§7. Resistive Modes Observed in Nonlinear MHD Simulations of a Helical System

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In order to study three-dimensional, nonlinear behavior of a helical plasma, we have developed a new simulation code which solves a fully nonlinear, resistive and viscous MHD equation in the helical coordinate system. This research aims to study unstable motions of a helical plasma with low toroidal modes, to clarify mechanism of nonlinear saturation of pressure-driven instabilities by using our new code. Here we report some preliminary results on an LHD-like helical plasma obtained by this code.

Since a simulation of the fully toroidal system needs a long computational time, we have solved the system under the helical symmetry in order to estimate appropriate parameters for fully-toroidal system. Initial equilibria were obtained by the HINT-code[1)]. Initial position of the magnetic axis was located 17*cm* inside of the center of the poloidal section.

In Fig.1, time-evolutions of the kinetic energy for various values of the resistivity η and viscosity μ, for the central beta $\beta_0 = 4\%$ and 8% are shown. Although initial equilibria are kept stable when μ is sufficiently large and η is sufficiently small, it grows exponentially when μ is small and/or η is large. The growth rate of the kinetic energy is almost proportional to the power of the resistivity. It is typical to the resistive instability.

In Figs 2(a) and 2(b), contour plots of the toroidal current on poloidal sections are shown for the case $\beta_0 = 4\%, \eta = 10^{-6}$ and $\mu = 10^{-3}$. Some deformations of contour lines are seen in upper (right-hand) side of Fig. 2(a) (Fig. 2(b)), in th outer direction of the toroidal curvature. The deformation becomes very clear on the horizontally-elongated section, where the curvature of the magnetic line becomes the worst. It suggests that this exponential growth is brought by a ballooning instability.

Results seen in Figs.1 and 2 suggest that the system is dominated by a resistive ballooning instability. Although the largest growth rate should be achieved at the infinite toroidal wavenumber when the system is dominated by an ideal ballooning instability, it is not the case because the plasma is viscous. A rough estimation of active poloidal (m)/poloidal(n) wavenumbers on a simulation shown in Figs.2 results to $m/n = 15/10$. Note that $n = 10$ is the smallest toroidal mode achievable under the helical symmetry. It suggests that an appropriate viscosity let the toroidal wavenumber with the largest growth rate shift to lower wavenumber when the system is solved without imposing the helical symmetry.

Results shown above should be followed by simulations on fully toroidal system.

Reference

1) H. Harafuji, T. Hayashi and T. Sato, J. Comp. Phys., **81** (1989) pp.169-192.

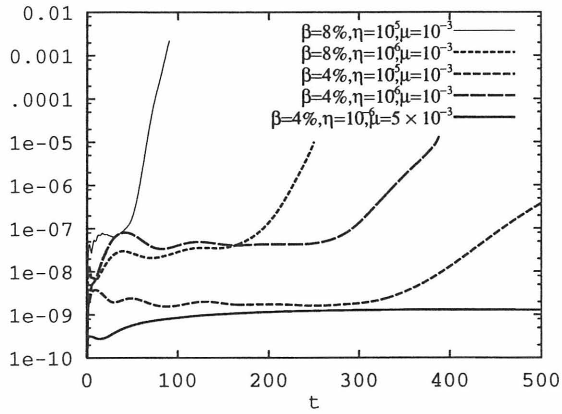

Figure 1: Time evolution of the kinetic energy

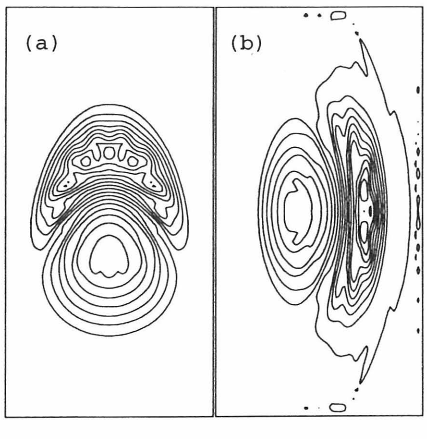

Figure 2: Contour plots of the toroidal current.