§11. Investigations of Pressure Deformations in the LHD System by Means of Nonlinear MHD Simulations

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We have investigated pressure deformations of an MHD plasma in the LHD system by means of nonlinear simulations. Special attention has been paid to dependence of plasma behaviors on the position of the magnetic axis R_{ax} of initial equilibria. We have restricted ourselves to MHD simulations under the the stellarator symmetry. The stellarator symmetry allows us to solve only 1/20 of the full-torus system.

We have prepared two initial ideal equilibria by using the HINT code.[1] One equilibrium has the initial central $\beta_0 = 4\%$ and $R_{ax} = 3.7m$ (equilibrium (A)), while the other one has $\beta_0 \simeq 3.6\%$ and $R_{ax} = 3.6m$ (equilibrium (B)). Both equilibria (A) and (B) are weakly unstable in the sense of Mercier criterion[2] and the latter is relatively more unstable the former. Hereafter, we refer to series of simulations which start from the initial equilibria (A) and (B) as series A and B, respectively.

In Fig.1(a) and (b), contour plots of the pressure fluctuations, which was obtained by a simulation of series B, on horizontally- and vertically-elongated poloidal sections are shown, respectively. In this simulation, we set the dissipative coefficients as the conductivity $\kappa = 1 \times 10^{-6}$, the resistivity $\eta = 3.16 \times 10^{-5}$ and the viscosity $\nu = 2 \times 10^{-3}$. In Figs.1, the outer side of the torus is in the directions of the black thick arrows. We observe growth of the ballooning mode with the poloidal/toroidal modes $m/n = 16/20$, which is similar to the structure observed in our previous work on simulations series A[3].

Results of our simulations series A and B can be summarized as follows.

1. Growth rate of fluctuations in the initial stage of simulations are roughly proportional to $\eta^{-1/3}$.

2. Pressure fluctuations are strongly localized in the outer side of the torus.

3. Sufficiently long simulations show that a clear, well-confined state is recovered after sufficiently long period of simulations.

4. In the time evolution, dissipative processes such as the thermal conduction and the viscous heating play important roles for the pressure deformation.

It is noteworthy that the saturation levels of the initial growth of fluctuations are almost comparable between series A and B. In Fig.2, the time evolutions of the kinetic energies of series A and B, with the dissipative coefficients $\kappa = 1 \times 10^{-6}, \eta = 3.16 \times 10^{-5}, \nu = 2 \times 10^{-3}$ are shown as a typical example. The fact that we do not observe clear difference of saturation levels between series A and B despite more unstable nature of initial equilibrium (B) than (A) suggests that behaviors of MHD plasmas in the LHD are insensitive to variations of R_{ax} and that the insensitivity should be attributed to the nonlinear properties of MHD plasmas.

1) H. Harafuji, T. Hayashi and T. Sato, J. Comp. Phys., **81** (1989) 169.
2) K. Ichiguchi et al., Nucl. Fusion **33**, 481 (1993)
3) H. Miura, T. Hayashi and T. Sato, Phys. Plasmas **8**, 4870 (2001)

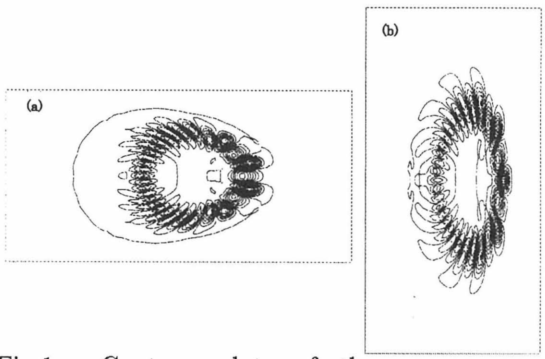

Fig.1: Contour plots of the pressure on (a)horizontally-elongated and (b) vertically-elongated poloidal sections.

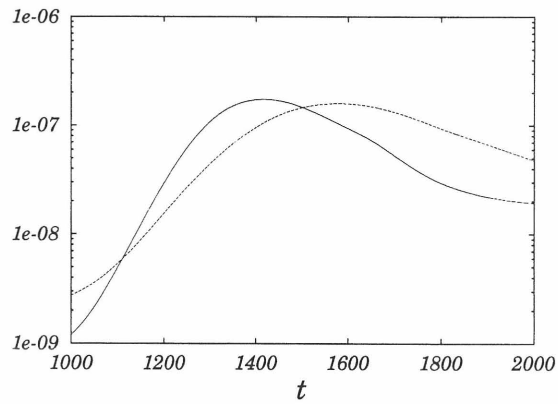

Fig.2: Energy growth caused by resistive ballooning modes. Solid and dashed lines are for runs of series A and B, respectively.