§23. Nonlinear Simulation of Electromagnetic Current-Diffusive Interchange Mode Turbulence

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The model equation for the electrostatic current diffusive interchange mode turbulence is extended for both electrostatic and electromagnetic turbulence. Not only $E \times B$ convective nonlinearity but also the electromagnetic nonlinearity which is related to the parallel flow are incorporated into the model equation. The two dimensional nonlinear simulation of the electromagnetic current diffusive interchange mode is performed based on the extended fluid model.

Basic set of equations for $\{\phi, A, p_\phi, p_i\}$ are given as

$$\frac{\partial}{\partial t} U + [\phi, U] + [A, W] = -i k_y \nabla_\perp^2 A - i k_y \alpha_e p_e - i k_y \alpha_i p_i + \mu_\perp \nabla^2 U,$$

(1)

$$\frac{\partial}{\partial t} W + [\phi, W] - [A, W] + [A, p_e] = -i k_y \phi + i k_y p_e - i k_y A + \lambda_\perp \nabla^2 W - \lambda_y k_y^2 W,$$

(2)

$$\frac{\partial}{\partial t} p_e + [\phi, p_e] = -i k_y (1 - S_{18}) \phi - S_{19} i k_y p_e - S_{17} i k_y \nabla^2_{\perp} A + \chi_{ej} \nabla^2_{\perp} p_e - \chi_{e}\phi k_y^2 p_e,$$

(3)

$$\frac{\partial}{\partial t} p_i + [\phi, p_i] = -i k_y (1 - S_{19}) \phi + S_{19} i k_y p_i + \chi_{ej} \nabla^2_{\perp} p_i - \chi_{i}\phi k_y^2 p_i,$$

(4)

with $U = \nabla^2_{\perp} \phi$ and $W = -\nabla^2_{\perp} A + A$.

The parameters are chosen as $L_x = 120$ (the system size of x-direction), $L_x = 2\pi \times 6.4$ (the system size of y-direction), $M = 64$ (the Fourier modes), $\alpha_e = \alpha_i = 0.25, s = 0.5, \mu = \chi_{ej} = \chi_{i\perp} = 0.2, \chi_{e\parallel} = \chi_{i\parallel} = 0.5, S_{15} = 0.2, S_{16} = 2, S_{17} = 2, S_{18} = 0.2, S_{19} = 2$.

Figure 1 shows the time evolution of the heat flux. The solid line represents the electrostatic component of the electron heat flux defined by

$$q_e^s = \sum_{k_y} \frac{1}{L_x} \int_{-L_x/2}^{L_x/2} dx \, p_e^* ik_y \phi,$$

(5)

and the dotted line, the electromagnetic component of the electron heat flux defined by

$$q_e^m = \sum_{k_y} \frac{1}{L_x} \int_{-L_x/2}^{L_x/2} dx \, p_e^* ik_y \phi,$$

(6)

with respect to the three components of the heat flux, we observed that they do the temporal oscillations. Three oscillation periods are found to be the same order, which are of the order of $T_{osc} \approx 15$. This period is similar value to the oscillation period of the fluctuation energy level in the low $k_y$ part. However, their evolutions are different.

This study is performed by using the SX-3 super computer at NIFS.