§7. Effect of Plasma Current on Distribution Function of High Energy Ions in LHD

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It is one of the characteristics of helical devices, such as LHD, that the magnetic field required for the plasma confinement can be produced without the net plasma current. However, it sometimes happens that the net plasma current flows when the experimental conditions are modified. Although the effects of the plasma current on the MHD equilibrium and/or stability have been studied, the effects on the high energy particles produced by NBI or ICRF. The purpose of the present study is to analyze the effect of the plasma current on the distribution function of the high energy particles produced by NBI by use of MORH code[1, 2].

MORH is one of the Monte Carlo codes to calculate the steady state distribution function by tracing the high energy particle orbit including collisions and charge exchange loss. In MORH code, the re-entering particles, which repeatedly go out and into the last closed magnetic surface, can be treated appropriately since the real coordinate system is adopted. We improve MORH code by changing the guiding-center equations in vacuum to Liitlejohn's guiding-center equations[3], in which the plasma current effect on the particle orbit is included.

The improved MORH code is applied to the low B and high β plasma in LHD and the effect of the plasma current on the high energy particles produced by the tangential NBI is studied. It is noted that the net plasma current is zero and that this sustains the equilibrium. The density distribution of the co-injected particles is shown in Fig. 1. As shown in Fig. 1, the density in the core region ($\rho < 0.5$) decreases and that in the peripheral region ($\rho > 0.5$) increases. This can be explained by the increase of the deviation of the co-injected particle orbit from the magnetic surface due to the plasma current. However, it is found that the effective heating power due to the co-injected particles is independent of the plasma current effect. On the other hand, it can be seen from Fig. 2 that the density of the counter-injected particles increases in the whole region ($\rho < 1$). This can be explained by the reduction of the deviation of the counter-injected particle orbit from the magnetic surface by the plasma current effect. As a result, the effective heating power due to the counted-injected particles is increased by the plasma current effect.

The plasma current effect on the re-entering particles is also investigated. It should be noted that the re-entering particles is regarded as the lost particles in the studies based on the magnetic coordinate system. It is found that both the number of re-entering particles and the effective heating power increase in the case of co-injected particles. In contrast, in the case of the counter-injected particles, both the number of re-entering particles and the effective heating power decrease. These results suggest that the re-entering particles the low B and high β plasma in LHD play an important role in the NBI heating.

We will apply the MORH code to the equilibrium, in which the finite net current flows.

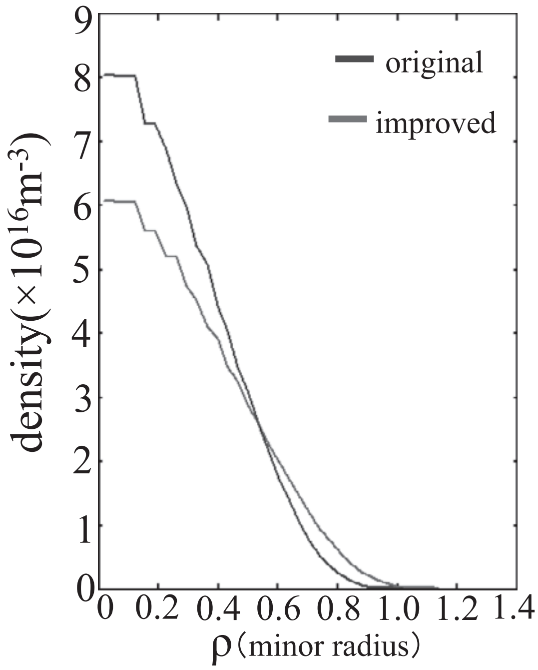

Fig. 1. Density distribution of the co-injected particles.

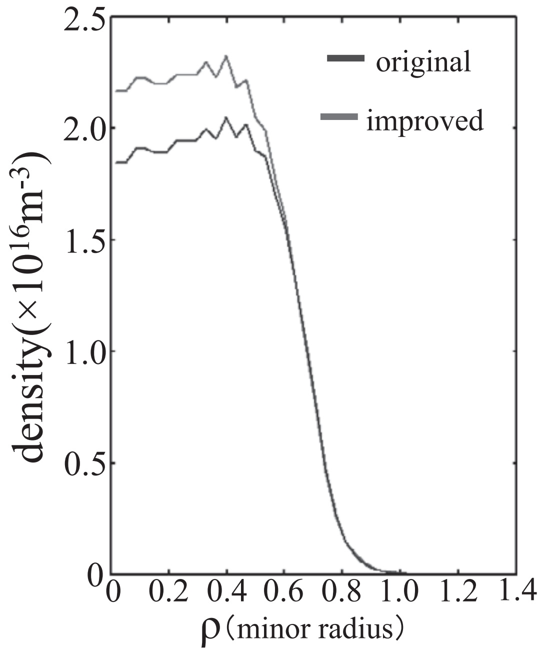

Fig. 2. Density distribution of the counter-injected particles.

1) Seki, R. et al.: J. Plasma Fusion Res. **5** (2010) 014.
2) Seki, R. et al.: J. Plasma Fusion Res. **5** (2010) 027.
3) Littlejohn, R. G.: J. Plasma Phys. **29** (1983) 111.