§25. Toroidal Flow Development after the Tangentially Injection of Neutral Beams

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i) Introduction There are great interests in the formation mechanism of the toroidal flow in the magnetic confinement devices. Not only externally driven toroidal flow but also spontaneously driven flow contributes to the formation of toroidal flow structure in the plasma. It has been observed that the toroidal flow is driven to the direction of the injected tangential beams just after the injection, and then it changes gradually in time to the co-direction independent on the direction of the injected beams in the 17th campaign experiment. The experiment shown here was performed in order to investigate whether the toroidal flow change occurs even though if there is no net toroidal momentum input but the heating with the neutral beams.

ii) Experiment and Results The plasma is produced with ECH and sustained with perpendicularly injected neutral beams (BL4 and BL5) in the magnetic axis position is 3.6m and magnetic field strength is -2.75T.

Figure 1(a) shows the time evolutions of ion temperature for the case with counter dominant injection (a co-directed beam; BL2 and two counter-directed beams;BL1, BL3) and balanced injection (a co-directed beam; BL2 and a counter-directed beam; BL3). The injection of the tangential beams starts at 5.3s. The ion temperature in the phase with only the perpendicular beams is about 1.5keV and then it decreases to 1keV associated with the increase of the electron density due to the injection of perpendicular beams. The ion temperature with the counter dominant injection is higher than that with the balanced injection because the total injection power is higher in the case of counter dominant injection than that in the case of balanced injection. Figure 1(b) shows the time evolutions of the difference of the toroidal velocity from the velocity at the $t = 3.6$s. The toroidal flow velocity is kept constant for the duration of the injection with the perpendicular beams only. The velocity in the balanced injection is kept constant also while the velocity changes fast to the co-direction just after the start of the tangential beam injection due to the small imbalance of the injection power of the beams. On the other hand, the velocity changes slowly ($dVT/dt \sim 10\text{km/s}^2$) to co-direction in the counter-dominant injection while the velocity changes fast to the counter-direction just after the start of the tangential beam injection. The slow change of the toroidal flow to the co-direction during the tangential beam injection is reappeared same as the 17th campaign.

Figure 2 shows the time evolutions of the auto-power spectrum of the signals measured for the phase contrast imaging (PCI). The signal obtains the integration of the density fluctuations. The broad fluctuation near the 50kHz is disappeared after the counter-dominant injection while the fluctuation is kept in the case with the balanced injection. The observations shows that the change of the fluctuation pattern observed in the discharge in which the slow change of the toroidal flow to the co-direction occurs. Observations in the discharge with higher ion temperature for the balanced injection is necessary to clear the conditions of this phenomena.

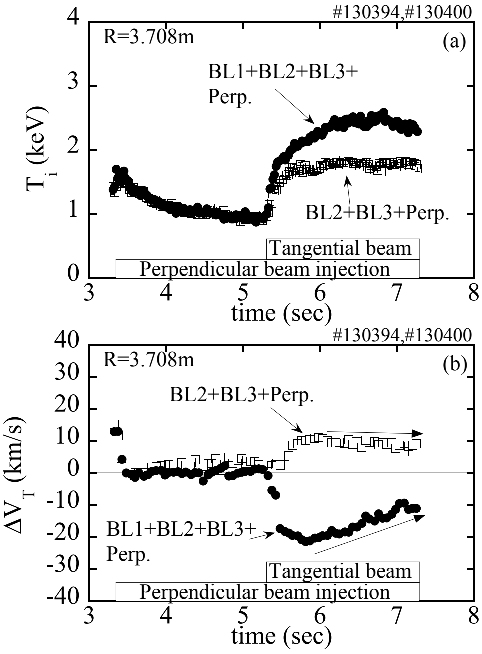

Fig. 1: Time evolutions of (a) ion temperature and (b) the difference of the toroidal flow velocity from the velocity at the 3.6s in the case of counter dominant injection (circle) and balanced injection (square).

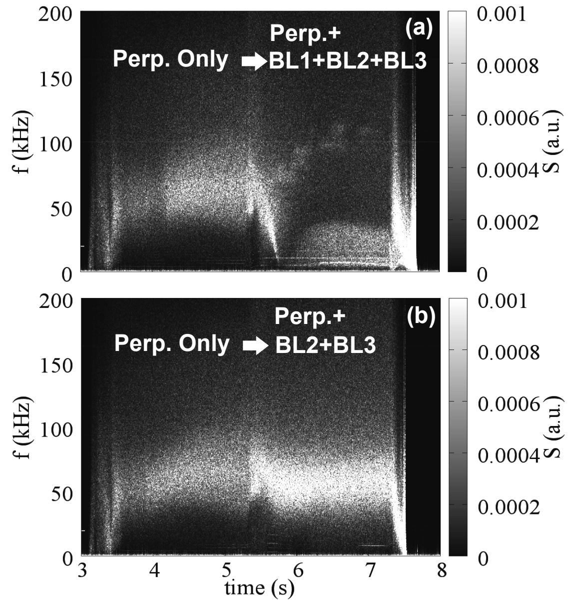

Fig. 2: Time evolutions of auto power spectrum of the PCI signal in the case with counter dominant injection (circle) and balanced injection (square).