§11. Slow Oscillations of Impurity Accumulation and Pumping Out in LHD Long Pulse Discharges

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In LHD long pulse discharges, we found impurity accumulation window in a specific 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 with low NBI power of 1~1.5 MW. When the NBI heating power was increased up to 2.5 MW, we observed a slow oscillation of impurity accumulation and pumping out during one long pulse discharge (τ_d ~ 10 s). Therefore, we report a new type of oscillation phenomenon in LHD long pulse discharges, unlike 'breathing' oscillation.

Figure 1 shows a typical long pulse discharge with slow oscillations during the discharge. In this discharge, the plasma density is controlled so as to keep 2.8 x 10^{19} m^{-3} by a feedback control loop. However, the density increases with time despite of decreasing the gas puffing until 5 s. After that, the plasma density decreases in spite of increasing the gas puffing and increases again. In such a way, the density oscillates with time. There are also seen remarkable oscillations in the electron temperature and radiation in the core region. On the other hand, no remarkable oscillation of plasma parameters is observed in the peripheral region. Furthermore, there is no remarkable oscillation in low-Z impurity line intensities (CIII, OV). This means that metal impurities are accumulated and pumped out repeatedly during the discharge. In this discharge, we can also observe a peaking of density profile as shown in Fig. 2, where time evolutions of core (ρ = 0.3) density, edge (ρ = 1.0) density and the density ratio are indicated. The time variation of edge density seems to be influenced by the amount of gas puffing. While the core density seems to be changed by particle transport. This suggests that there exists a strong inward convection in the peaking phase and an outward convection in the pumping out phase.

Figure 3 shows temperature profiles in the long pulse discharges. In the initial phase of the discharge, the central electron temperature is about 2 keV and the shape of temperature profile is peaked. When the metal impurities are accumulated in the core region, the electron temperature is remarkably reduced by impurity radiation in the whole region except for the edge region (r > 0.8). However, there remains a temperature gradient in the core region even if the impurity radiation arrives at the maximum point. It is different from the temperature profiles obtained in the discharge with low NBI power. This suggests that there is a possibility for impurity pumping out due to temperature screening effect in high collisionality regime (PS regime). It seems to be a key point in order to understand the physical mechanism of slow oscillations during the discharge. We need further investigation to understand impurity transport in helical plasmas.

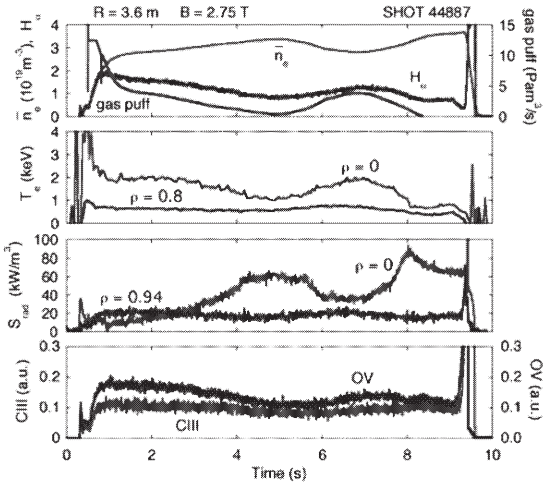

Fig. 1. A typical discharge with slow oscillations of impurity accumulation and pumping out.

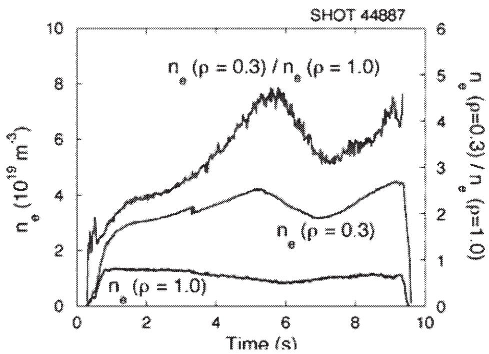

Fig. 2. Time evolutions of core, edge plasma density and the density ratio.

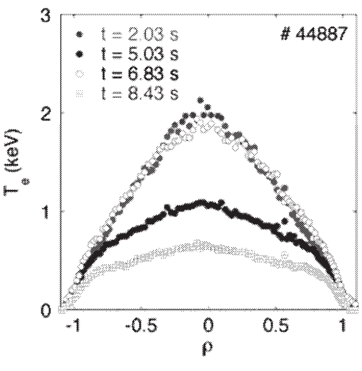

Fig. 3. Change of temperature profile due to impurity accumulation and pumping out.

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