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Density Profiles and Particle Transport of High Ion Temperature Mode in CHS Plasmas

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Abstract

The particle confinement characteristics of high Ti mode and L-mode on Compact Helical System (CHS) are studied. Comparison between measured electron density profiles and those from the transport model is done by a fitting analysis of transport model.

Keywords:

CHS, high Ti mode, L-mode, particle confinement, diffusion coefficient, convective velocity

1. Introduction

The high ion temperature mode (high Ti mode)[1-3] was achieved on CHS in co-injected neutral beam heated plasmas under low recycling wall condition and without gas puffing. Figures 1(a) and 1(b) show the high Ti mode discharge and the L-mode discharge, respectively. Not only higher ion temperature was achieved in high Ti mode, but also, there is a big difference of the ion temperature at the same volume averaged electron density ($\langle n_e \rangle$). The ion temperatures are 640 eV and 380 eV at 75 msec in Fig. 1 (a) and at 55 msec in Fig. 1 (b), respectively. The improvement factor is about 70%. In addition, the electron density profile is more peaked in the former case (the peaking factor, which is defined by the ratio of central electron density $n_e(0)$ to $\langle n_e \rangle$, is 1.6) than in the latter case (the peaking factor is 1.0).

Two different discharges are compared from the view point of the particle transport.

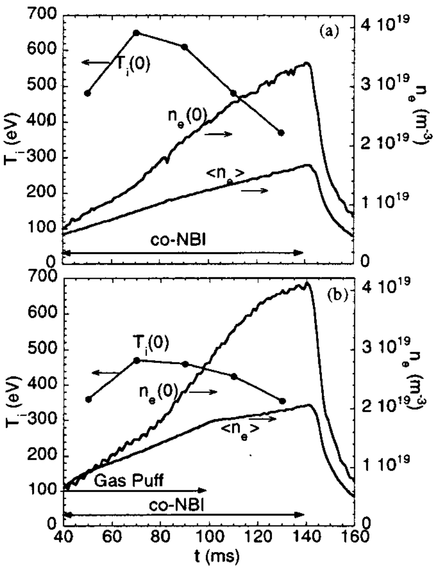

Fig. 1 Temporal evolutions of ion temperature (Ti), central electron density $n_e(0)$ and volume averaged electron density $\langle n_e \rangle$ in (a) high Ti mode, and in (b) L-mode. Ti was measure by the charge exchange spectroscopy, $n_e(0)$ and $\langle n_e \rangle$ were measured by the multi channel HCN laser interferometer.

2. Analysis Procedure and Results

In this analysis, the particle balance is assumed to be in equilibrium at each calculation time period in the following particle balance equation.

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$$\frac{\partial n_e}{\partial t} = -\nabla \cdot \Gamma + S$$
$$\Gamma = -D\nabla n_e + V n_e \quad (1)$$

Here, n_e is the electron density, Γ the particle flux, S the source rate, D the diffusion coefficient and V the convective velocity.

D is assumed to be spatially constant and V to be $V(r) = r/a V_0$ (here r is the radial position, a the average minor radius). This simple transport model well fits the results of gas puff modulation experiments on TEXT tokamak[4]. The source term S consists of particle fueling from the neutral beam (S_{NBI}) and wall recycling (S_{wall}) including gas puffing as shown in Fig. 2 (a). The profile and absolute value of S_{NBI} are calculated by the energy transport code PROCTR-MOD using the measured pressure profile by Thomson scattering[3]. On the other hand, since the profile and absolute value of S_{wall} are unknown, five cases of S_{wall} are examined for this analysis by the changing its absolute value and penetration length as shown in Fig. 2 (b).

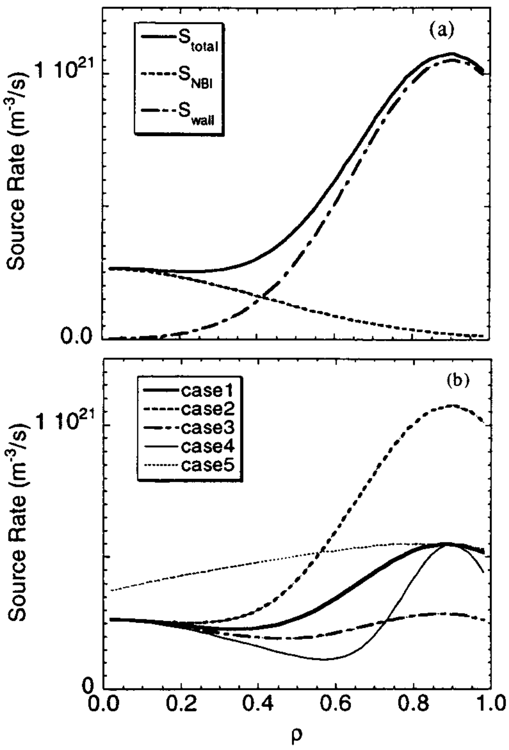

Fig. 2 (a) Model of source profile, (b) Five cases of source model for the particle transport analysis. Each case consists of S_{NBI} and S_{wall}.

The relative changes of S_{wall} during the discharge are assumed as follows. The total amount of S_{wall} is assumed to change temporarily in proportion to the measured Hα intensity, and the penetration length is assumed to change temporarily in proportion to the inverse of line density at the edge (the position is $r/a = 0.9$), which are measured by the interferometer.

Using above assumptions of source profiles, n_e is obtained as the solution of Eq.(1) with particular values of D and V. In this analysis Eq.(1) is solved numerically with the boundary condition of $dn_e/d\rho = 0$ at $\rho = 0$ (here, $\rho = r/a$) and $n_e = 0$ at $\rho = 1$. D and V are obtained by fitting the line integration of n_e to the measured line density from the interferometer.

Figures 3 are examples of the fitting results. Figures 3 (a) and (c) show the calculated line density well fits the experimental data. This indicates the simple transport model is available to explain the experimental data of high Ti mode and L-mode as long as the assumed source profiles are used.

Figures 4 shows temporal changes of D, V and particle confinement time τ_p in high Ti mode and L-mode discharges. Here, τ_p is calculated from the ratio of the volume integrated electron density to volume integrated source rate.

In high Ti mode and L-mode, D, V change similarly, on the other hands, τ_p is almost constant in both modes as shown in Fig. 4. The particle confinement time τ_p is slightly longer in high Ti mode than in L-mode actually caused by the smaller D and smaller outward V in high Ti mode.

3. Discussion

In both high Ti mode and L-mode, with source model case 1, 2, 5, the convection velocity V changes the direction from outward to inward, with source model case 3, 4, V decreases down to zero during the discharge. These results are different from the previous report[5,6] by the measurements of the density profiles by Thomson scattering and the measurement of source profile using the laser induced fluorescence spectroscopy with neutral particle simulation analysis, although the magnetic configurations are same. At present, it is not clear this difference is caused by the difference of transport or caused by the difference of the accuracy of the measurements. More detailed study should be done including the detail spatial profile and absolute value of source term and the particle balance equation Eq.(1) should be solved by taking account of temporal variations.

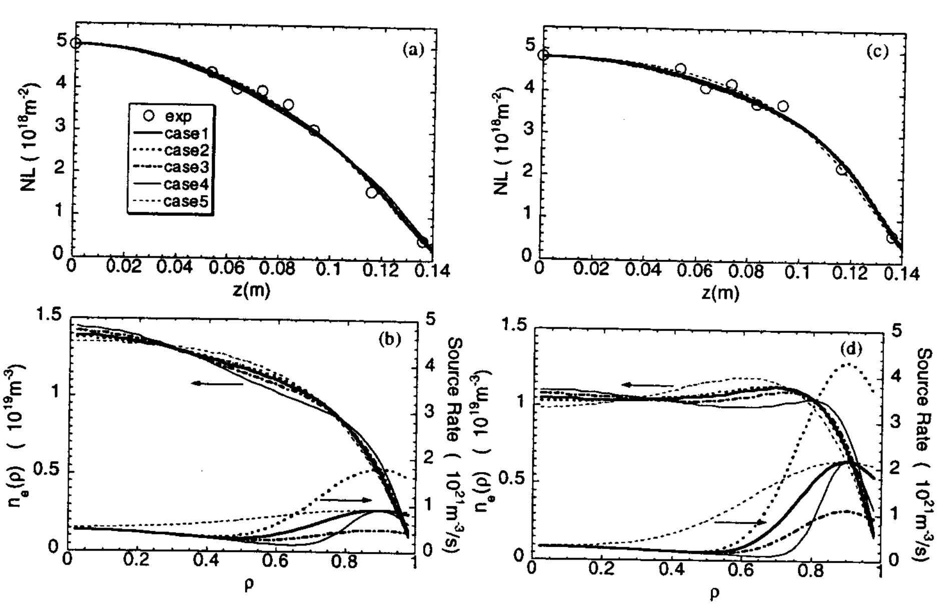

Fig. 3 (a), (c) Measured line density and calculated line density of five cases of source profile. Z indicates the position of the interferometer. (b), (d) Calculated radial electron density profiles and assumed source profiles.
(a), (b) are at t=70 msec of Fig. 1 (a) (high Ti phase), (c), (d) are at t=50 msec of Fig. 1 (b) (L-mode phase).

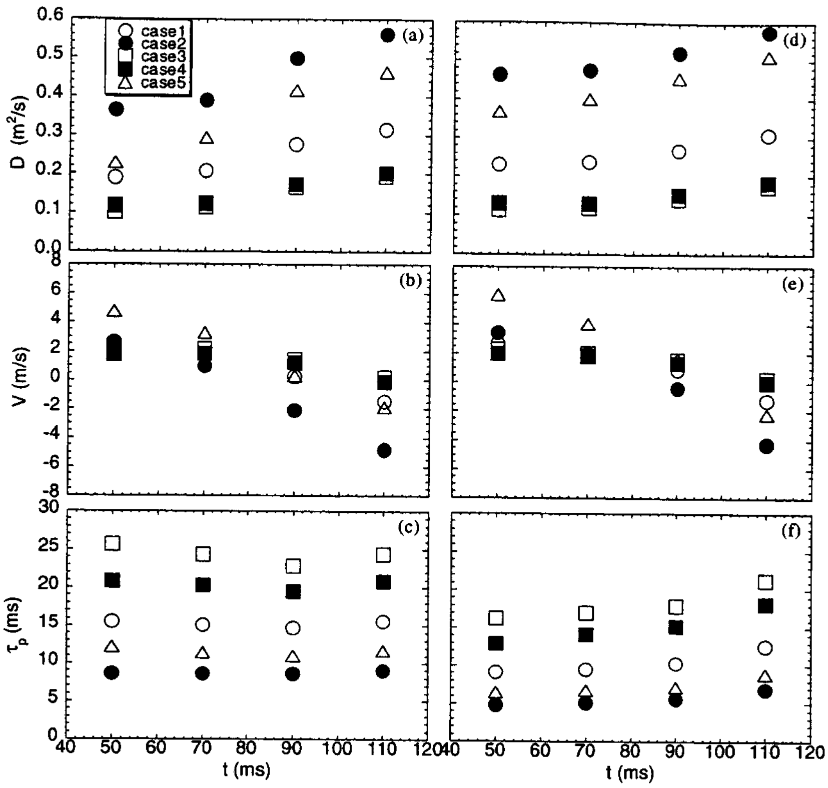

Fig. 4 The temporal change of the particle transport coefficients. Each number of the case corresponds to the case of Fig. 2 (b). (a)-(c) are results from Fig. 1 (a) (high Ti mode), (d)-(f) are from Fig. 1 (b) (L-mode). Negative V indicates inward convection velocity.

4. Summary

Temporal changes of particle transport characteristics were studied in high Ti mode and L-mode from the fitting analysis of transport model. D, V change similarly in both case. Using the assumed source profiles the particle confinement of High Ti mode discharge seems to be slightly better than that of L-mode.

References

[1] K. Ida *et al.*, Phys. Rev. Lett. **76**, 1268 (1996).
[2] K. Ida *et al.*, in these Proceedings, p.239 (1998).
[3] T. Minami *et al.*, in these Proceedings, p.239 (1998).
[4] K.W. Gentle *et al.*, Plasma Phys. Control. Fusion **29**, 1077 (1987).
[5] H. Iguchi *et al.*, Plasma Phys. Control. Fusion **36**, 1061 (1994).
[6] H. Takenaga, Doctoral thesis [*in Japanese*], Kyusyu University, (1994).