§6. Theoretical Study about Self-organization in a Low-aspect-ratio Plasma

Sanpei, A., Masamune, S., Oki, K., Nakamura, M., Higashi, A., Motoi, H., Fukahori, D. (Kyoto Inst. Tech.),
Kondoh, Y., Takahashi, T. (Gunma Univ.),
Mizuguchi, N.

We have been carrying out direct numerical simulations[1)] of the fully three-dimensional, nonlinear magnetohydrodynamics (MHD) equations in a low aspect ratio (A) reversed field pinch (RFP) plasma. One of our research purposes is analysis of MHD properties of low-A RFP. In this study, all calculations assume the following parameters of the low-A RFP device, REversed field pinch of Low Aspect eXperiment (RELAX):[2)] $R/a = 0.51$ [m]/0.25 [m], $A = 2$. The device is operated with a 4 mm SS vacuum vessel (field penetration time $\tau_w < 3$ ms), where R is the major radius and a is the minor radius. In the RELAX experiment, growth of fluctuations is considered to be dominated by kink mode $m = 1$. The toroidal mode spectrum is narrowed by reducing the toroidal field reversal, and the Quasi Single Helicity (QSH) state tends to be realized in shallow reversal discharges[3)].

Here we report our numerical results obtained by a MHD simulation. An initial condition has been provided by equilibrium reconstruction code from several external diagnostics on RELAX[4)]. We adopt resistivity η, the viscosity μ, and the isotropic heat conductivity κ, are assumed to be uniform. The simulations with these parameters are carried out for a set of the grid points, $153 \times 128 \times 153$. The simulation starts from a linearly unstable configuration which causes initial tiny perturbations to grow spontaneously. The perturbation is introduced on the plasma velocity field at $t = 0\tau_A$ as a random white noise.

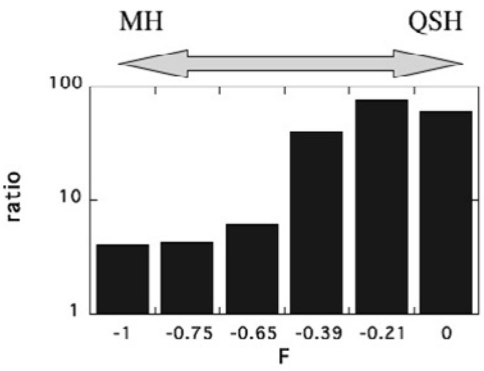

Fig. 1: Ratio of the amplitude of the dominant to secondary mode is plotted as a function of field reversal parameter F of initial RFP configuration.

Dependence of the mode spectrum on initial distribution is shown in Fig. 1. In Fig.1, ratio of the amplitude of the dominant to secondary mode is plotted as a function of field reversal parameter F, which is ratio of edge toroidal field $B_t(a)$ to average toroidal field $< Bt >$. These ratios are obtained when after the relaxation event, which occurs $t = 60\tau_A$. In the shallow reversal case, growth of single mode (QSH) is observed. In deep reversal case, on the other hand, the magnetic fluctuation amplitudes decrease and spectrum with a broad peak. This computational result is consistent with experimental result[3)].

Figure 2 shows snapshots of time evolution of the pressure profile on poloidal cross-section in shallow reversal configuration. The pressure profile is elliptically elongated in the poloidal cross section, reflecting the structure of m=1 mode. This m=1 deformation is corresponding m=1/ n=4 helical deformation. Such helical deformation will remain in the later stage. A part of these result is presented on 15th Workshop on MHD Stability Control and Joint US-Japan Workshop[5)].

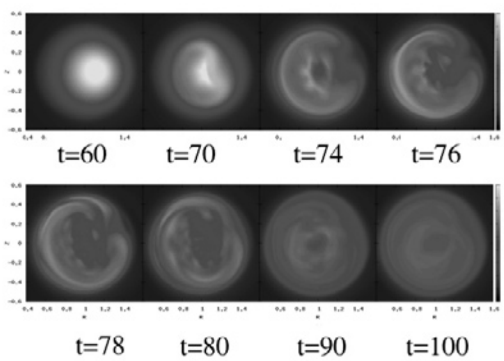

Fig. 2: Snapshots of time evolution of the pressure profile on poloidal cross-section in shallow reversal configuration.

1) N. Mizuguchi *et al.*, Phys. Plasmas, **7** (No.3) (2000) 940.

2) S. Masamune *et al.*, J. Phys. Soc. Jpn. **76** (No.12) (2007) 123501.

3) R. Ikezoe *et al.*, *Proc. 35th EPS Conf. on Plasma Phys* (2008) P4.067.

4) A. Sanpei *et al.*, J. Phys. Soc. Jpn. **78** (No.1) (2009) 013501.

5) A. Sanpei *et al.*, 15th Workshop on MHD Stability Control and Joint US-Japan Workshop, University of Wisconsin-Madison, Madison WI, 2010/11/15-17.