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Observation of damped oscillating flow and momentum change associated with a pellet injection

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We report the discovery of oscillatory flow and rapid momentum change as a result of the pellet injection. New diagnostics tools with high spatial and temporal resolution applied to the perpendicular flow velocity $V_\perp$ and turbulence intensity measurements in Large Helical Device (LHD) plasma experiments show the following results. Just after the pellet injection, (1) the damped oscillating flow velocity and the increasing turbulence intensity are observed in a few milliseconds. (2) The propagating flow structure towards the core direction is observed, and its speed is faster than the pellet penetration speed. These results are quite meaningful for understanding the physics of pellet penetration in toroidal plasma.

The oscillatory perpendicular flow velocity is observed just after the pellet injection as shown in Fig. 1(a). The damped oscillation model can be applied to fit the observation data. The toroidal mode number of this oscillation is estimated to be 0 or 10. We can also measure the turbulence intensity at the same position. The turbulence increases rapidly and then decreases before the end of the damping of the oscillatory flow as shown in Fig. 1(b). The generation and damping of flow itself might be caused by the turbulence. On the other hand, the electron density increases and the electron temperature decreases with finite delay. Therefore, it is found that the change of local density gradient seems likely not to play an important role for the start of this oscillation.

The ballistic propagation of the change of flow structure towards the core direction is observed in the region at r/a<0.97, where the mono-cycle temporal oscillation is observed. The propagation speed increases at the location of r/a~0.97 and exceeds 1.5 km/s, which is three times faster than the pellet penetration speed. This indicates that the rapid propagation of information of momentum change is present. Currently, it is also found that the location of the pivot point is not at the rational surface of low-*m*/*n*, and the information of momentum change propagates at least r/a~0.86 before the start of the electron density rise. Therefore, it is found that the momentum changes rapidly, and this may lead the global change of the radial electric field and affect the bulk plasma transport.

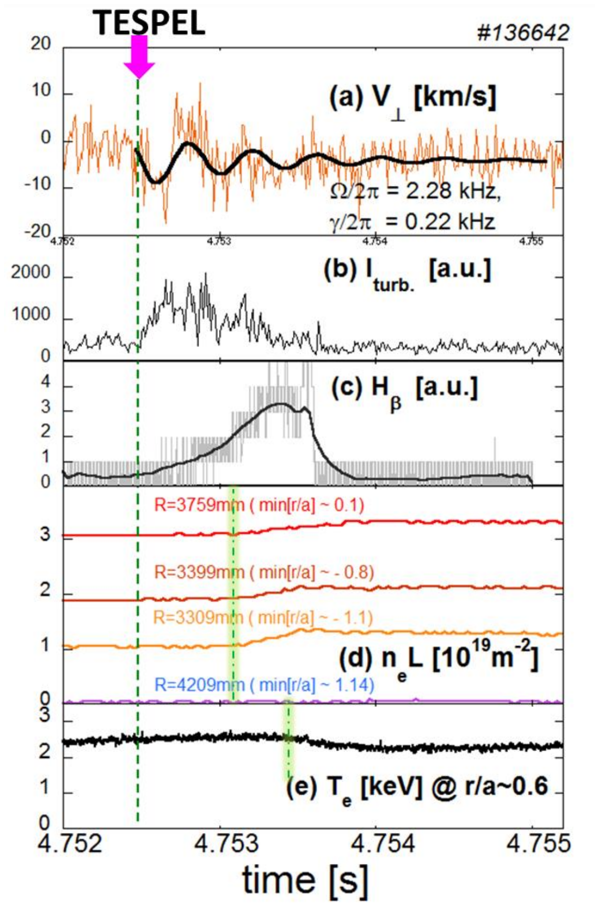

Fig. 1. Oscillating $V_\perp$ is observed at r/a ~ 0.98 just after the TESPEL injection (t~4.7524 s). (a) Time evolution of perpendicular velocity $V_\perp$. Here, the black line shows the fitting curve which indicates the oscillation frequency of 2.1 kHz, and the damping rate of 0.2 kHz. Time evolutions of (b) turbulence intensity (high frequency components of density fluctuation), (c) H_β radiation, (d) line integrated electron densities at each line-of-sight (here, min[r/a] ~ 0.1 indicates that the minimum radial location of this viewing channel is 0.1), and (d) electron temperature at the most outer channel.

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