§ 47. Long Pulse Plasma Discharge

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An achievement of a steady state plasma discharge is a one of the main objectives in the Large Helical Device (LHD). The trial to sustain the steady state plasma discharge was started in the 3rd experimental campaign using the ICRF heated plasma. A long discharge of 68 sec was achieved in the plasma of n_e=1.0x10^{19}m^{-3} and the electron temperature on the axis T_{e0}=2.0keV with P_{ICH}=0.7MW. The pulse length was limited by the RF power generator problem. Then it was prolonged from 68sec to 127sec in the 4th experimental campaign. The plasma duration time was seemed to be limited to an uncontrollable electron density increase up to the critical density; however data was not enough to analyze the cause of the density increase.

During 5th experimental campaign an RF breakdown occurred at the ceramic bearing for the movable antenna mechanism. It was fixed and then the RF test at V_{RF}=20kV was carried out for 300s in the vacuum before the 6th experimental campaign was started.

Time evolutions of plasma parameters of a typical long pulse plasma discharge are plotted in Fig.1; this is the case of the longest plasma discharge so far achieved on the LHD. A plasma with the electron density n_e=5~6x10^{18}m^{-3} and the electron temperature and the ion temperature on the magnetic axis T_{e0}=T_{i0}=2.0keV was produced with the ICRF heating power of P_{ICH}=0.5MW. The line-averaged electron density is controlled with a He gas puffing feedback system using a measured micro-wave interferometer signal. During the plasma discharge a very low puffing rate of He gas, i.e., less than 0.1 Pam^3/s is sufficient to maintain the plasma. After 90 seconds the electron density is observed to increase and the plasma temperatures decreases with the time. The electron density increases up to n_e=1x10^{19}m^{-3} and the radiated power increases to 250kW before the plasma suddenly disappears at 150 seconds. Time evolutions of the vacuum pressure, the visible emission of Hα and HeI normalized by the electron density, and the temperatures increase in the vacuum wall and in the divertor plates are plotted in Fig.2: The vacuum pressure is increased by 3x10^{-5}Pa from P_V=2x10^{-4}Pa after 90s. The intensity of Hα signal (3-O, which is near the ICRF heating antenna) is increased by a factor 2, whereas Hα at 8-O and HeI are almost constant. The temperature of the divertor plate is increased to 400°C (3-I) and 100°C (8-I), whereas the vacuum vessel temperature increases by 3°C. The increase in the divertor temperature will be discussed the relation of the Hα signal increase at another section. As the time constant of the divertor plate is an order of 100 sec, the measured temperature is almost saturated; however as the time constant of the vacuum vessel is about 1 hour, the temperature increase is found to be small.

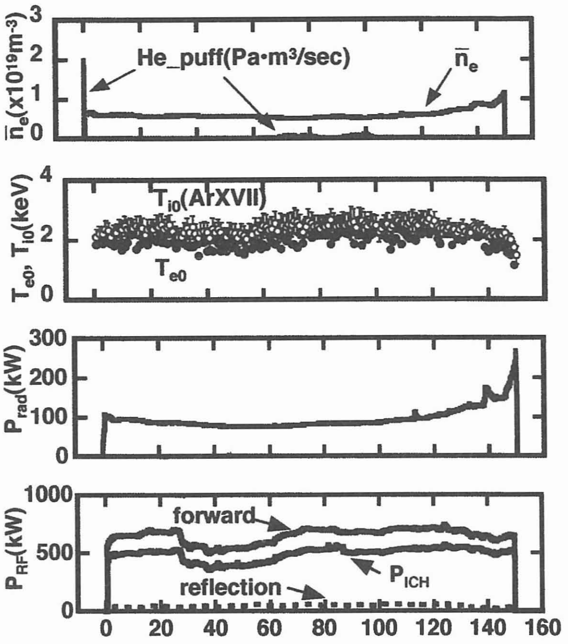

Fig.1 Time evolutions of plasma parameters, the electron density n_e, the electron T_{e0} and the ion temperature T_{i0} on the magnetic axis and the radiated power P_{rad} with the He gas puffing rate and the ICRF heating power P_{ICH}.

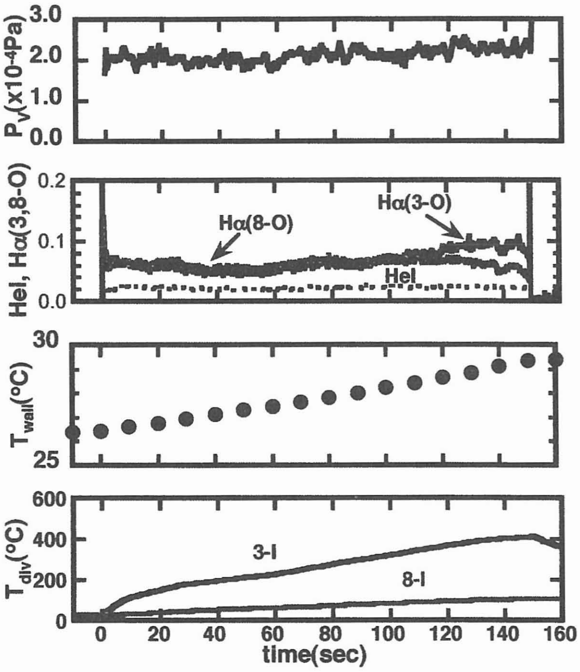

Fig.2 Time evolutions of the vacuum pressure P_V, the visible light emission of Hα and HeI, the temperature increase at the vacuum wall and at the divertor plates.