§53. Dependence of Impurity Accumulation Window on Magnetic Configuration

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In NBI heated long pulse discharges, we found impurity accumulation window in collisionality regime, where metallic impurities were accumulated in the plasma core with a long time constant (several seconds) [1, 2]. These discharges have been carried out in the magnetic configuration with R = 3.6 m and B = 2.75 T. We suggest that impurity transport due to helically trapped particles plays an important role in this phenomenon. Therefore, we investigate the effect of helicity for impurity accumulation by changing the 'effective' helical ripple (ε_{eff}), that is, scanning the magnetic axis (R).

Figure 1 shows a typical discharge with impurity accumulation. In this discharge, the plasma density is controlled so as to keep 3.4 x 10^{19} m^{-3} by a feedback control loop. However, the density increases with time in the accumulation phase despite of decreasing the gas puffing. This means that there exists a strong inward velocity component in the accumulation phase. In this phase, the core radiation increases with time and the core electron temperature decreases. In order to evaluate a degree of impurity accumulation, we observe an increasing rate of radiation power signal ($dP_{rad}/dt \sim dS_{rad}/dt$) at a central chord of the plasma. The large value of dP_{rad}/dt corresponds to a strong impurity accumulation. Figure 2 shows the dependence of impurity accumulation region on magnetic configuration together with the radial electric field measured at the peripheral region ($\rho \sim 0.8$). In the inward shifted configuration (R = 3.6 m), the impurity accumulation window is observed in the vicinity of plateau regime for the plasma at $\rho \sim 0.5$. In other cases (R = 3.75 m and R = 3.9 m), there is no clear impurity accumulation window. However, it is found that impurity accumulation region moves to high collisionality regime as the magnetic axis is shifted outward. The radial electric field has positive (electron root) in low collisionality region and negative (ion root) in high collisionality region for all magnetic configuration. The transition point from electron to ion root moves to high collisionality regime in the same way as the impurity accumulation region. At the critical point for impurity accumulation, the electric filed indicates the same value of ~ 3 kV/m. This suggests that impurity accumulation is closely related to the radial electric field, which depends on helical ripple transport. In LHD, the 'effective' helical ripple for v^{-1} transport, which can be estimated by a simulation code, depends on the magnetic configuration and becomes quite large as the magnetic axis moves outward. The dependence of electric field on magnetic configuration can be explained by the change of the helical ripple. As a result, it is concluded that impurity helical ripple transport depending on the radial electric field leads to accumulation in the plasma core.

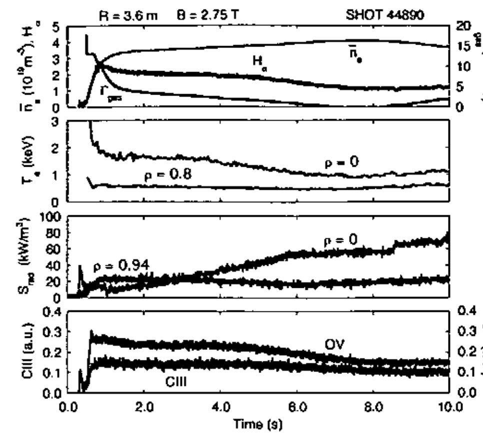

Fig. 1. A typical discharge with impurity accumulation.

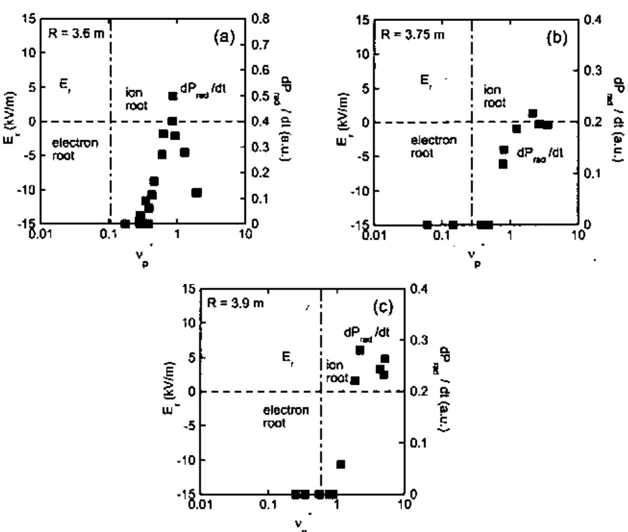

Fig. 2. Dependence of impurity accumulation region and radial electric field on magnetic configuration ((a) R = 3.6 m, (b) R = 3.75 m, (c) R = 3.9 m).

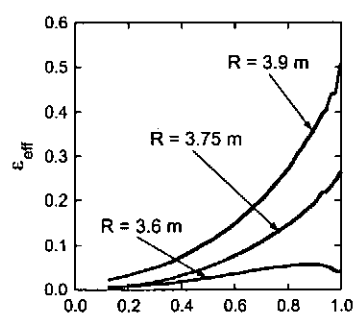

Fig. 3. Dependence of the 'effective' helical ripple for v^{-1} transport on magnetic configuration

References
[1] Nakamura, Y., et al., PPCF **44** (2002) 2121.
[2] Nakamura, Y., et al., Nuclear Fusion **43** (2003) 219.