§18. Comparison of High Energy Ion Behavior in Inward-Shifted and Standard Magnetic Axis

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The energy confinement time is found to be 1.5~1.6 times longer than International Stellarator Scaling 95 (ISS95) at the inward-shifted magnetic axis, *i.e.*, R_{ax}=3.6m. This is derived from the fact that a displacement of the orbit of deeply trapped particles in the helical ripple from the magnetic surface is reduced in the inward-shifted magnetic axis configuration. The phenomenon is thought to be similar to that in high energy ions accelerated by an RF (radio frequency) electric field.

A typical plasma discharge is shown in Fig.1; this was the case of the most efficient ICRF heating, in which the ion cyclotron resonance layer was located at the saddle point on the mod-B surface. The high energy ions were produced by the ICRF electric field in the NBI heated plasma. The plasma with the stored energy W_p=120kJ, the line-average electron density $n_e=3\times10^{18}m^{-3}$ and the electron temperature on the magnetic axis T_{e0}=2.1keV was produced with the ICRF heating power of P_A=0.35MW and P_{NBI}=0.8MW. A flux of high energy ions was measured by a fast-neutral analyzer (Si-diode FNA) using an electrically cooled Si-diode detector[1]. A distribution of the energy of ions during t=1.2~1.24s is plotted in Fig.2 by taking into account of the charge exchange process of H and ^{+}He[2]. The measured tail temperature was T_{tail} =52keV. The effective temperature T_{eff} was calculated using plasma parameters (n_H, n_e and T_e are a minority proton density, an electron density and an electron temperature) and the absorbed RF power from the ICRF antennas P_A in accordance with Stix's formula[3];

$$T_{eff} = T_e(1+\frac{P_{abs}\tau_s}{3n_H V_H T_e}) = T_e(1+A\frac{\eta_h (n_H/n_e)P_{ICH}T_e^{1/2}}{(n_H/n_e)n_e^2 V_H}).$$

Here η_h and V_H are a heating efficiency and a minority heating volume. η_h depends on the minority ratio and has a maximum value of 0.85~0.9 at n_H/n_e=7%. The ratio n_H/n_e was deduced from the ratio of the intensities of Hα and HeI lines spectroscopy. The heating volume was estimated to be 8.4m^3, which was calculated using a cyclotron damping[4]. The effective temperature was calculated T_{eff}=60keV in the discharge shown in Fig.1. A relation between the tail temperature measured by Si-diode FNA, T_{tail} and T_{eff} is plotted in Fig.3. It is found that a wide range of T_{eff} was achieved at R_{ax}=3.75m; it was from 10keV to 200keV. However, a range of T_{eff} at R_{ax}=3.6m was from 10 to 60keV, which was caused by an insufficient reduction of the minority ion density, *e.g.*, n_H/n_e=30%. It is found a saturation of T_{tail} at R_{ax}=3.75m; this reflects us a shorter energy loss time τ_E^{loss}.

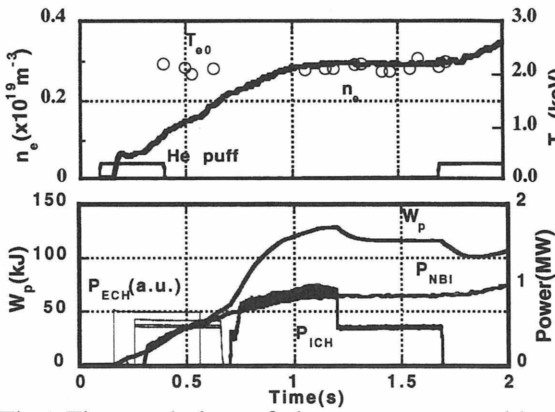

Fig.1 Time evolutions of plasma parameters with RF and NB injected power.

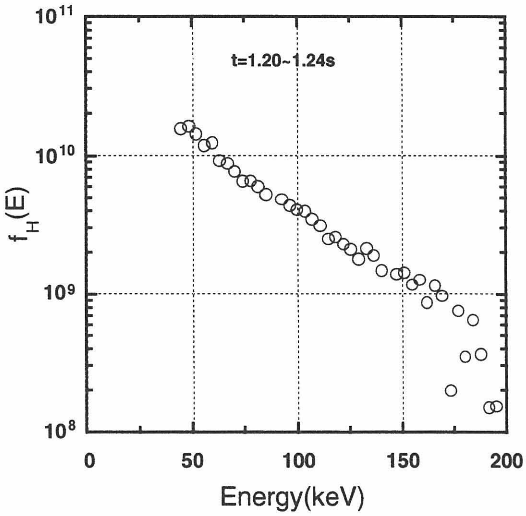

Fig.2 Spectrum of high energy ions during t=1.2s to 1.24s.

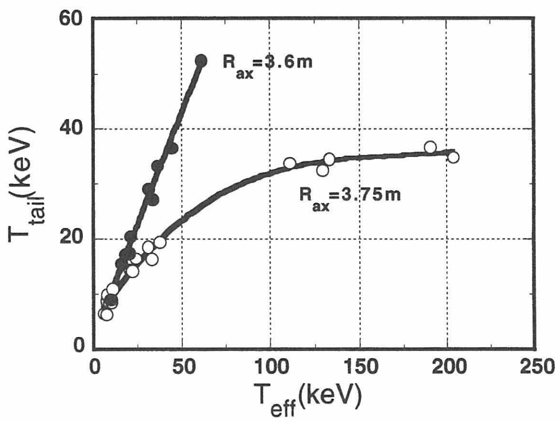

Fig.3 A relation between T_{tail} and T_{eff} in the two cases of R_{ax}=3.6m and =3.75m.

References
1) M.Osakabe et.al., Rev. of Scientific Inst. **72** (2001) 590 & 788.
2) A.Krashilnikov et. al., Nucl. Fusion **42** (2002) 759.
3) T.H.Stix, Nuclear Fusion **15** (1975) 737.
4) K.Saito et. al., Nucl. Fusion **41** (2001) 1021.