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

Matsumoto, Y., Ueda, R., Takado, W., Iwabuchi, S. (Hokkaido Univ.),
Osakabe, M., Seki, R.

In LHD, high energy ions produced by NBI are lost due to the charge exchange reaction with cold neutrals as well as the Coulomb collisions. The increase of the charge exchange loss is conducive 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 distribution function of high energy ions is computed by the MORH code. MORH is one of the Monte Carlo codes to calculate the steady state distribution function by tracing the high energy particle orbit including Coulomb collisions and charge exchange loss. In MORH code, the re-entering particles, which repeatedly go out and into the last closed magnetic surface (LCMS), can be treated appropriately since the real coordinate system is adopted. The cold neutral density profiles in the core region are assumed as

$$n_{\rm H} = \rho^k \times 10^{15} (k = 1, 2, 4, 6), \qquad (1)$$

where ρ is the normalized minor radius. In the stochastic region ($\rho > 1$), the cold neutral density is set as

$$n_{\rm H} = 10^{15} = \text{const}. \qquad (2)$$

The low magnetic field and high beta plasma is assumed as the background plasma.

The normalized density profiles of high energy ions produced by co-NB and ctr-NB are shown in Fig. 1. It is noted that the densities in Fig. 1 are normalized by the density for $n_{\rm H} = 0$. It is seen from Fig. 1 that the charge exchange loss in the core plasma region have greater effect on high energy ions in co-NB case than that in ctr-NB case.

The normalized heating efficiencies by high energy ions are shown in Fig. 2. It is noted that the heating efficiencies in Fig. 2 are also normalized by the heating efficiency for $n_{\rm H} = 0$. It can be seen from Fig. 2 that the effect of the charge exchange loss on high energy ions is independent of the injection direction of NB. This implies that the number of high energy ions lost due to charge exchange in co-NB case is larger than that in ctr-NB case and that the energy giving to the background plasma is almost the same between co- and ctr NB cases.

We have studied the effect of cold neutrals on high energy ions produced by NBI under the assumption of the various neutral density profiles. Especially, the difference of the effect of the charge exchange loss on the high energy ions due to the injection direction of NBI is discussed. We will investigate the cold neutral effect on high energy ions by means of the cold neutral density profile calculated by the AURORA code, and EIRENE code.

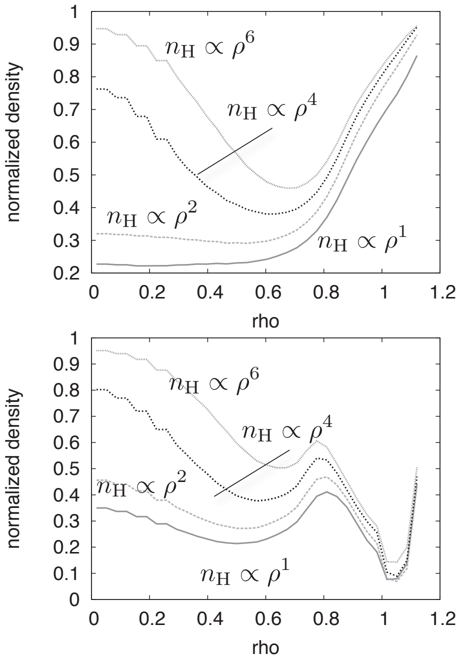

Fig. 1. Normalized density profiles of high energy ions produced by co-NB (upper) and ctr-NB (lower). Densities are normalized by the density for $n_{\rm H} = 0$.

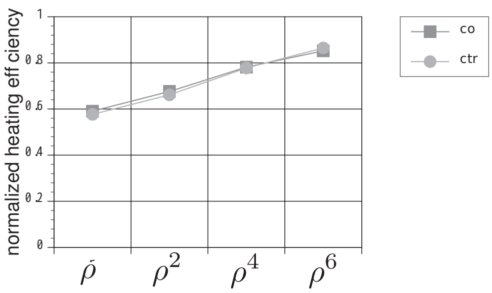

Fig. 2. Normalized heating efficiencies by high energy ions produced by co- and ctr-NBs. Heating efficiencies are normalized by the heating efficiency for $n_{\rm H} = 0$.