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§16. Measurement of Sparks and Dusts Released from an ICRF Antenna Just before Termination of an ICRF Heated Long Pulse Discharge

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Identification of causes of termination of plasmas in ICRF heated long pulse discharges is an urgent task for the Large Helical Device (LHD) project. Two fast framing cameras were applied to monitor the plasmas and plasma-wall interactions in the long pulse discharge experiments in the last experimental campaign. One of the fast cameras (Photron APX-RS) was installed in an outer port (10-O) for observing plasma-wall interactions on closed helical divertor components near 10.5-U port. Other new fast camera (Photron SA-X) was used for monitoring the plasmas from two positions in 6-O and 6-T ports using two image fibers with a stereo-optics which can convert two images transferred from the two different positions to one image. The two fast framing cameras can monitor about 60% of the area inside of the LHD vacuum vessel, which includes two ICRF antennas installed in 3.5-U&L and 7.5-U&L ports. Capturing images with the fast cameras was performed in an end-trigger mode in which sequential images are cyclically stored in a storage memory until at an end trigger. Thus, the cameras can acquire several thousand images just before termination of the long pulse discharges.

Shown in Figure 1 are the three snapshots of the plasma and the 7.5-U&L ICRF antennas observed from the 6-T port just before termination of a long pulse discharge. Figure 2 is time evolutions of the total ICRF power, the plasma density, and spectroscopic measurements of impurities (Fe and C) just before the plasma termination. The power from the 7.5-L antenna stopped with a moderate sparks observed in the lower part of the antenna at 745.47s as shown in Figure 1 (a). At the restart of the ICRF oscillation at 745.70s, the fast camera clearly observed an intense spark in the lower part of the antenna followed by release of many incandescent dusts from the antenna (b).

Spectroscopic measurements have shown that the emission from Fe ions drastically increased just after the spark. It suggests that impurities (mainly Fe) included in the dusts released from the antenna reached to the main plasma inside of the last closed flux surface, which enhanced radiation cooling and plasma density rise. Spectroscopic measurements indicate that the re-restart of the ICRF oscillation at 745.94s enhanced emission from Fe ions accompanied with a somewhat moderate spark in the ICRF antenna as shown in Figure 1 (c). From the viewpoint of the effect of impurity shielding by the peripheral plasma (the ergodic layer), it is possible that the stop of the ICRF oscillation (7.5-L) itself spoiled the function of the impurity shielding because of the low electron temperature and plasma density on the ergodic layer after the stop of the oscillation, which increased the impurity content, leading to the plasma termination.

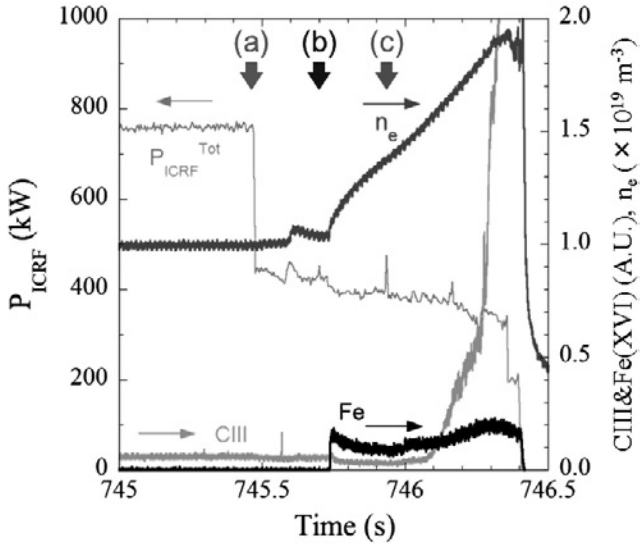

Fig. 2 Time evolutions of the total ICRF power, the plasma density and spectroscopic measurements (C and Fe) just before the plasma termination.

For extending the duration time of ICRF heated long pulse discharges, reasons for the stop of the oscillation have to be identified. In addition, improvements of the antenna are necessary for minimizing dusts released with the intense spark, which can contribute to reduction of radiation cooling by impurities in the plasma.

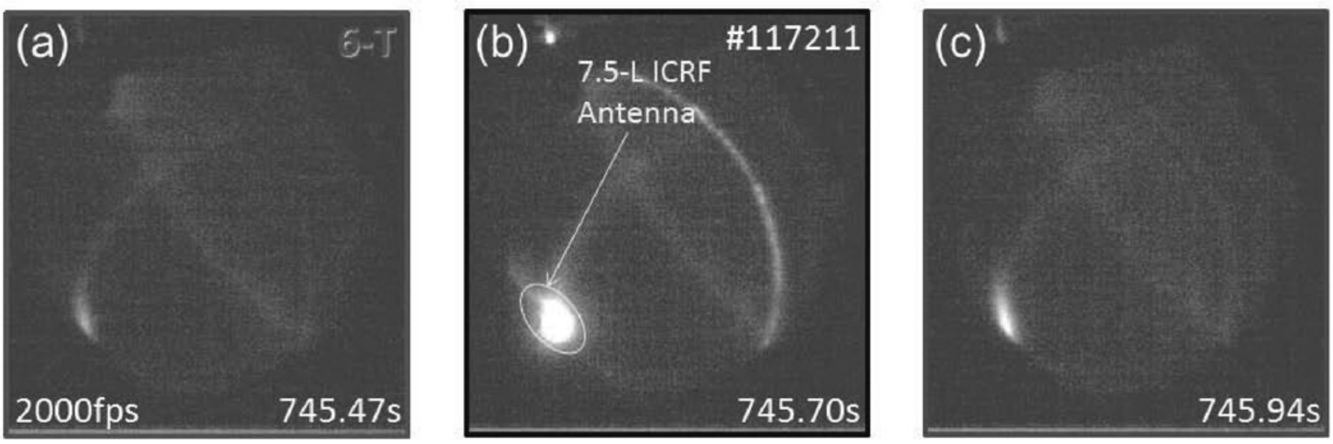

Fig. 1 Three snap shots of sparks occurred in the lower part of an ICRF antenna (7.5-L) observed with a fast framing camera installed in a tangential port (6-T) just before the termination of an ICRF heated long pulse discharge.