§26. Neutral Particle Effect on High Energy Ion in LHD

Matsumoto, Y., Aoki, S., Oikawa, S., Itagaki, M., Tomioka, S. (Hokkaido Univ.),
Osakabe, M., Seki, R., Kawamura, G.

In LHD, high energy ions produced by NBI are lost due to the charge exchange reaction with cold neutrals as well as the particle drift. The increase of the charge exchange loss is lead to the degradation of the heating efficiency by NBI. Thus, it is one of the important issues to investigate the effect of the charge exchange loss on high energy ions produced by NBI. However, the effect of the charge exchange loss of high energy ions with cold neutrals going into the core plasma region have not been studied in detail. In the present study, the distribution function of high energy ions are calculated under the assumption of the various neutral density profiles. The effect of the charge exchange loss due to cold neutrals on high energy ions produced by NBI is investigated.

The cold neutral density inside the last closed flux surface (LCFS) is assumed as

$$n_{\mathrm{H}} = 10^{m} \times \exp\frac{\rho - 1}{\lambda} \quad (1)$$

where ρ is the normalized minor radius, λ the penetration length and m the density parameter changing as 14, 15, …18. Here, the cold neutral density is assumed as $n_{\mathrm{H}} = 10^{m} = \mathrm{const}$ outside the LCFS. Under this assumption, the distribution function of the high energy ions and the heating efficiency of NBI are calculated.

Figures 1 and 2 show the steady state density profile of high energy ions produced by NBI in the case of $m = 16$. It is seen from Fig. 1 that the co-injected high energy ions are affected by the charge exchange loss when $\lambda \geq 0.3$. The charge exchange loss has a large effect on the counter-injected high energy ions when $\lambda \geq 0.5$.

The NBI heating power when the injected power is 1 MW are shown in Table 1 in the case of $m = 16$. The charge exchange loss has a effect on the ion heating efficiency rather than the electron heating efficiency. If the penetration length is controlled as $\lambda < 0.1$ by the wall conditioning and so forth, NBI can heat the plasma with the equivalent efficiency to that not including the charge exchange loss.

We investigate the effects of the charge exchange loss to high energy ions produced by NBI under the assumption of the various cold neutral density profile. It is found that the heating power by NBI is almost the same as that not including the charge exchange loss due to the cold neutrals if $\lambda < 0.1$ is satisfied. The 3D neutral density profile calculated by EMC3-EIRENE[1] will be introduced in our simulation and the effect of the 3D cold neutral profile on the charge exchange loss of NBI-produced ions will be investigated.

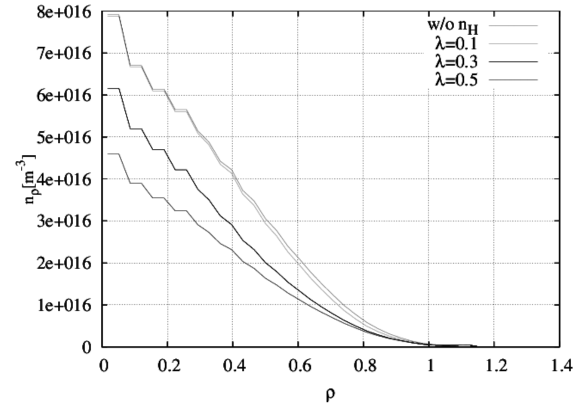

Fig. 1. Steady state density profile of high energy ions produced by co-NBI.

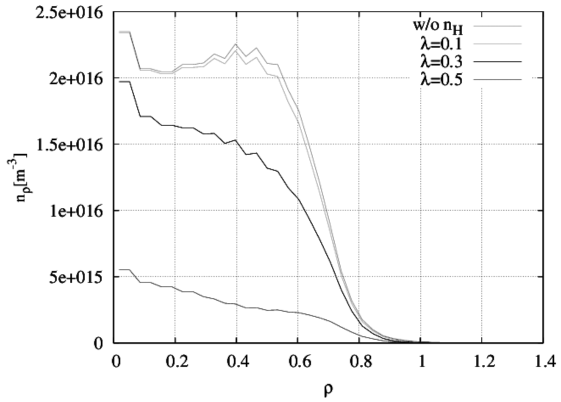

Fig. 2. Steady state density profile of high energy ions produced by ctr-NBI.

Table 1. NBI heating power when the injected power is 1 MW.

		P^{all} (MW)	P^{ion} ($\times 10^{-2}$MW)
co	w/o n_{H}	0.905	4.13
	λ = 0.1	0.889	3.85
	λ = 0.3	0.813	2.15
	λ = 0.5	0.813	1.41
ctr	w/o n_{H}	0.471	2.18
	λ = 0.1	0.464	2.04
	λ = 0.3	0.422	1.09
	λ = 0.5	0.396	0.72

1) Feng, Y. and Kisslinger, J.: Contrib. Plasma Phys. **46** (200) 271.