§12. Development of a Monte-Carlo Simulation Code for Radial Profiles in Magnetic Island

Nunami, M., Kanno, R., Jimbo, S., Satake, S., Takamaru, H. (Chubu Univ.), Hayashi, T., Okamoto, M.

Almost magnetized plasmas are confined by magnetic surface, however, sometimes shape of external perturbation coil, and electric current in plasmas form magnetic island which is one of magnetic structure. The structure of magnetic island is observed by various plasma experiments, and the thermal distribution is flat at the interior of magnetic island. Recently, however, the Large Helical Device (LHD) experiments found that if the field which is made by external perturbation magnetic field is sufficiently large, and if the the vacuum magnetic island width exceeds the critical value (15% - 20% of minor radius), the flow along the magnetic flux surface inside the magnetic island in the direction to reduce the flow shear at the boundary of the magnetic island is observed. And radial profiles of temperature of ion and the plasma flow are measured in $m/n = 1/1$ island\(^ {1,2}\). These results says that the potential is not flat in magnetic island, then this is very interesting for us.

We attacked for this results in terms of neoclassical particle transport. At first, we must specify magnetic surfaces, so we developed a code to label magnetic surface in island by calculating arbitrarily toroidal flux with high accuracy. (See Fig.1)

Next, to calculate radial electric field without magnetic island, we use $\delta f$ Monte-Carlo method in terms of neoclassical transport. In this method, the distribution function of plasma is separated into

$$f = f_M + \delta f,$$

where $f_M$ is a local Maxwellian and $\delta f$ is considered as a small perturbation from $f_M$. And then, using two weight scheme, we solve the linearized kinetic equation for $\delta f$,

$$\left( \frac{\partial}{\partial \Omega_t} + \left( \mathbf{v}_1 + \mathbf{v}_\perp \right) \cdot \nabla + k \frac{\partial}{\partial \mathbf{k}} - C_T \right) \delta f = C_F - k \frac{\partial}{\partial \mathbf{k}} f_M - \mathbf{v}_\perp \cdot \nabla f_M$$

(1)

where $k$ is kinetic energy ($k = mv^2/2$), and $C_T$ is the test particle collision operator implemented by random kicks in the velocity space, and $C_F$ is the field particle collision term.

Then we compare the results of our calculation and the results in 3).

At next step, we calculate radial electric field in magnetic island where MHD equilibrium is generated by three-dimensional MHD equilibrium code “HINT”, After this, we have to compare our results and the data of the LHD experiments.

Figure 1: Toroidal flux in $m/n = 1/1$ magnetic island at a poloidal section. As color darker, the flux becomes smaller.

References
1) K. Ida, et al.
2) K. Ida, et al.,
3) R. Kanno, et al.,