§22. Nonlinear Interchange Mode Including Reynolds Stress

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L to H transition[1] is the recent topic in the magnetic fusion research, since confinement improvement of about a factor of two is crucial to realize ignition. It is also recognized that ELM (Edge Localized Mode) is essential to control H-mode plasmas.[2] Therefore, it is important to understand mechanism of the L-H transition and ELM.

We have studied nonlinear evolution of the two dimensional interchange mode in the edge plasma with the poloidal shear flow.[3] We obtain a sawtooth like relaxation oscillation in the nonlinear stage for Rayleigh number (R_a) of the order of 10^4. This oscillation is caused by the change of poloidal velocity shear due to Reynolds stress. When the poloidal velocity shear becomes weak, the fluctuation level increases suddenly and the Reynolds stress enhances the velocity shear to stabilize the nonlinear interchange. In this case the shear flow does not overcome the vortex flow, and the decrease of fluctuation level weakens the Reynolds stress gradually. Thus the sawtooth like relaxation oscillation of fluctuation energy appears.

Here the Rayleigh number is increased up to the order of 10^5. Then a new oscillatory behavior of nonlinear interchange mode is obtained in the presence of appropriate velocity shear as shown in Fig. 1. Here Prandtl number is $Pr = 1.0$. When the shear flow produced by Reynolds stress increases sharply at $t \simeq 60$ (see the $m = 0$ mode in Fig. 1), the fluctuation level dominated by the $m = 1$ mode decreases accordingly. The relaxation oscillation continues as long as R_a and P_r are fixed. This behavior of the nonlinear interchange mode gives clear effects on the radial transport measured with Nusselt number as shown in Fig. 2.

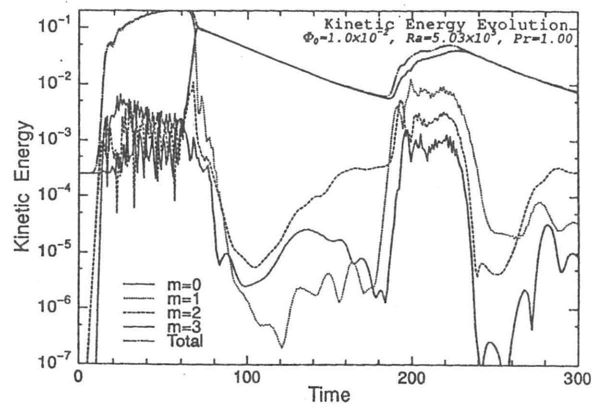

Fig. 1. Time evolution of kinetic energy of dominant Fourier modes ($m = 0 \sim 3$) for $R_a = 5.03 \times 10^5$ and $P_r = 1.0$. Total kinetic energy is also shown. Time is normalized by the linear growth rate of interchange mode.

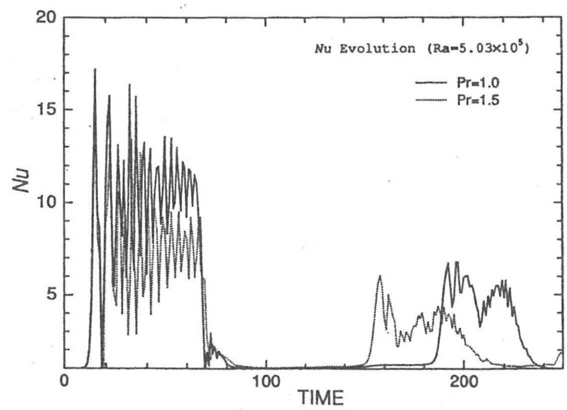

Fig. 2. Time evolution of Nusselt number for the case shown in Fig. 1, and $P_r = 1.5$ case.

References

1) Wagner, F. et al., Phys. Rev. Lett. 49 (1982) 1408.

2) Burrell, K. H. et al., Plasma Phys. Controlled Fusion 31 (1989) 1649.

3) Takayama, A., Wakatani, M., and Sugama, H., J. Phys. Soc. Jpn 64 (1995) 791.