§65. Analysis of NBI Particle Orbit and Distribution Function in LHD

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In helical devices, it is one of the important subjects to analyze the confinement and the behavior of the high-energy particles produced by NBI heating to realize the helical reactor. A fast-ion charge exchange spectroscopy (FICXS)[1] diagnostic has been applied to measure the distribution function of the particles produced by NB. In the previous studies, the distribution function obtained in FICXS measurement has been compared with the distribution function obtained by Monte Carlo codes based on the magnetic coordinate system, such as the Boozer coordinates. However, the number of the lost particles is over-estimated in such codes, since re-entering particles, which repeatedly go out and enter into the last closed magnetic surface, are regarded as the lost particles. We have developed a Monte Carlo code *MORH*[2,3], by which the distribution function after the relaxation of the high-energy particles are obtained. In the MORH code, the effect of re-entering particles on the distribution function can be taken into account, since the particle loss boundary is set at the vacuum vessel wall. Additionally, the effect of the charge exchange loss is also included in the code. The purpose of the present study is the evaluation of the distribution functions obtained by FICXS by use of the MORH code.

The Littlejohn's guiding-center equation is introduced to the particle orbit trace code. The high-energy particle orbit in the high beta plasma of LHD is analyzed. It is found that the particle orbit calculated by the modified code is almost the same with the orbit calculated by the conventional code in the strong magnetic field strength case. On the other hand, in the weak magnetic field case, the particle drift calculated by the conventional code tends to be larger than that calculated by the modified code.

The Littlejohn's guiding-center equation[4] is also introduced to the MORH code. The modified MORH code is applied to particles produced by the tangential NB. The obtained distribution functions of the particles produced by the co-NB in the vacuum magnetic field are shown in Fig. 1. It can be seen from Fig. 1 that the distribution function calculated by the modified MORH code is almost the same with that by the conventional MORH code. The distribution functions of the particles produced by the co-NB in the high beta plasma are shown in Fig. 2. It is found that in the velocity space the distribution function calculated by the modified MORH code is almost the same with that by the conventional MORH code. As shown in Fig. 2, however, the difference between the distribution functions for the minor radius. Such difference is expected to the contribution of the plasma current flowing in the high beta plasma.

The difference of the distribution function for the minor radius is investigated in detail. Additionally, the comparison between the distribution function obtained by the FICXS measurement and that calculated by the modified MORH code will be done.

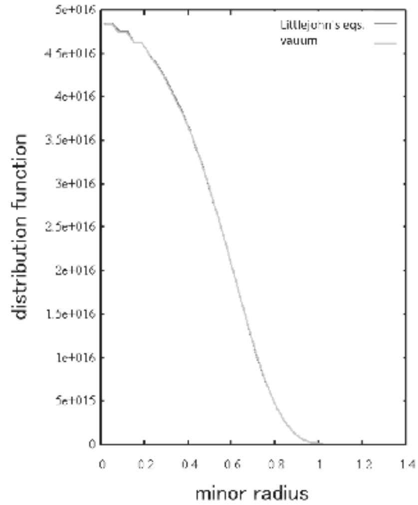

Fig. 1. Distribution function of the particles produced by co-NB in the vacuum magnetic field.

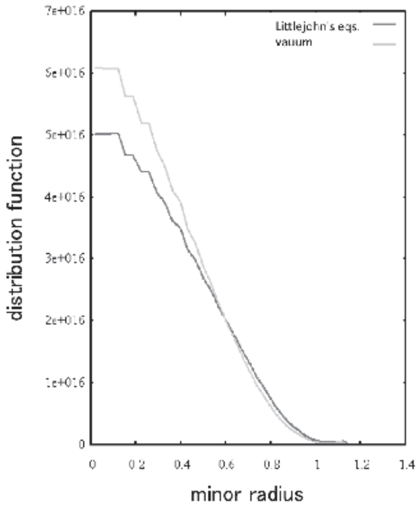

Fig. 2. Distribution function of the particles produced by co-NB in the high beta plasma.

1) Osakabe, M. et al.: Fusion Sci. Tech. **58** (2009) 131.
2) Seki, R. et al.: J. Plasma Fusion Res. **5** (2010) 014.
3) Seki, R. et al.: J. Plasma Fusion Res. **5** (2010) 027.
4) Littlejohn, R. G.: J. Plasma Phys. **29** (1983) 111.