§57. Estimation of Distribution Function of Fast Ions Induced by NB Based on Orbit Following in Real Coordinates

Matsumoto, Y. (Hokkaido Univ.),
Seki, R., Watanabe, K.Y., Suzuki, Y.,
Hamamatsu, K. (JAEA)

A perpendicular neutral beam (NB) injector and three tangential-NBs have been installed on LHD. Using these NBs the volume-averaged beta $\langle\beta\rangle$ have reached 5 % in low field strength (the field strength at magnetic axis $B_{\rm ax} \simeq 0.5$ T) [1]. In the high-beta plasma of LHD, it is pointed that the beam pressure and/or the pressure anisotropy significantly affect the properties of magneto-hydrodynamics equilibrium and stability[2]. Therefore, it is important to accurately estimate the beam pressure. It is also pointed out that a lot of the fast ions produced by NB becomes re-entering particles[3], which repeatedly pass in and out of the last closed flux surface, in the high-beta plasma of LHD[4]. In order to numerically investigate the beam pressure and the heat power due to the fast ions produced by NB, it is necessary to properly treat the re-entering particles.

We have developed a new Monte Carlo code (MORH[5]) to investigate the velocity distribution function and heat power including the re-entering particles. The Beam pressure can be calculated from the velocity distribution function. Our code can calculate the steady-state solution of the drift kinetic equation through particle tracing in real coordinates. Using the equilibrium magnetic field obtained by HINT, the particles are traced with particle loss boundary set on the vacuum vessel wall. Thus, the re-entering particles can be properly treated. The particle loss due to charge exchange reaction in the peripheral region is also included in this code.

Using the code, we have investigated the velocity distribution function of the fast ions produced by NBs. In this report, NB beam is assumed to be the pencil beam and the temperature and density of the background plasma are assumed to be constant ($T_{\rm b}$ = 1 keV, $n_{\rm b} = 10^20$ m^{-3}). Figure 1 shows the density profile for fast ions produced by the tangential-NBs (BL1 (counter) and BL2 (co)) in the typically finite beta plasma ($\langle\beta\rangle \simeq 2.7\%$, $B_{\rm ax} \simeq 0.5$ T). The density profile for fast ions is calculated by integrating the velocity distribution function in term of velocity. Solid lines show the density profiles including the re-entering particles and dashed lines the ones without re-entering particles. The differences between the solid line and dashed line show effect of the re-entering particles on the density profiles for fast ions. This figure implies that a lot of the fast ions produced by tangential-NBs becomes re-entering particles and that the re-entering particle have a large effect on the density profile in the finite beta plasma with the low field. The density profile for fast ions produced by perpendicular-NB is shown in Fig.2. In this case, $B_{\rm ax} \simeq 3$ T because the guiding center may not be able to approximate the high-energy particle orbit in the low field. In the perpendicular-NB, the re-entering particle have a large effect on the density profile in the finite beta plasma, even with $B_{\rm ax} \simeq 3$ T.

We will investigate the velocity distribution function and heat power with conditions much closer to those used in the actual LHD experiments. The $E \times B$ drift that is currently ignored also plans to be introduced to this code in the near future.

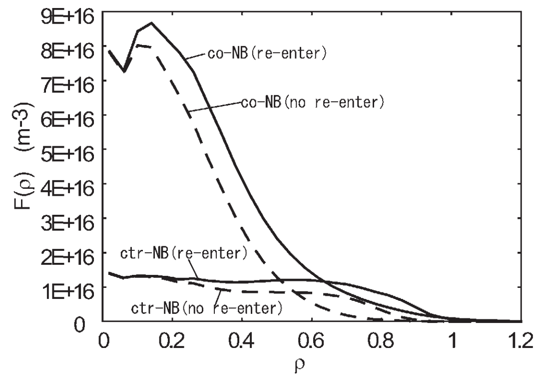

Fig. 1: Density profile for fast ions produced by the tangential-NB.

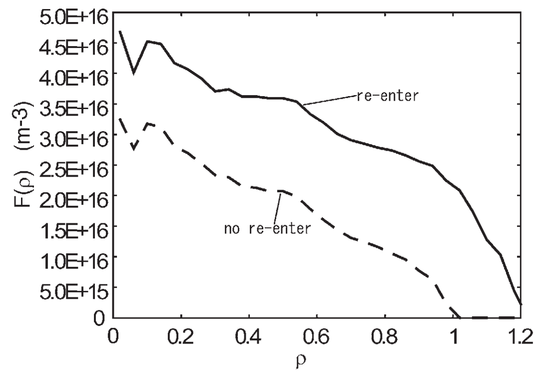

Fig. 2: Density profile for fast ions produced by perpendicular-NB.

1) K.Y. Watanave, *et al.*, in Proc. of ITC-17 and ISWS-16 Toki I-13 (2007).

2) W. A. Cooper *et al.*, Fusion Sci. Tech. **50** 245 (2006)

3) K. Hanatani and F. -P. Penningsfeld, Nucl. Fusion. **32** 1769 (1992).

4) R. Seki, *et al.*, Plasma Fusion Res. **3** 016 (2008).

5) R. Seki, *et al.*, Plasma Fusion Res. **5** 014 (2010).