§63. Long Pulse Plasma Sustenance by ICRF Heating

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ICRF heating experiment in LHD has started from the 2nd experimental campaign [1,2]. In the 3rd experimental campaign, a long-pulse plasma was sustained by the ICRF heating alone because many modifications of the ICRF heating system and so on were performed after the 2nd experimental campaign. They are as follows; the increase in the ICRF frequency corresponding to that of magnetic field and the change of the impedance matching system for that using a triple stub configuration. In addition, the wall conditioning with Ti-gettering, the optimization of heating scheme, the installation of carbon divertor tiles, and the inward-shifted magnetic configuration are different from the experimental conditions in the 2nd campaign.

The experiment was conducted in the following conditions. The magnetic field and wave frequency were 2.75 T and 38.47 MHz, respectively. The line averaged electron density was about 1×10^{19} m^{-3}. Hydrogen ions were mixed with the helium plasma as a minority species of ion. In this case, the ion cyclotron resonance layer for hydrogen ions is located inside the plasma region and splits vertically. The two-ion hybrid resonance layer is also located inside the plasma region. The ion heating at the cyclotron resonance layer and the electron heating by the ion Bernstein wave, which was mode-converted at the two-ion hybrid resonance layer, are expected.

One pair of loop antennas was installed from the 3.5U and 3.5L ports. Each antenna was connected to each transmitter via the liquid stub tuner. All components of the system were newly developed in NIFS to perform steady-state operation for several years [3,4].

The long-pulse experiment was carried out in a day. The pulse duration was gradually extended as follows; the duration was several seconds for ~10 shots at the beginning, 15 sec for 3 shots, and 30, 45 and 68 sec for the last 3 shots, respectively. Figure 1 shows the time evolution of plasma parameters in the longest-pulse plasma sustained by the ICRF heating. The ICRF power of 700 kW was injected into the ECH target plasma and the stored energy more than 100 kJ was maintained during the discharge. The gas puff was controlled manually to keep the averaged density of 1×10^{19} m^{-3} by watching the plasma light. The center electron and ion temperatures were about 2 keV. The radiation loss power and the ratio of H_α to HeI were almost constant for 68 seconds. The line intensity of OV and FeXVI was also kept constant during the discharge. Almost all plasma parameters were kept constant for more than one minute. Therefore, it is expected that the plasma is sustained for a duration much longer than 68 sec by the ICRF heating. In the long-pulse discharge, we observed hot spot on the carbon protector of the antenna by a CCD camera. However, we could not find out any damage near the hot spot.

The transmitter limited the duration of the longest discharge. Since we had a problem around the tetrode tube of the final power amplifier before long-pulse operation, we have exchanged the well-conditioned tube for another one. Furthermore, we did not have enough time to condition the transmitter for steady-state operation. This longest-pulse discharge was terminated by a trouble of the transmitter. If we had enough time to optimize the transmitter for steady-state operation, we could have injected a longer ICRF pulse in the longest discharge.

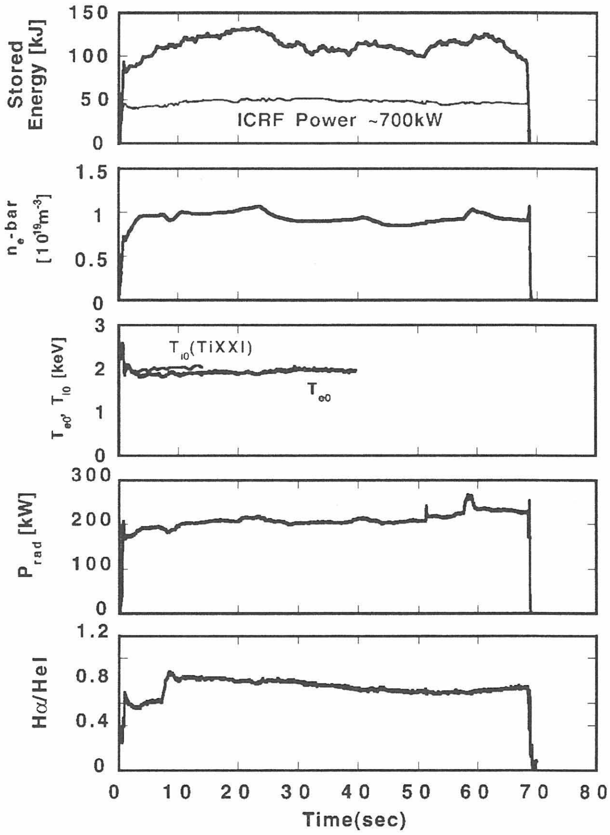

Fig.1. Time evolution of plasma parameters; from the top in order, plasma stored energy and ICRF power, line averaged electron density, central electron and ion temperature, radiation loss power, and ratio of hydrogen to helium.

References

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3) Kumazawa, R. et al.: Rev. of Sci. Instr. **70** (1999) 2665.

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