§13. Initial ICRF Heating Experiment in the LHD

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First ICRF heating experiment was carried out in the second experimental campaign in 1998.1) One pair of loop antennas installed at the toroidal section #3.5 was used. The loop antenna is described on the heating device section in this issue. ICRF heating was applied to the ECH produced plasmas whose density was relatively low of $0.8 \times 10^{19} m^{-3}$. The magnetic field strength of the LHD was 1.5 Tesla and RF frequency was 25.6 MHz. It was the lowest frequency limit of the transmitter used in the experiment. Helium plasma contains the hydrogen as minority ion was heated.

Due to the low target plasma density and low RF frequency, the coupling of antenna to plasma was not so large and it was a comparable level of the vacuum loading or a little larger than that. Therefore the maximum coupling power was limited to less than 300 kW.

The antenna is located near the helical winding on the outboard side of the toroid. In this experiment, the regions of cyclotron resonance and mode conversion from fast wave to ion Bernstein wave are located at the half radius or more outer radius of the inboard side of the toroid. In the neighborhood of the launcher, the antenna launches the wave from the high magnetic field side. However the launched wave is propagated to the inboard side and its power is absorbed near the resonance layers. On the resonance layers, the wave is mainly propagated from the low magnetic field side. It is due to the unique features of the heliotron magnetic field. Therefore the heating mechanism follows the usual low field side excitation in tokamaks. Therefore the main heating mode was varied as increasing the minority ion ratio from minority heating to mode conversion electron heating and finally to ion heating due to the reflection at thick evanescent layer.

In the experiment, minority ion ratio was changed by gas-puffing ratio. The heating properties depend on the gas puffing-ratio and maximum increment of plasma stored energy was obtained at H/(He+H)=30 %. Electron heating is observed at high H concentration region. These heating physics are described in the next report.

Time evolutions of the plasma parameters are shown in Fig.1. The stored energy, line averaged electron density, impurity line (OV) and radiation power are shown. Dotted line is the ECH target plasma and solid line is the ICRF heated plasma. ICRF pulse was applied at 0.3 sec to 0.5sec and about one third of ICRF pulse was overlapped with the ECH pulse. Plasma energy was raised from 13kJ to 23.5kJ. in this discharge. Maximum energy obtained was 26 kJ at almost same conditions. During the ICRF operation, the plasma density is sustained at constant level. Radiation power and impurity lines are increased during the ICRF pulse. The stored energy began to decrease during the ICRF pulse which coincides with the increase of the radiation power.

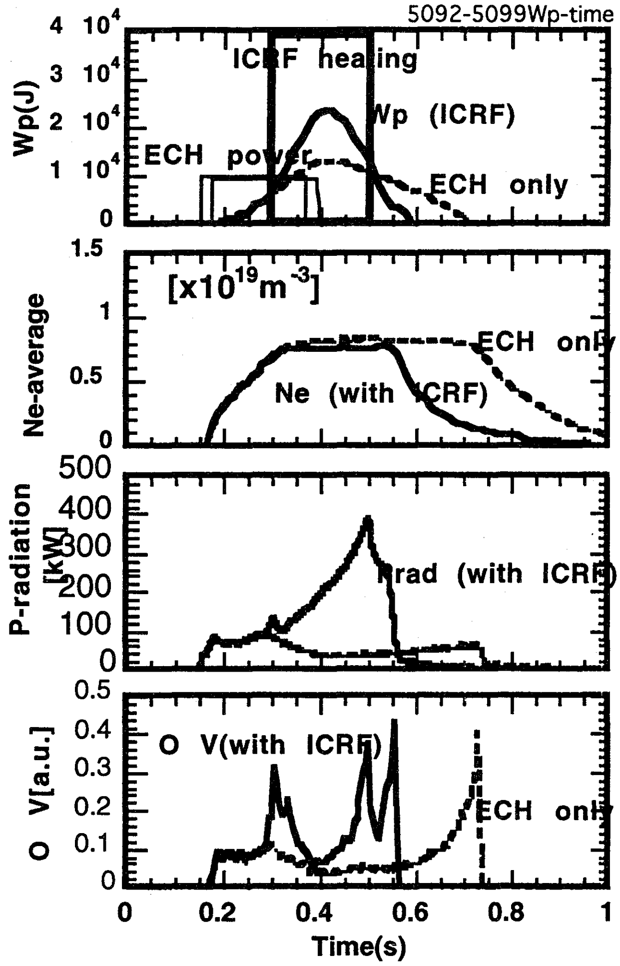

Fig.1 Time evolutions of plasma parameters. Solid lines are data of the ICRF heated plasma and dotted lines are of the ECH target plasma.
(B=1.5Tesla, Freq.25.6MHz, Gas puff ratio H/(He+H)=30%, Picrf =300kW)

Reference:

1) R.Kumazawa, T.Mutoh, T.Seki, K.Saito,et.al., in the proceeding of 13th Topical Conference on Applications of Radio Frequency Power to Plasmas 1999, Annapolis