## §19. Studies on the Edge $E_r$ Structure

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In this report, we present the result from NBI switching experiments (from co- to counter-NBI or counter- to co-NBI) in the low β regime ($\beta \approx 0.4\%$) at the $B_T = -2.75$ T, investigating the spontaneous toroidal flow at the plasma edge region. The plasma configuration has a vacuum magnetic axis position of $R_{AXIS} = 3.60$ m having the helical pitch parameter of $\gamma = 1.254$. It should be noted that the separatrix location, at which the spatial derivative in the $E_r$ structure ($\nabla E_r$) had a local maximum value (termed to "$R_{CXS}^{LCFS}$"), was determined by CXS diagnostic. [1)] As shown in Fig. 1 (a) and (b), the Shafranov shift is expected to be not so large in low β regime and hence the real location of the LCFS might be close to that for the LCFS location of the vacuum magnetic field configuration.

According to a change in direction of the momentum injection to the plasma core region from co- to counter-direction (or counter- to co-), we observed a finite change in the toroidal flow outside the separatrix towards the direction anti-parallel to the plasma core region (a few km/s, typically). In case of the counter- to co-NBI, the toroidal flow at the plasma axis was co-direction (in a direction to increasing the rotational transform) as expected, while the plasma flow outside the separatrix exhibited to change in the counter-direction as shown in Fig. 2 (a). An opposite phenomena was also seen in the NBI switching experiment form co- to counter-NBI as shown in Fig. 2 (b), indicating a spontaneous toroidal rotation outside the separatrix in the co- direction. It should be noted that the toroidal flow at the separatrix was unchanged due to the NBI switching for both cases.

It is suggested that the momentum was pumped-out from the nested magnetic surfaces to the open field lines. We observed a similar phenomenon in the $T_i$-ITB formation experiments by means of the Carbon pellet injection in this experimental campaign at the $B_T = -2.85$ T ($0.6\% \le \beta \le 0.7\%$), where the spontaneous toroidal flow at the plasma core region in the co-direction was generated as shown in Fig. 3. In this case, the spontaneous toroidal flow outside the separatrix was found to be in the counter-direction.

At the moment, we cannot explain these new findings by means of a simple model for the momentum diffusion due to the plasma viscosity, and hence this phenomenology remains theoretically rich and complex. The experimental data presented here could aid the verification of the non-local momentum transport.

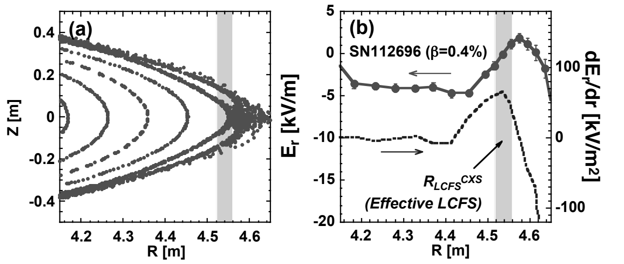


Fig. 1. (a) Poincar´e plots of vacuum magnetic field lines on the horizontally elongated poloidal cross section, and (b) radial electric field and its shear.

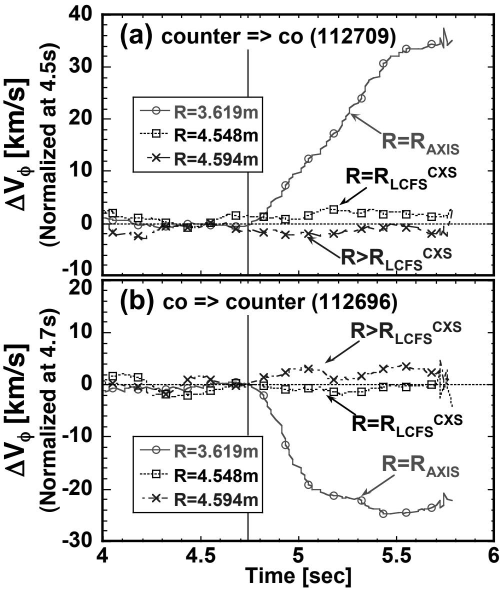


Fig. 2. Temporal evolution for the change in the toroidal rotation velocity at different radii.

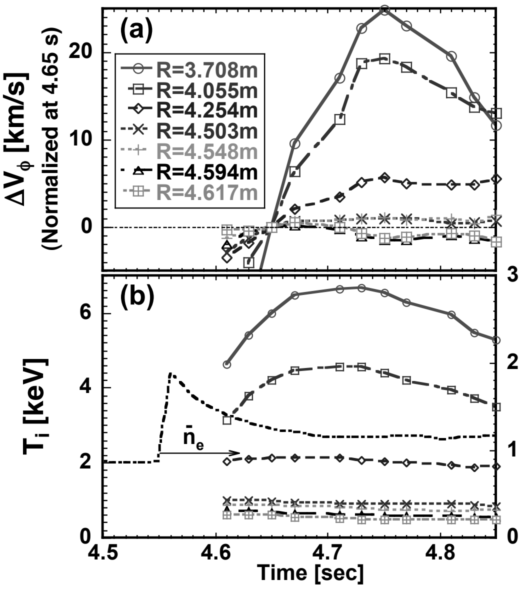


Fig. 3. Temporal evolution for the change in (a) toroidal rotation velocity and (b) ion temperature at different radii. Line-average electron density are also shown in (b).

1) Kamiya, K. et al.: Nucl. Fusion **53** (2013) 013003 (9pp).