§43. Characteristics of Impurity Content in Long-Duration Discharges with Magnetic Axis Sweeping

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Significant progress in LHD has been made in terms of injected energy: an energy of 1.6 GJ has been injected into plasmas lasting more than 54 min in the 2005 experimental campaign. These long-duration discharges were terminated by radiation collapse due to penetration of metallic flakes into the plasma. Therefore, we investigate the dependence of impurity content on magnetic configuration and the direction of magnetic axis sweeping.

Steady state operation was carried out in various magnetic configurations by scanning the magnetic axis in time during the discharge. Figure 1 shows the discharge duration and the normalized radiation as a function of the magnetic axis. In the inward shifted configuration (R = 3.55 ~ 3.6 m), the discharge duration was limited up to 160. The discharge duration was extended gradually by shifting the magnetic axis outward, Finally, the discharge was sustained for more than 30 min with real-time magnetic axis sweeping between R = 3.672 ~ 3.693 m in the 2004 experimental campaign. In this experimental series, there exists another key point for extending the discharge duration. As seen in Fig. 1, the radiation normalized by the averaged electron density remarkably decreases by shifting the magnetic axis outward. An abrupt termination of the steady state plasmas was frequently observed without any trouble in the heating system. In that case, the abrupt increase of density and radiation was observed at the end of the discharge in spite of constant heating power input. Spectroscopic measurements show that light impurity line intensities do not increase but metallic impurity (mainly iron) line intensities increase suddenly at the same time as the increase of density and radiation. This suggests that a relatively large iron mass comes into the plasma. The events mentioned above can be seen in most of the long pulse discharges terminated unexpectedly. Most probably, the discharge durations are limited by the penetration of metallic flakes into the plasma, which may be caused by localized heat deposition or power concentration.

Figure 2 shows the time behavior of radiation and impurity line radiations in thirty minutes discharge. The averaged central chord radiation was maintained at a constant level during the discharge. The detailed time behavior is similar to that in the line radiation of the metallic impurity (FeXXIII). On the other hand, the light impurity line intensity (CIII) has no significant change in time. This suggests that the main impurity in the core plasma is iron and its content is significantly large. In addition, it is found that the normalized radiation is dependent upon the magnetic axis and the sweeping direction as shown in Fig. 3. The radiation normalized by the line averaged electron density indicates the impurity content in the plasma. The data points indicate an averaged value in the magnetic axis sweeping of 18 times except for those during the injection of neutral beam. In the outward shifting phase, the normalized radiation increases in the vicinity of R = 3.678 m and then decreases by shifting the magnetic axis outward. When the magnetic axis moves inward, the radiation increases monotonously. These results indicate a strong interaction between the plasma and SS wall in the inward shifted magnetic configuration.

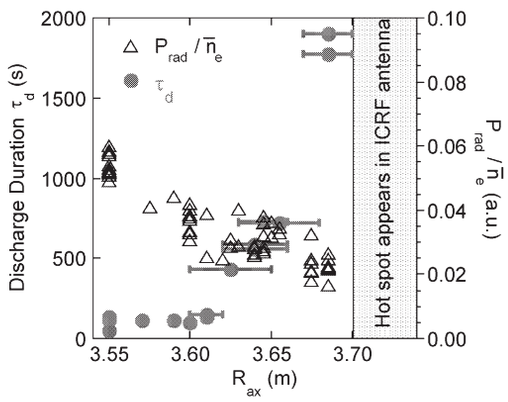

Fig. 1. Progress in discharge duration by scanning axis and dependence of normalized radiation on the magnetic axis.

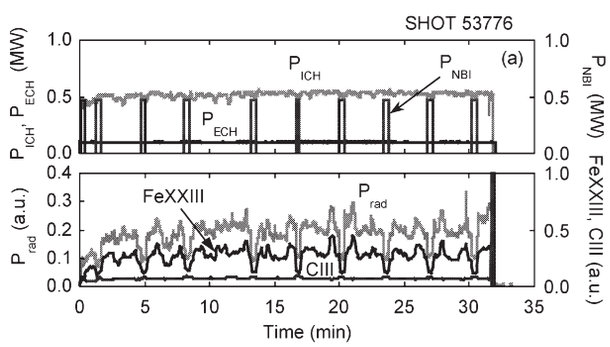

Fig. 2. Time behavior of radiation and impurity line radiation in thirty minutes discharge.

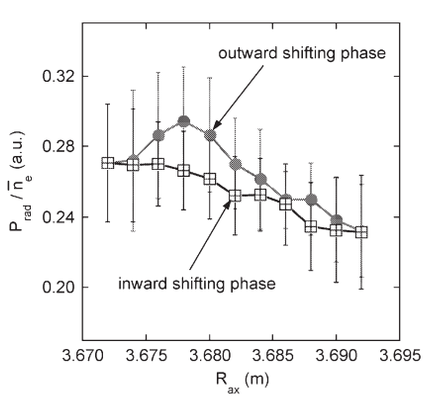

Fig. 3. Dependence of normalized radiation on the magnetic axis during thirty minutes discharge.