§25. Higher Frequency Fluctuation and Related Particle Transport in a Field-reversed Configuration

Takahashi, T. (Gunma Univ.),
Asai, T., Takahashi, T. (Nihon Univ.),
Inomoto, M. (Univ. Tokyo), Mizuguchi, N.

Particle transport mechanism in a Field-Reversed Configuration (FRC) is an ambiguous but important issue for the scaling of confinement time and future reactor study of FRC with advanced fuel [1]. Main mechanism of particle transport has not been determined as yet because of difficulties in diagnostic technique to measure the pulsing events. Since the obtainable data are restricted by an experimental approach, it is very important to investigate the cross-field transport in an FRC by numerical method. In the history of transport study of FRC, lower hybrid drift instability has believed to be the dominant process[2], however, it is disproved by Carlson's experiment[3]. The combination of radial and open-field transport is also found to be possible to modify the scaling of gross confinement time[4]. One of the authors proposed the adiabaticity breaking process near X-points[5] enhances the end loss rate, which also increases the density gradient and resultant radial flow around the separatrix. Though the open-field transport is possible to affect the gross confinement time, we consider that the radial transport is still more dominant in the FRC confinement mechanisms. In the present paper, the electron fluid perturbation with relatively high frequency is considered as the transport mechanism of electrons themselves. Electron trajectories in the prescribed fluctuating field are calculated, and response to the fluctuation and associated transport is discussed by collection of their motion.

The wave equations of electromagnetic fields are expressed by the cylindrical coordinates system and solved by the finite difference method. Now, let us assume that the field perturbation is caused by plasma current fluctuations. Since an FRC plasma has a high beta value, the confinement field is sustained mainly by the plasma current containing fluctuation coming from typical electron motions. The obtained spatial profiles of a fluctuating component of the axial magnetic field on the midplane are shown in Fig. 1, where the profiles are drawn for the toroidal mode number n of 0, 1, 2, 3, and 4.

Electron orbits in the prescribed fluctuating field are calculated, and the position and particle flux of electrons are summed in the counting cell with a use of the PIC method. The weight of super-particle is set by the Maxwell distribution. The number of super-particles is about 1.4 billion. Coulomb collisions are reproduced by a Monte Carlo method [6].

The resultant end loss electron ratio is shown in Fig. 2. It is found that the loss ratio for the perturbation case gradually exceeds the static case at $t = 20\tau_{ec}$, because electrons diffused out from the separatrix due to perturbation reach the mirror end by this time. Here, τ_{ec} is the typical time of electron cyclotron motion. About 120% electron loss rate enhancement is observed for the perturbation case.

The electron fluid perturbation fields have been calculated by assuming that its source results from the current fluctuation. In the prescribed perturbation fields, trajectories of electrons have been investigated, and the electron flow and density are calculated by the particle-in-cell method. It appears that the end loss rate enhances due to the perturbation.

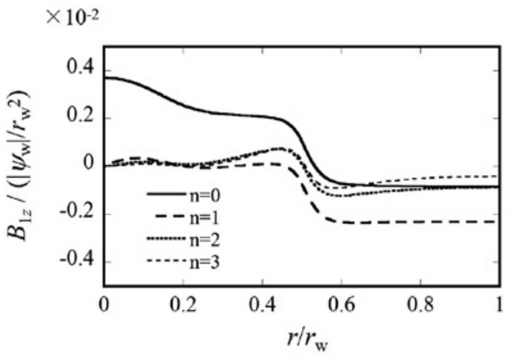

Fig. 1. The spatial profiles of the amplitude of axial magnetic field fluctuation caused by electron fluid perturbation.

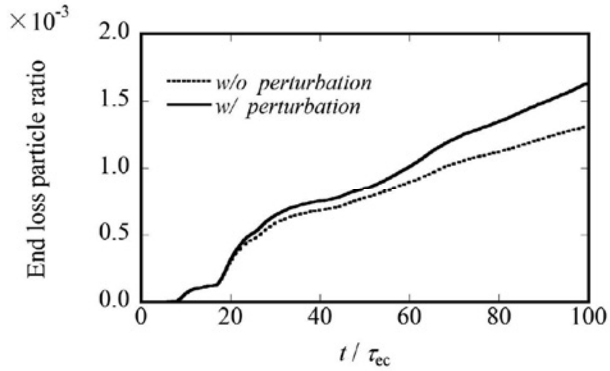

Fig. 2. The time evolution of the ratio of end loss electrons.

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3) Carlson, A. W.: Phys. Fluids **30** (1987) 1497.
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