydrogen atoms were almost completely ionized and hence the particle source localized at the plasma edge had no influence for the evolution of the *perturbed* $n_e$-profile. The most simple model of $(D,V)$=(constant,0) hardly reproduces the observed $n_e$-profile evolution. As shown in Fig. 3(A), the fit with $D$=0.5m$^2$/s inevitably accompanies an in-going $n_e$-perturbation. This inward propagation is hindered by deliberately lowering the $D$ in the inner region, which mimics an internal transport barrier (ITB) as shown in Figure 3(B).

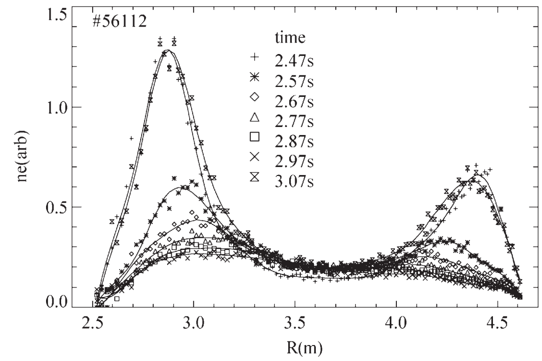


Fig. 2. Evolution of $n_e$-profile between two pellet-injections.

One can better reproduce the observation by choosing a two-valued $(D, V)$ combination:

$D$= 0.5 m$^2$/s, $V$=0 m/s in the outer region

$D$= 0.05 m$^2$/s, $V$=1.5 m/s in the inner region

as shown in Fig. 3(C). Here the boundary between the inner- and outer-regions is guessed to be at $R$=3.0m and 4.2m, which are marked by the vertical lines.

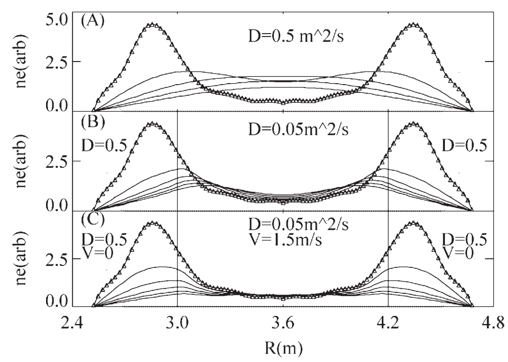


Fig. 3. Calculated $n_e$-profile evolutions every 0.1 s after a pellet injection: for (A) uniform $D$=0.5 m$^2$/s; (B) an 'ITB' with 10-times insulation; (C) the 'ITB' plus an outward convection. The right side of each figure is reflection of the left with plane of symmetry at $R$=3.6m. The dotted triangles at the edges are the estimated source profile.

In considering the bi-directional property of the diffusion process, we could guess from the present result that the core region can hold plasma a longer time once plenty of particles are introduced inside by some means.

[1] Narihara, K., *et al*, Plasma and Fusion Research: Rapid Communications 1, 023 (2006).