§10. Observation of the Spontaneous Toroidal Plasma Flow in Co-direction at about Half the Plasma Minor Radius

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In this report, we present the result from NBI switching experiment (from co- to counter-NBI) with a high input power and low density regime (n_e<1x10^{19} m^{-3}) at the B_T = +2.75 T, investigating the spontaneous toroidal flow at the plasma core region. The plasma configuration has a vacuum magnetic axis position of R_{AXIS} = 3.60 m having the helical pitch parameter of γ = 1.254.

We observed a finite change in the toroidal plasma flow for carbon impurity ions at ρ ~ 0.5 in the co-direction (a few km/s, or more) even in the counter-NBI phase as shown in Fig. 1. In this case (discharge 119645), the direction of the momentum injection to the plasma core region was switched from co- (1 unit) to counter-direction (0.5 to 1.5 unit). This indicates a spontaneous toroidal plasma flow in the plasma core region in particular at about half the plasma minor radius (but this phenomenon is seen in transiently). It should be noted that the toroidal plasma flow at the plasma axis reached almost stationary phase at about 200 ms after the NBI switching from co- to counter-NBI, and it was unchanged at the separatrix due to the NBI switching. It is suggested that the momentum was pumped-out from the plasma central region to the half plasma minor radius, transiently. As shown in Fig. 2 (b), we observed the toroidal plasma flow structure having a W-like shape around the plasma axis during this transient phase at which the external momentum input direction is switched from co- to counter-direction. It should be noted that the gradients in the mean plasma parameters at about half plasma minor radius exhibit a little increase in response to the beam switching as shown in Fig. 2 (a, d~f). The poloidal plasma flow at the half plasma minor radius (R~4.2 m) seems to be damped during NBI switching phase as shown in Fig. 2 (c).

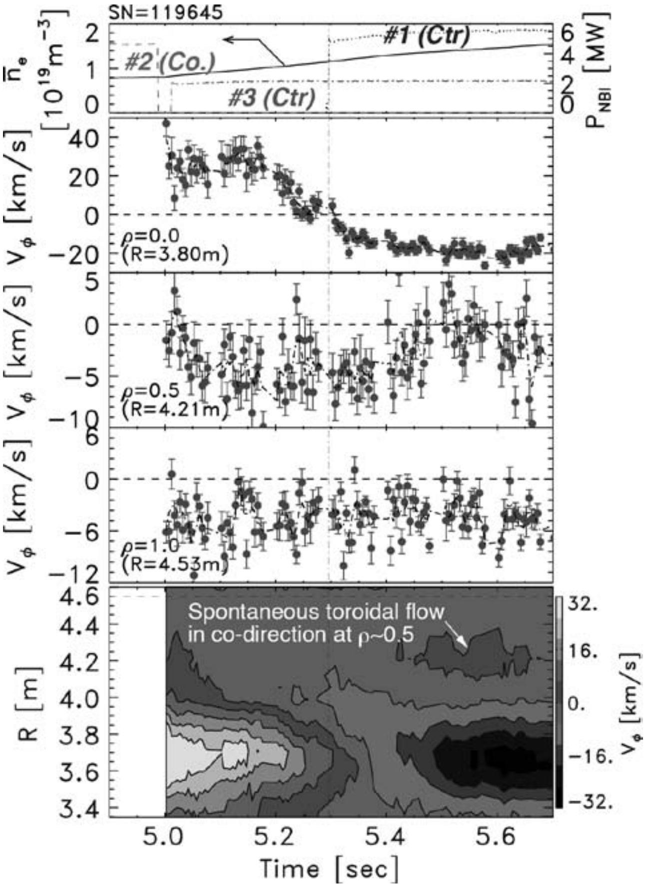

Fig. 1. Temporal evolution of (a) NBI power, toroidal rotation velocity at (b) ρ = 0.0, (c) ρ = 0.5, and (d) ρ = 1.0. Contour plot of the spatiotemporal evolution for toroidal rotation velocity is also shown in (e).

There are various driving and damping mechanism in the momentum transport, including the contribution from an off-diagonal term of the transport matrix, which does not depend on velocity shear or the velocity itself.[1)] 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.

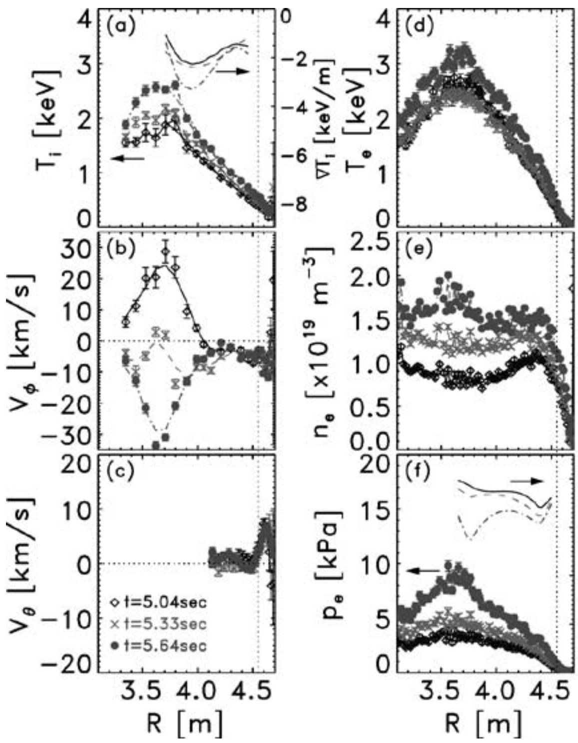

Fig. 2. Profiles for (a) ion temperature, (b) toroidal, (c) poloidal rotation for carbon impurity ions, electron (d) temperature, (e) density, and (f) pressure vs. major radius.

1) Ida, K. and Rice, J. E : Nucl. Fusion **54** (2014) 045001.