§7. Nonlinear MHD Simulations of the LHD System

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We have investigated nonlinear behaviors of an MHD plasma in the LHD system by using our simulation code which solves fully nonlinear MHD equations in the helical coordinate system. Though we could solve full-torus system by using this code, we first conducted simulations under the stellarator symmetry. The stellarator symmetry allows us to solve only 1/20 of the full-torus system.

An Initial equilibrium with initial $\beta_0 = 4\%$ and $R_{ax} = 3.7m$ was obtained by the HINT-code[1], where R_{ax} represents the position of the magnetic axis. This equilibrium is weakly unstable in the sense of Mercier criterion according to a previous study by Ichiguchi et al.[2]

Contour plots of the pressure on horizontally- and vertically-elongated poloidal sections obtained by the simulation with the conductivity $\kappa = 1 \times 10^{-6}$, the resistivity $\eta = 3.16 \times 10^{-5}$ and the viscosity $\nu = 2 \times 10^{-3}$ are shown in Fig.1(a) and (b), respectively. The outer side of the torus is in the directions of the black thick arrows. It is observed that oscillations of contour lines are localized in the outer side of the torus. Thus these growth was brought by a kind of ballooning instability. Dependence of the growth rates on the resistivity is investigated in Fig.2. It is observed that the growth rates are proportional to 1/3-power of the resistivity. Thus, the instability which drives the plasma is thought to be the resistive ballooning instability.

Sufficiently long simulations revealed that plasma relaxed to a new equilibrium state after the nonlinear saturation of the resistive ballooning instability. In Fig.3, Poincare plots of the magnetic field lines on the horizontally-elongated poloidal sections in the (a)initial and (b)final ($t = 1700\tau_A$) state of the simulation are shown. It is observed that clear, nested magnetic surfaces are recovered.

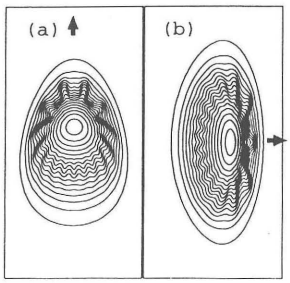

Figure 1: Contour plots of the pressure on (a)horizontally-elongated and (b) vertically-elongated poloidal sections. Thick arrows represent the direction of the outer side the torus.

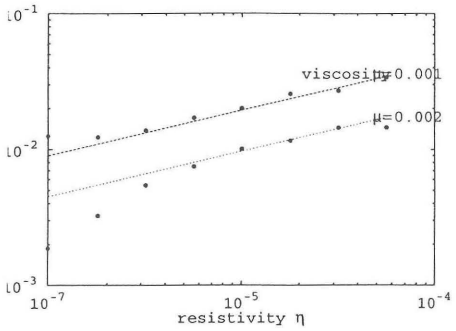

Figure 2: Growth rates of resistive modes.

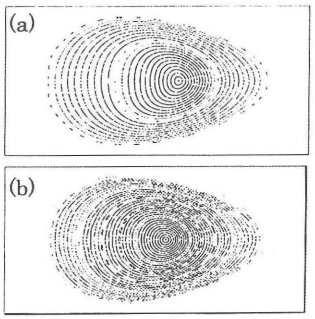

Figure 3: Poincare plots in (a)initial and (b)final state on the horizontally-elongated poloidal section.

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