§10. Theoretical Study for Clarification of Self-organization in a Low-aspect-ratio RFP

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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.

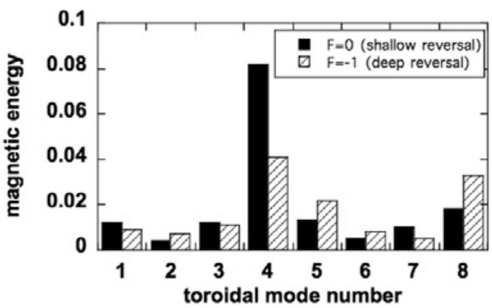

Fig. 1: The mode spectrum at $t = 150\ \tau_A$.

Dependence of the mode spectrum on initial distribution is shown in Fig. 1. This mode spectrum obtained when after the relaxation event, which occurs $t = 60\tau_A$. In the shallow reversal case, growth of single mode (QSH) is observed. This computational result is consistent with experimental result[3]. Figure 2 shows an equi-pressure surface at $t = 150\tau_A$ in shallow reversal discharge. A helical deformation (m=1/ n=4) is observed. This helical deformation will remain in the later stage.

Fig. 2: The equi-pressure surface at $t = 150\ \tau_A$. The m= 1 / n= 4 helical deformation is observed.

Next, the dependence of the spectral index N_s on Hartmann number $H = (\mu\eta)^{-0.5}$ is examined. When a single mode is excited, N_s becomes 1. The N_s is plotted as a function of H in Fig. 3. Transition QSH to Multi Helicity (MH) state by increasing H is observed. Such transition by increasing H has been observed in Ref[5]. More detail comparison remains as a future work.

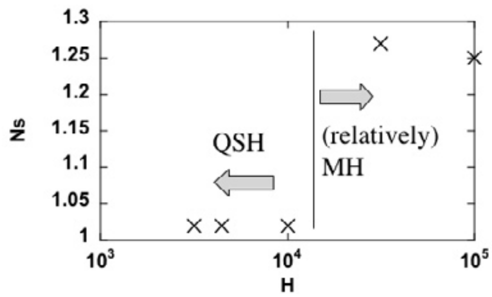

Fig. 3: Dependence of N_s on H. Transition QSH to MH state by increasing H is observed.

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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) S. Cappello *et al.*, Phys. Rev. Lett, **85** (2000) 3838.