§ 7. Measurement of Plasma Rotation by Using Fast Charge Exchange Spectroscopy System

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Charge exchange spectroscopy (CXS) has been used to measure the profile of ion temperature and plasma rotation velocity and radial electric field. The time resolution of CXS System was improved in LHD to study the dynamic behaviors in the plasmas such as transitions from ion root to electron root and breathing phenomena.

In order to compare the radial electric field E_r transition at the edge observed in LHD plasma to the predictions of neoclassical theory. The electron density is scaned in the single discharge. The time evolution of ion temperature and the rotation velocity of the plasma is measured with the time resolution of 100 msec by using the fast CXS system.

Figure 1 shows the time evolution of poloidal rotation velocity when the electron density is ramped up and down. The direction of poloidal rotation, which is strongly related with the ***ExB*** drift, changes from positive to negative then negative to positive afterwards. Before the ramp up of the electron density the plasma rotates in positive of poloidal direction. Associated qith the quick increase of electron density by hydrogen gas puffing, the direction of rotation changes from positive to negative quickly and then change back to positive slowly. There are no clear differences of the critical density, where the sign of radial electric field changes, between the phase of density ramp up and down.

In general, the ripple loss strongly depends on the magnetic configuration controlled by magnetic axis shift. A critical density for the transition from a large positive E_r (electron root) to a small negative E_r (ion root) is also depends on the magnetic configurations.

Figure 2 shows the dependence of poloidal rotation velocity on the electron density measured for the plasma with inward shifted (R_{ax}=3.5m), standard (R_{ax}=3.75m), and outward shifted (R_{ax}=3.9m) configurations. Dashed line indicates the neoclassical predictions for the critical density. In the case of inward shifted configuration, the electron density in this experiment is always higher than the critical density and the rotation velocities are negative. However in the case of outward shifted configurations, the electron density in our experiment is lower than the critical density and the rotation velocities are positive. In the case of standard shifted configurations, the rotation velocities are changes from negative to positive when the electron density becomes slightly lower than the critical density. These observations are consistent with the prediction from the neoclassical theory.

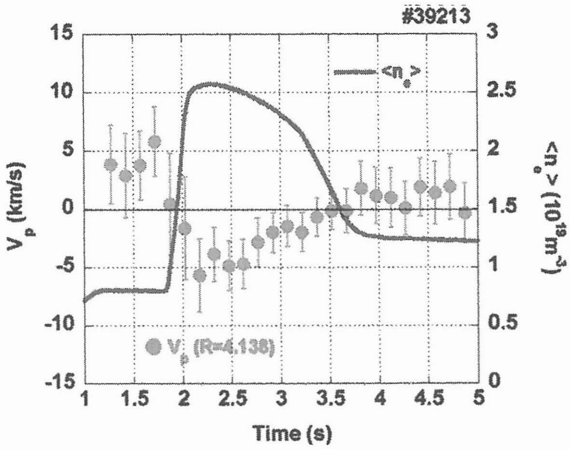

Fig.1. Time evolution of poloidal rotation velocity (circle) while the electron density (solid line) goes up and down.

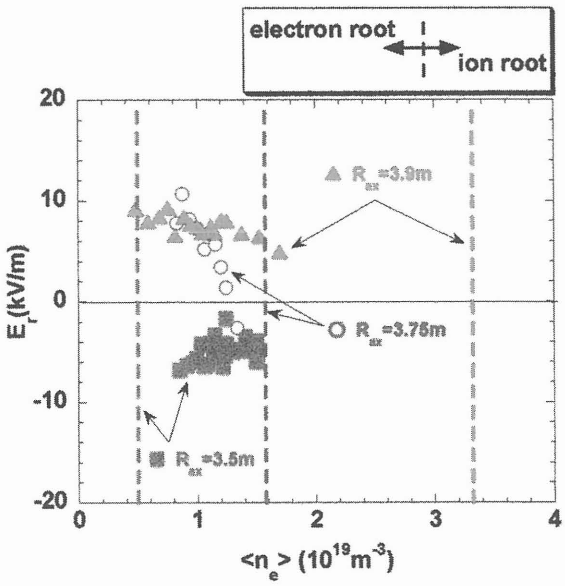

Fig.2. Dependence of poloidal rotation velocity on electron density measured by the fast CXS system in R_{ax} = 3.5m (square), 3.75m (circle), 3.9m (triangle). Dashed lines indicate the critical densities which are boundary of the region where E_r can be electron root (left hand side) and E_r is ion root (right hand side) predicted by neoclassical calculation.