§16. Monte Carlo Collision Operator for Simulation of Edge Transport in Torus

Wang, W.X. (Grad. Uni. Advanced Studies)
Okamoto, M., Nakajima, N., Murakami, S.

At the edge region of the torus the presence of large gradients in plasma temperatures and density makes analytical study of neoclassical transport very difficult. Monte Carlo simulation, however, may provide an effective way for solving the problem. We are developing a Monte Carlo simulation code for the purpose of studying neoclassical transports near the edge.

Constructing an appropriate Monte Carlo collision operator is an important step in the simulation. In the previous work[1,2], the Monte Carlo scheme which uses Lorentz collision operator has a substantial limitation due to lack of momentum conservation. However, the momentum conservation is important since, for example, it may cancel the contribution of like particle collisions to the particle flux. The Monte Carlo collision operator developed here does exactly conserve not only energy but also momentum. The velocity alternation of particle a$(m_a, \vec{v_a}, e_a)$ during a collision with particle b$(m_b, \vec{v_b}, e_b)$ in a time interval Δt is determined as follows,

$$\Delta \vec{v_a} = \frac{m_b}{m_a + m_b}(e^{\epsilon \hat{n} \times} - 1)\vec{u} \qquad (1)$$

and small parameter ϵ is given as

$$\frac{\epsilon^2 u^3}{3} = \Delta t(4\pi e_a^2 e_b^2 \ln \Lambda)(\frac{1}{m_a} + \frac{1}{m_b})\frac{n_b}{N_b} \qquad (2)$$

where $\vec{u} = \vec{v_a} - \vec{v_b}$ is relative velocity before the collision, $\ln \Lambda$ is Coulomb logarithm, $\hat{n}$ is a random unit vector, and n_b, N_b are particle density and model particle number of species b. Its equivalence to Fokker Planck equation of Landau form is proved by keeping the lowest order term in the friction and diffusion coefficients. In addition, considering each particle collisions with all other particles in the same cell makes the equivalence more reasonable. In order to check the collision model, we perform simulations for temperature relaxation processes in a uniform plasma. The results are shown in Fig.1 and Fig.2.

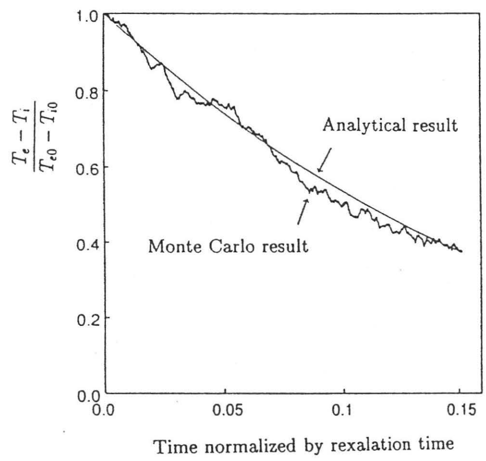

Fig. 1: *The relaxation between ion temperature T_i and electron temperature T_e.*

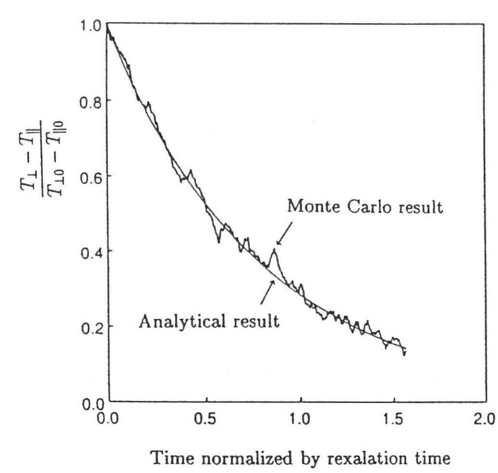

Fig. 2: *The relaxation between longitudinal temperature $T_\parallel$ and transverse temperature $T_\perp$.*

References

1) Allen H. Boozer and Gioietta Kuo-Petravic, Phys. Fluids 24(1981)851.

2) R. H. Fowler, J. A. Rome and J. F. Lyon, Phys. Fluids 28(1985)338.