§1. Theoretical Study on Self-organization in a Spherical 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. The low-A RFP has the advantage of simpler MHD, because the mode rational surfaces are less densely spaced. 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 $m = 1$[3].

Here we report our preliminary numerical results obtained by a MHD simulation to study the MHD properties of low-A RFP. An initial condition has been provided by using the modified MSTFit code[4] for the low-A RFP by changing the boundary conditions, from several external diagnostics on RELAX[5]. We adopt resistivity η, the viscosity μ, and the isotropic heat conductivity κ, are assumed to be uniform values of 1.0×10^{-9}, 1.5×10^{-4} and 1.0×10^{-9}, respectively. The simulations with these parameters are carried out for a set of the grid points, $57 \times 68 \times 57$. The boundary condition is put as a perfect-conducting and no-slip wall at all boundaries of the computation region, as shown in Fig.1

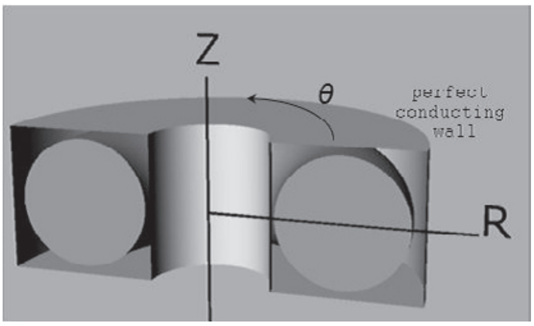

Fig. 1: The schematic of geometry of the computation region.

Shown in Fig.2 is the time evolutions of the perturbation in magnetic energy for each toroidal Fourier component. This computational result that $n = 4$ mode is dominant is consistent with experimental result[3]. Moreover, another feature is that the relative amplitude of $n = 8$ mode is non-negligible, as shown in Fig.2. Our experimental results[3] suggest that $m = 2$ mode is non-negligible which is usually ignored in high- or medium-A RFP plasmas. Figure 3 shows the pressure profiles on poloidal cross section of $m/n = 1/4$ and $2/8$ at $t = 350$ τ_A, respectively. Nonlinear coupling between the dominant $m = 1$ modes have been considered to be the origin of $m = 2$ mode, however more detailed study of relations between origin of $m = 2$ mode and lowering A remains as a future work.

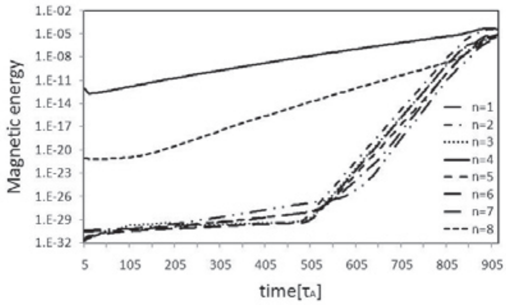

Fig. 2: Time evolutions of the Fourier-amplitudes of the magnetic fluctuations.

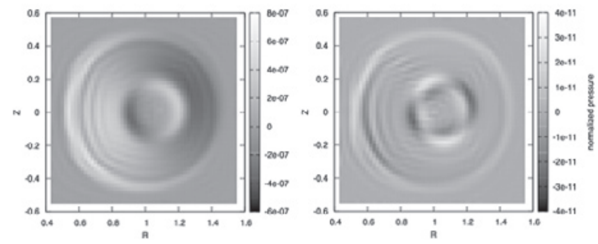

Fig. 3: Pressure profiles of $m/n =$ (a) 1/4 and (b) 2/8 at $t = 350$ τ_A.

In order to clarify the effect of mesh size, the computation with larger number of grid points, $113 \times 68 \times 113$ is now underway.

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

4) J. Anderson *et al.*, Nucl. Fusion **44** (2004) 162.

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