§ 48. Uncontrollable Density Increase during Long Pulse Discharge

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In the previous section time evolutions of plasma parameters of a typical long pulse plasma discharge were described. The line average electron density was gradually increased from n_e=5~6x10^{18}m^{-3} after 90s accompanied by the increase in the radiated power. When the electron density was increased to n_e=1x10^{19}m^{-3} at 150s, the radiated power fraction P_{rad}/P_{ICH} of the injected ICRF heating power P_{RF} reached 50% and then the plasma was terminated. In Fig.1 the behavior of P_{rad}/P_{ICH} is depicted against the normalized electron density by the critical electron density n_e/n_{ecr}. Here P_{rad}/P_{ICH} against n_e/n_{ecr} obtained in the other series of the experiments is plotted. In this case the ICRF heating power and the electron density twice larger than those in the long pulse discharge.

The density limit of the ICRF heated plasma was examined in a series of the experiments as shown in Fig.2. Experimental data are plotted in P_{ICH}-n_e(1x10^{19}m^{-3}) plane. The critical electron density n_{ecr} is given in the following relation;

$$n_{ecr}(10^{19}m^{-3}) = 1.8P_{ICH}(MW)$$

On the other hand the scaling of the critical electron density to the heating power was given in the neutral beam heated plasma as follows [1, 2],

$$n_{ecr}(10^{19}m^{-3}) = 2.83\frac{(P(MW)B(T))^{1/2}}{(a^2R_{ax})^{0.423}} = 4.2P(MW)^{1/2}$$

When B(T)=2.75T, a=0.6m and R_{ax}=3.6m are employed, the numerical factor is calculated to be 4.2 as shown in the above equation. n_{ecr} is twice larger than that in the ICRF heated plasma at P=P_{ICH}=1MW and there is a difference in the heating power dependence, which have not been understood so far.

The vacuum pressure and the Hα intensity were increased at the latter half in the long pulse discharge. In Fig.3 the toroidal asymmetry of the increase in the Hα intensity [3] is plotted. It is the normalized ratio of t=150sec to that at t=90sec. It is easily found that the increased ratio in Hα is prominent at 3-O (3-outer horizontal vacuum port) and is about 3. Here the ICRF heating antennas are installed at 3.5U&L vacuum port, that is between 3-O and 4-O as pointed by arrow. The temperature increase in the graphite side protector of the antenna can be a candidate of the source of the hydrogen out-gassing. On the other hand the temperature increase in the divertor plates is measured in 90 plates. In generally the plasma energy flow is found to be dominant in the inboard side divertor plates. The toroidal asymmetry in the temperature increase in the inboard side divertor plate is found as described in the previous section. It is found that the temperature increase in the 3-I and 2I (3 and 2 of Inboard side divertor plate) is prominent. These temperature increases are discussed at next sections.

References
[1] Sudo, S. et.al., Nuclear Fusion, 30, (1990) 11.
[2] Nishimura, K., Annual report 200-2001, 14.
[3] Goto. M. et al., Physics of Plasmas 5(2003) 1402.

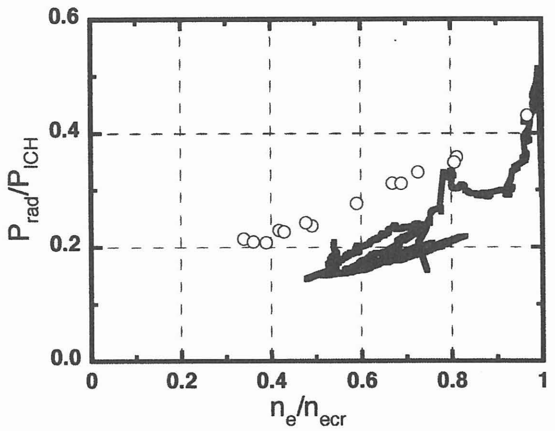

Fig.1 The fraction of the radiated power to the ICRF heating power vs. the ratio of the electron density to the critical electron density.

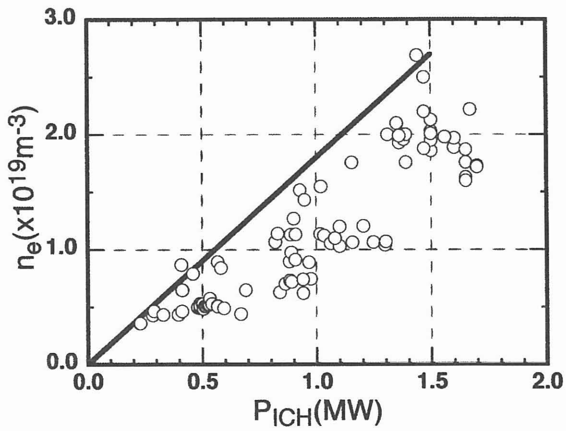

Fig.2 The relation between the critical electron density and the ICRF heating power.

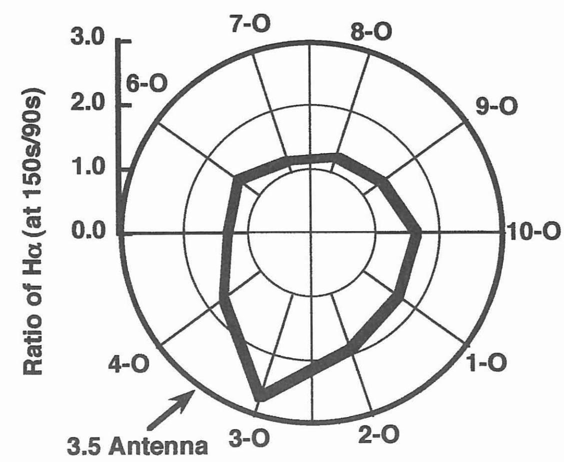

Fig.3 Toroidal distribution of Hα.