§22. Linear and Nonlinear Simulation of Kinetic Internal Kink Modes

Naitou, H., Kitagawa, H.
(Yamaguchi Univ. Eng.)
Tokuda, S. (J.A.E.R.I)

The collisionless reconnection process associated with the $m = 1$(poloidal mode number) and $n = 1$ (toroidal mode number) kinetic internal kink modes is simulated by the three dimensional two field (the electrostatic potential and the component of the vector potential in the direction of the toroidal magnetic field) gyro-fluid code[1] including the effects of the electron inertia and the perturbed electron pressure gradient. The computational model represents a straight tokamak with periodic boundary condition in the toroidal direction and a square cross section with perfectly conducting walls in the poloidal direction. The linear mode is analysed by the linear gyro-fluid code including only $n = \pm 1$ modes in addition to the equilibrium $n = 0$ mode. The measured linear growth rates agree well with the theory of Zakharov in which $\gamma \propto d_e$ for $d_e \gg \rho_s$ and $\gamma \propto d_e^{\frac{1}{3}} \rho_s^{\frac{2}{3}}$ for $d_e \ll \rho_s$ (d_e is the collisionless electron skin depth and ρ_s is the ion Larmor radius estimated by the electron temperature). The fast Kadomtsev-type full reconnection (first step) followed by the second step reforming the configuration of $q_0 < 1$ is observed by the nonlinear gyro-fluid code (see Fig. 1). Results of the gyro-fluid code agree quite well with those of the gyrokinetic particle code (GYR3D)[2,3] up to the first step (full reconnection phase) of the instability. For the second step (post full reconnection phase), both codes reproduce the similar phenomena with some differences. Although careful comparison of both codes needs further study, we believe that they capture the basic physics of the phenomena related to the nonlinear dynamics of the kinetic internal kink modes.

Finally, we want to emphasize that the better understanding of the physics associated with the kinetic MHD phenomena in tokamaks will be achieved by executing simultaneously the gyrokinetic particle simulation being faithful to physics and the gyro-fluid simulation with a realistic spatial resolution.

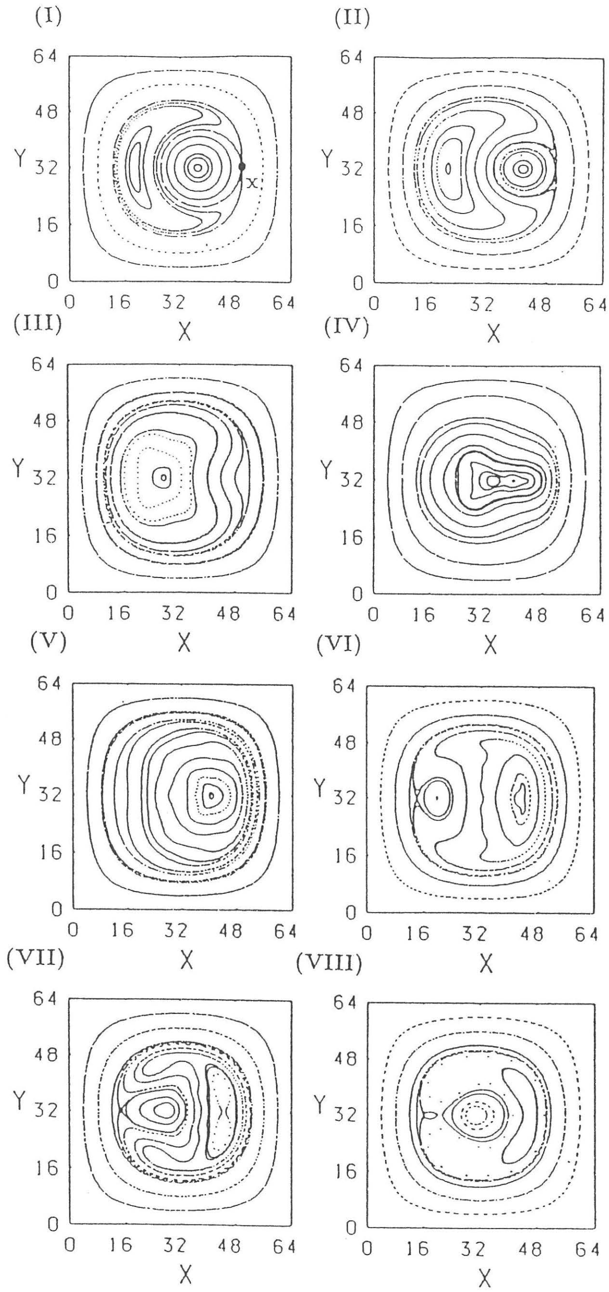

Fig. 1. Time evolution of the magnetic field structure.

References
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2) Naitou, H., Tsuda, K., Lee, W.W., Sydora, R.D., Physics of Plasmas 2 (1995) 4257.
3) Naitou, H., Sonoda, S., Tokuda, S., Decyk, V.K., J. Plasma and Fus Res. 72 (1996) 259.