§13. Dynamics of the Nonlinear Drift Vorex in Drift Unstable Plasmas

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The behavior of the dipole vortex, so-called modon, in Hasegawa-Mima equation has been studied. However, in more realistic situation we cannot ignore the effect of the drift instability. Therefore, it is important to investigate the behavior of the dipole vortex for the drift instability. In collisional magnetized plasmas, we have obtained two model equations; one is the vorticity equation instead of Hasegawa-Mima equation and another is the continuity equation of the current, as follows:

$$\frac{\partial q}{\partial t} + \{\phi, q\} = 0 \qquad (1)$$

$$\frac{\partial \omega}{\partial t} + \{\phi, \omega\} + \nabla_{\parallel}^2(\phi - n_1) = 0 \qquad (2)$$

where $q = \omega - n_1 - \nu_0 x$, $\omega = \nabla_{\perp}^2\phi$, ν_0, n_1 and ϕ are the potential vorticity, the vorticity, gradient and perturbation of the density, electrostatic potential, respectively, and brackets in both are Poisson brackets with respect to x and y. The third term in eq. (2) is the current in the z direction parallel to the constant magnetic field, and other terms are the current in the surface perpendicular to z axis in term of polarization drift.

In numerical simulation, we assume $\nabla_{\parallel}^2 = -k_{\parallel}^2$ for convenience, the modon as initial condition and periodic boundary condition. At $t = 0$ the density perturbation n_1 is equal to the electrostatic potential ϕ, that is, the density has the Boltzmann distribution. The discrepancy between ϕ and n_1 grow up and is saturated as shown in Fig. 1.

Figure 2 shows the contour plot of density perturbation at $t = 6$, and the large Dipole vortex is the modon, and convective cells whose phase velocity is zero appear in the place the modon passed through. Convective cells damp after the discrepancy from Boltzmann distribution is saturated.

We found out, when the phase velocity of the modon is more different from the drift velocity $-\nu_0$, it results more large convective cells.

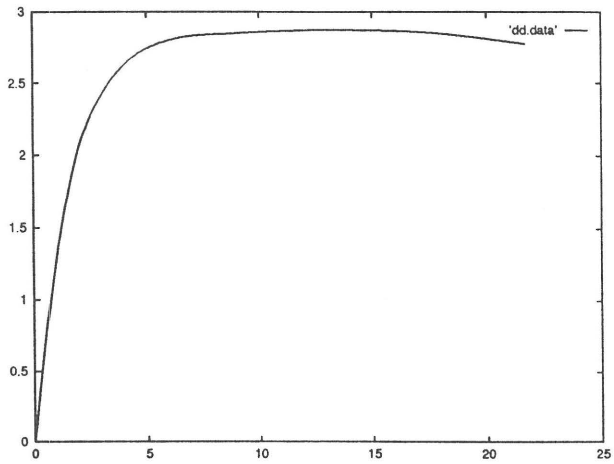

Fig. 1. Time development for the integral of the discrepancy from Boltzmann distribution, which is equal to difference between the electrostatic potential ϕ and the density perturbation n_1.

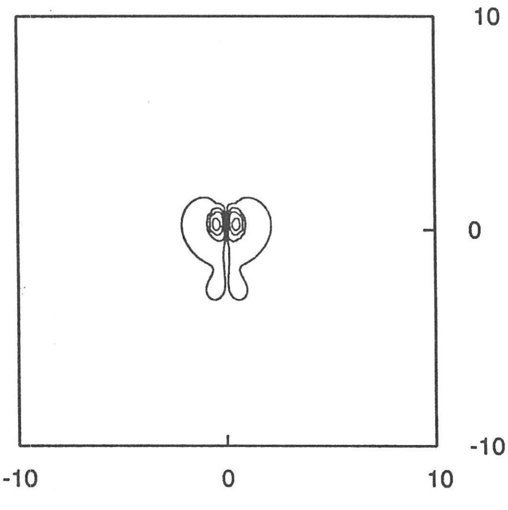

Fig. 2. Contour plot of the density perturbation for the density gradient $\nu_0 = -0.2$, the wave number $k_{\parallel}^2 = 0.1$ parallel to $\boldsymbol{B}_0$ and the modon phase velocity $u = 0.4$.

References
1) B. D. Scott, Phys. Fluid B **4**, 2468 (1992)
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