§13. Energy Confinement Time for ICRF Heated Plasma in Heliotron/Torsatrons

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ICRF heating produces a high energy tail distribution and this modifies the total energy confinement of plasma when the tail distribution is large enough. Additionally the orbit loss of the high energetic particle would reduce the energy confinement time in non-axisymmetric configurations. In this paper we have investigated the global energy confinement time for ICRF heated plasma in heliotron/torsatrons including the effects of tail distribution and losses of those particles. The power loss due to the orbit loss of tail ions is consistently included based on the results of Monte Carlo simulations. Considering the tail ions and bulk plasma separately we can derived the formula of global confinement time as

$$\tau_E = \eta(\tau_E^{bulk} + \tau_s/2), \qquad (1)$$

where η, τ_E^{bulk}, and τ_s are the heating efficiency, the energy confinement time for bulk plasma and the slowing down time. Based on the results of Monte Carlo simulation[1] we assume the heating efficiency of the ICRF minority heating as $\eta = 1/(1+CP_{abs}T^{\alpha}n^{-\beta}B^{-\gamma})$. Then the global energy confinement time is derived as

$$\begin{aligned}\tau_E &= \eta[Fn^{\delta}B^{\varepsilon}(\eta P_{abs})^{-\sigma} \\ &+\frac{k}{2}n^{\frac{1}{2}(3\delta-5)}B^{\frac{3}{2}\varepsilon}(\eta P_{abs})^{\frac{3}{2}(1-\sigma)}], \qquad (2)\end{aligned}$$

where we assume $\tau_E^{bulk} = Fn^{\delta}B^{\varepsilon}P^{-\sigma}$.

The results are applied to the ICRF minority heating in the plasma of LHD. We here assume the density, temperature, and magnetic field strength dependencies on the heating efficiency as $\alpha \simeq 3$, $\beta \simeq 3$, and $\gamma \simeq 1$ with the same faction of minority ion density. The constant C has been obtained as $C = 0.082$ for LHD with 3% of minority fraction. Fig. 1 shows the heating efficiency with changing the density. We can see the strong density dependency. Fig. 2 shows the energy confinement time as a function of RF input power in the LHD. The obtained slowing down time for the LHD plasma is shorter than the energy confinement time and the reduction of energy confinement time from the value of simple LHD scaling due to the power loss is found (Fig. 1). Since the heating efficiency is sensitive to the density (Fig. 2), the stronger density dependency on the energy confinement time is observed.

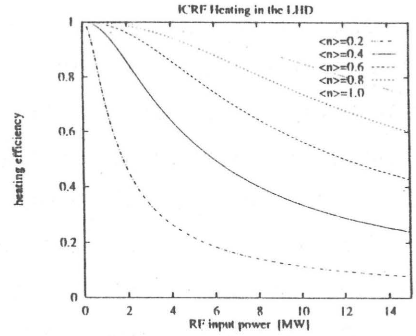

Fig. 1: *Heating efficiencies of ICRF minority heating in the LHD with changing the density.*

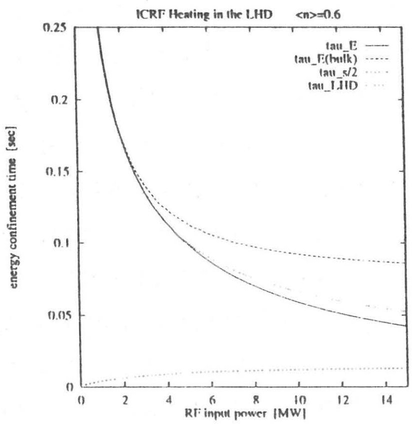

Fig. 2: *Energy confinement time as a function of RF input power in the LHD:* $\langle n \rangle = 0.6 \times 10^{20} m^{-3}$

References

1) Murakami, S., et al., Nuclear Fusion **34** (1994) 795.