§26. Dependence of ICRF Heating Performance on Magnetic Axis

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The position of the magnetic axis, R_{ax} is a key parameter to determine the behavior of the deeply trapped ions, e.g., accelerated by RF electric field and the MHD stability aspect. The inward-shifted configuration reduces the deviation of the particle orbit from the magnetic surface in spite of deteriorating the MHD stability. The standard configuration has been selected to be R_{ax}=3.75m by compromising these two aspects. When the orbits of ions with perpendicular pitch angle are compared between the different magnetic axis configurations, i.e. R_{ax}=3.6m and =3.75m, the improvement of the drift surface of a trapped particle is remarkable in the inward-shifted configuration.[1] The bulk plasma confinement was different in two different magnetic axis. The energy confinement time was found to be 1.5~1.6 times longer than that of International Stellarator Scaling 95 at Rax=3.6m [2]; however no enhancement was not observed at the outward shifted configuration, i.e., R_{ax}=3.75m.

The most of ICRF heating was carried out at the inward-shifted magnetic axis, i.e., R_{ax}=3.6m. In addition to the selection of the position of the magnetic axis, the location of the ion cyclotron resonance layer affected the effective ICRF heating. So far the optimum ICRF heating has been found at the experimental condition of R_{ax}=3.6m and B=2.75T, where the proton cyclotron resonance layer is just located at the saddle point of the contour of the magnetic field strength at the applied frequency of f=38.47MHz.

In the 4th experimental campaign, the performance of the ICRF heated plasma was compared at the different magnetic axis configuration. Time evolutions of the plasma stored energy and the ICRF and the NBI heating powers are shown in Fig.1(a) and (b); The ICRF heating was applied to the NBI heated plasma during 1.7 to 2.3 seconds, and (a) and (b) is the case at R_{ax}=3.6m and 3.75m, respectively. The injected NBI power is 0.9MW in both plasma discharges and the average electron density is the same of $n_e=1.0\times10^{19}m^{-3}$. The absorbed ICRF heating power P_{abs} is 0.84MW at (a) and 0.45MW at (b), respectively. The achieved plasma stored energy W_p is 210kJ and 100kJ at the additional ICRF heating period; this was caused by the difference in the energy confinement time of the bulk plasma. The energy distribution of high energy ions was measured using a Natural Diamond Detector (NDD) in the energy range of 30keV to 250keV as shown in Fig.2(a) and (b). The high energy ions extended to 200keV and the tail temperature is calculated at the same value in both cases. Here the tail temperature T_{tail} can be compared using Stix formula as follows,

$$T_{eff} \cong T_e\left(1+\frac{P_{abs}\tau_s}{3n_H V_H T_e}\right)$$

T_{tail} was calculated to be almost the same, i.e., 28 (a.u.) and 25(a.u.), corresponding at R_{ax}=3.6m and 3.75m. Here the electron temperature and the minority ratio to the electron density, n_H/n_e were used at T_{e0}=2.0keV and 1.6keV, and n_H/n_e=8% and 4%, respectively. The confinement of the high energy ions was assumed to be determined by the electron slowing process only. When there exists an another energy loss of the high energy ions, the total energy confinement t_E^{tail} is expressed as,

$$\frac{1}{\tau_E^{tail}}=\frac{1}{\tau_S/2}+\frac{1}{\tau_E^{loss}}$$

Here $\tau_s/2$ is a slowing down time due to electrons and τ_E^{loss} is a power loss time of high energy ions, which includes the orbit loss and the charge exchange loss and is thought longer at R_{ax}=3.6m than that at R_{ax}=3.75m. As $\tau_s/2$ was much shorter than τ_E^{loss} at the present experiment, the difference in the tail temperature was not observed; therefore the difference of the measured ion temperature will be observed at a lower density plasma or a higher temperature plasma.

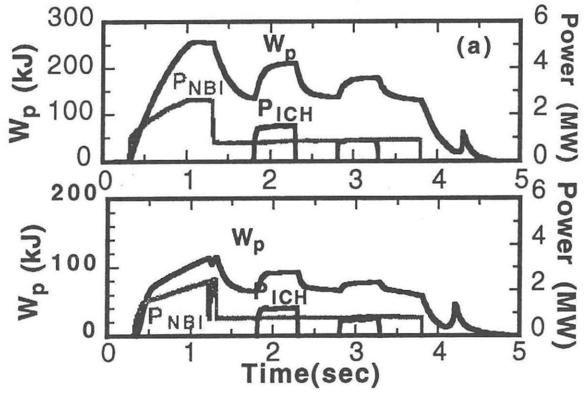

Fig.1 Time evolutions of plasma parameters; (a) at R_{ax}=3.6m and R_{ax}=3.75m.

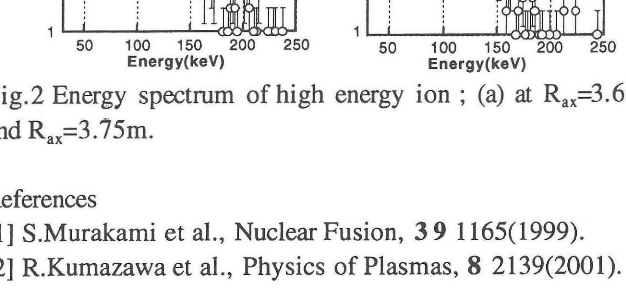

Fig.2 Energy spectrum of high energy ion ; (a) at R_{ax}=3.6m and R_{ax}=3.75m.

References

[1] S.Murakami et al., Nuclear Fusion, **39** 1165(1999).
[2] R.Kumazawa et al., Physics of Plasmas, **8** 2139(2001).