24aE07P

共鳴摂動磁場を印加したトロイダルプラズマの電子熱輸送
Electron heat transport in toroidal plasma affected by resonant magnetic perturbation

菅野龍太郎，沼波政倫，佐竹真介
KANNO Ryutaro, NUNAMI Masanori, and SATAKE Shinsuke

核融合研
NIFS

To understand properties of collisional transport in a perturbed magnetic field is important for control of fusion plasma by employing resonant magnetic perturbations (RMPs). In recent tokamak experiments, RMPs have been used to suppress edge localized modes (ELMs). It has been found simultaneously with the ELM suppression that theoretical estimates of the electron transport coefficients, which are based on the field line diffusion of Rechester and Rosenbluth (R-R) [1], are fairly different from the experimental results [2]. On the other hand, the R-R theory has been confirmed by a test particle simulation in a sufficiently ergodized region [3]. Therefore, there is an open question: why is the difference between the theoretical and experimental results occurred? In order to search for the answer, the purpose of this work is to reconsider the fundamental properties of the transport.

We estimate the electron transport by using a δf simulation code, KEATS, which solves the drift-kinetic equation. Under an assumption of zero electric field, which is the same assumption as in the R-R theory, we find the following results. See also Fig.1. 1) The radial thermal diffusivity of electron χ_r in the simulation is close to the diffusivity of the R-R theory $\chi_r^{\text{R-R}}$ if χ_r is evaluated in a temporary state of the guiding-center distribution function f during an extremely short time $\Delta t << \omega_t^{-1}$ around time $t << \omega_t^{-1} << \nu_{\text{eff}}^{-1}$. Here ω_t is the transit frequency and ν_{eff} is the effective collision frequency. The initial condition of f in the simulations is set to $f = f_M$ at time $t = 0$, where f_M is a Maxwellian. The temporary state relaxes finally to a quasi-steady state of f after being sufficiently exposed to Coulomb scatterings. Note that it is physically meaningful to evaluate χ_r in the quasi-steady state rather than in the temporary state. 2) The diffusivity χ_r evaluated in the quasi-steady state is extremely small compared with $\chi_r^{\text{R-R}}$.

These results partly explain the difference, but one of the most important effects is ignored; it is an effect of radial electric field E_r. It is found that positive E_r affects the transport. See Fig.2, where E_r = +0.7 kV/m at r/a = 0.6.

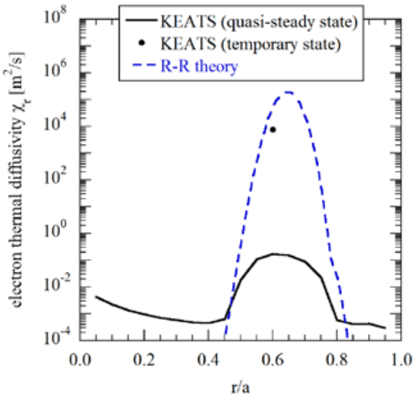

Fig.1. Comparison between results of KEATS simulations and R-R theory.

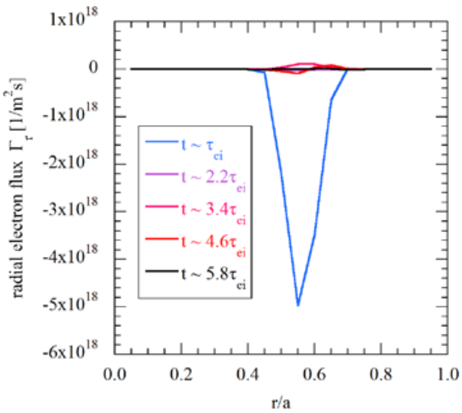

Fig.2. Time evolution of the radial electron flux affected by E_r.

The simulations in this work were conducted using the supercomputers “Plasma Simulator” at National Institute for Fusion Science (NIFS) and “Helios” at International Fusion Energy Research Centre - Computational Simulation Centre (IFERC-CSC). This work was performed with the support and under the auspices of the NIFS Collaborative Research Programs “NIFS13KNST060” and “NIFS15KNST076” and the IFERC-CSC projects “PETAMP3” and “PETAMP4.”

[1] A.B. Rechester and M.N. Rosenbluth, Phys. Rev. Lett. **40** (1978) 38.
[2] T.E. Evans *et al.*, Nature Phys. **2** (2006) 419.
[3] A.H. Boozer and R.B. White, Phys. Rev. Lett. **49** (1982) 786.