§1. Nonlinear Simulation of CDC Crash Phase and Comparison with Experiment

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Nonlinear magnetohydrodynamic (MHD) simulations are executed for the purpose of examining the mechanisms of pressure collapse phenomena in the core region of helical systems, such as Large Helical Device (LHD). The time development of MHD system is solved explicitly under realistic initial and boundary conditions by using a three-dimensional finite difference code, MEGA-D. Under a heliotron configuration with higher beta and large pressure gradient, a collapsing scenario of core plasma triggered by resistive ballooning modes appearing in the off-axis region is obtained. The simulation result is comparable to the experimental ones of so-called core density collapse(CDC) in LHD[1)].

The simulation is carried out by solving the nonlinear MHD equations for a compressive and resistive fluid with uniform resistivity and viscosity, starting from a numerical equilibrium obtained by the HINT2 code, which follows the LHD experimental plasma just prior to a CDC event. The pressure profile has a large gradient with the central and volume-averaged beta $\beta_0 = 6.6\%$ and $< \beta >= 1.8\%$.

The simulation result shows the growth of the resistive ballooning instability for larger resistivity. The growth of the modes are saturated soon, and the system experiences the energy relaxation three times in about $500\tau_A$ (< 1 msec). It should be noted that the linear mode structures are localized in the edge region, whereas the core pressure rapidly falls as the system reaches the finally relaxed state. The core pressure is remarkably reduced at a moment when the magnetic field structure is locally disordered at around the foot of the expanding region. It implies that the pressure is flushed out through magnetic reconnection processes.

The simulation result is comparable to the experimental observations of CDC events in LHD. Both show good agreement in :

- the time scale of the crash 1 msec

- not appear for low-beta

- relaxation in multiple steps

- convective process, rather than conductive one

- core crash is triggered by edge instabilities (see Fig. 1)

- related to magnetic reconnection.

On the other hand, a large $m = 1$ activity, where m means the poloidal mode number, is observed just posterior to the core crash only in the experiment. In the simulation result, the core region is destroyed gradually from the edge region. Our previous simulation study for the high-beta spherical tokamak case showed such a large mode activity after the core crash, through a spontaneous reconfiguration with a peaking of profiles. More detailed comparison on that point is our ongoing research, together with the dependence on the magnetic axis shift and the control parameters of the saturation level.

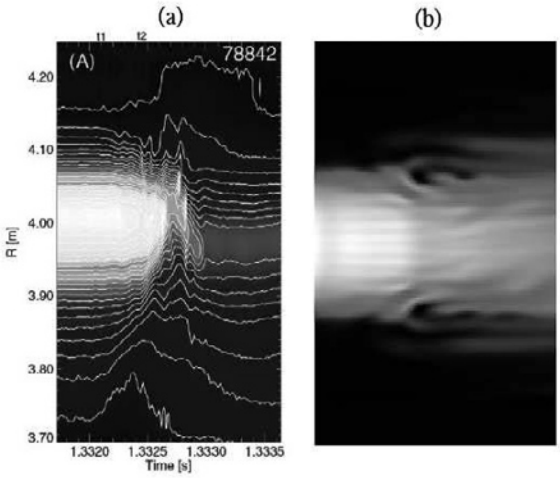

Fig. 1: Time development of radial pressure profile. (a)Experiment (SXR signal referred from Fig.3 in [2].) (b)Simulation.

1) N. Mizugucguchi and K. Ichiguchi, "Nonlinear analysis of MHD collapse phenomena in the core region of helical system", 20th International Toki Conference, Toki, Japan (2010) P2-16.

2) S. Ohdachi et al., "Density Collapse Events Observed in the Large Helical Device", Contrib. Plasma Phys. **50**, 552 (2010).