§8. Drift-kinetic Simulation including Effects of Resonant Magnetic Perturbations and Radial Electric field

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We numerically investigate the radial electron transport in a circular tokamak plasma affected by RMPs, where the perturbed region is assumed to be bounded radially on both sides by closed magnetic surfaces. The radial electron transport is estimated by using a δf simulation code, KEATS, which is programmed to solve the drift-kinetic equation in 5-dimensional phase space under the conditions that the magnetic and electric fields, density and temperature are fixed. Under an assumption of zero electric field, which is the same assumption as in [1, 2], we find that the radial thermal diffusivity of electron $\chi_r^{\rm e}$ evaluated in quasi-steady state is extremely small compared to the Rechester and Rosenbluth prediction $\chi_r^{\rm RR}$ in [1]. See Fig. 1. Here, the radial thermal diffusivity $\chi_r^{\rm e}$ is effectively evaluated as $\chi_r^{\rm e} = Q_r^{\rm e}/|n_{\rm e}\partial T_{\rm e}/\partial r|$ from the radial energy flux $Q_r^{\rm e}$ under the conditions of constant number density $n_{\rm e} = n_{\rm i} =$ constant and zero mean velocity $\mathbf{V}_{\rm e} = \mathbf{V}_{\rm i} = 0$. We should note that $\chi_r^{\rm e}$ in the quasi-steady state is given by the radial component of parallel velocity in $Q_r^{\rm e}$, which is the same as in the theoretical model of [1]. See Fig. 2. Effects of radial electric field on

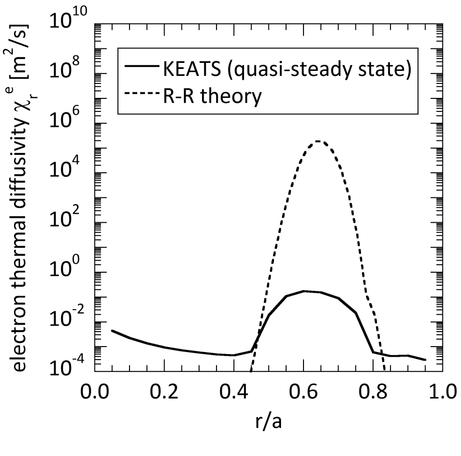

Fig. 1: *Profiles of the radial thermal diffusivity of electron given by the KEATS simulation in quasi-steady state (solid line) and the field-line diffusion model* $\chi_r^{\rm RR}$ *(dashed line), where the collisionality is* $\nu_* \approx 0.04$ *at the centre of the perturbed region,* $r/a \approx 0.6$.

the electron transport in RMP field are also investigated. Here, the electrostatic potential is modelled as $\Phi = -(\Phi_0/12)[\tanh\{12(r-0.6a)/a\} - 1]$, and the radial electric field at $r/a = 0.6$ is given as $E_r = \Phi_0/a$. Both

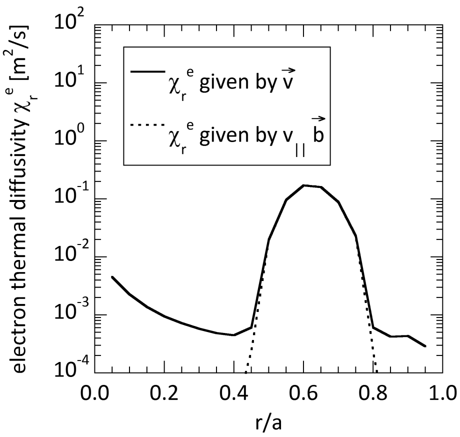

Fig. 2: *Estimations of* $\chi_r^{\rm e}$ *given by the radial components of particle velocity* $\nabla r \cdot \mathbf{v}$ *(solid line) and parallel velocity* $\nabla r \cdot v_\parallel \mathbf{b}$ *(dashed line) in* $Q_r^{\rm e}$.

the gradients of $T_{\rm e}$ and $n_{\rm e}$ are considered in this investigation, where $|\partial \ln T_{\rm e}/\partial r| = |\partial \ln n_{\rm e}/\partial r| = 0.227/a$ at $r/a = 0.6$. In general, in the sufficiently perturbed region, the radial electron flux is much larger than the radial ion flux, $\Gamma_r^{\rm e} \gg \Gamma_r^{\rm i}$, under the assumptions of zero electric field and $T_{\rm e} = T_{\rm i}$. Therefore, we preliminary estimate the electron heat flux $q_r^{\rm e} = Q_r^{\rm e} - (5/2)T_{\rm e}\Gamma_r^{\rm e}$ when $\Gamma_r^{\rm e} \approx 0$. It is found that the electron flux $\Gamma_r^{\rm e}$ is reduced by positive radial electric field, and that the condition of $\Gamma_r^{\rm e} \approx 0$ is satisfied in case of the model potential with $\Phi_0 \approx 700$ V (i.e., $E_r \approx +0.7$ kV/m at $r/a \approx 0.6$). While the electron flux $\Gamma_r^{\rm e}$ is reduced by the positive E_r in this case, the radial heat flux $q_r^{\rm e}$ enhanced by the RMPs is almost independent of the electric field in quasi-steady state. See Fig. 3.

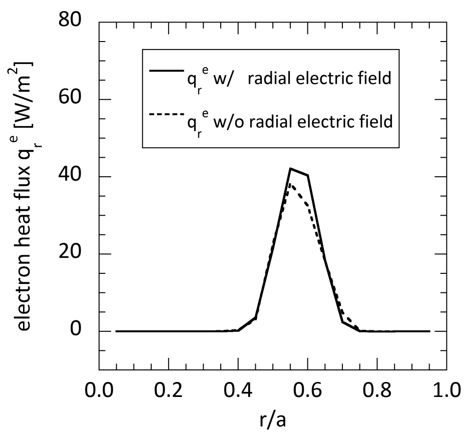

Fig. 3: *Profiles of radial heat flux of electron in quasi-steady state with* E_r *in case of* $\Phi_0 \approx 700$ *V (solid line) and without* E_r *(dashed line), where* $\nu_* \approx 0.04$.

[1] Rechester A B and Rosenbluth M N 1978 *Phys. Rev. Lett.* **40** 38
[2] Boozer A B and White R B 1982 *Phys. Rev. Lett.* **49** 786