§7. Nonlinear Analysis on Magnetic Perturbation in Periphery in LHD

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In the recent campaign of the Large Helical Device (LHD) experiments, the coherent magnetic field fluctuation resonating with m/n = 1/1, 2/3, 3/4 is observed in the peripheral magnetic field region outside the last closed magnetic surface[1]. The purpose of the present study is the analysis of these modes based on the MHD simulation in the LHD.

The nonlinear MHD code based on the real coordinate system has been developed to investigate the magnetic fluctuation in the peripheral region. The pseudo-plasma model, in which we assume the high resistivity plasma filled in the vacuum region, is adopted. As a result, the plasma deformation due to the instability can be treated appropriately. In this code, the time evolution of the vector potential instead of the perturbed magnetic field to satisfy div$\boldsymbol{B}$ = 0 condition. In addition, we use the projection scheme for the equilibrium magnetic field to satisfy div$\boldsymbol{B}$ = 0 condition. It is noted that the div$\boldsymbol{B}$ = 0 condition is not guaranteed in the general MHD codes using the real coordinates. As the computational techniques, the 4th order finite difference method, the 4th order Runge-Kutta method and the Rational Constrained Interpolation Profile (R-CIP) method[2] are used. To prevent the numerical oscillation, MmB method[3] is also adopted.

The developed code is applied to the LHD plasma, of which equilibrium is calculated by HINT2 code, with β = 2.4%. For the given initial velocity perturbation, the time evolutions of density, velocity, pressure and magnetic field are calculated. Figure 1 shows the time evolution of the energy. The linear growth and the nonlinear saturation of the perturbation can be seen from Fig. 1.

The perturbed pressure profile on the horizontally elongated poloidal plane at the linear stage (t = 80) is shown in Fig. 2. It can be seen from Fig. 2 that the instability also grows in the region outside the last closed magnetic surface (light blue lines). This implies that the plasma deformation can be appropriately calculated by the developed code.

The construction of Boozer coordinates including the region outside the last closed magnetic surface is required to perform the mode analysis of the instability. The magnetic island structure in the outside region of the last closed magnetic surface is investigated by the field line trace. Based on the obtained magnetic island structure, we attempt to construct Boozer coordinates including the outside region of the last closed magnetic surface. However, the satisfactory results have not been obtained for the time being. The method of evaluating the instability in the outside region of the last closed magnetic surface has to be developed.

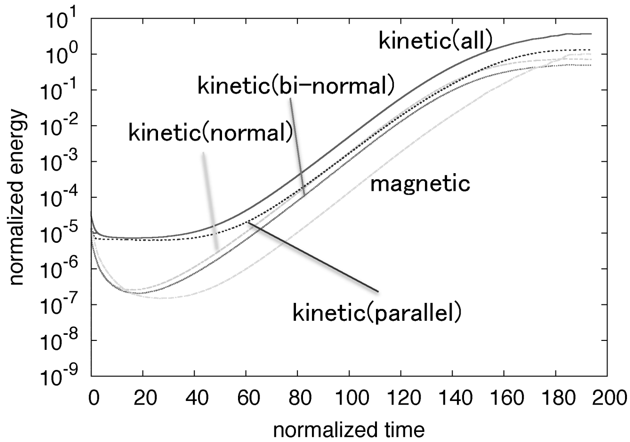

Fig. 1. Time evolution of kinetic and perturbed magnetic energy.

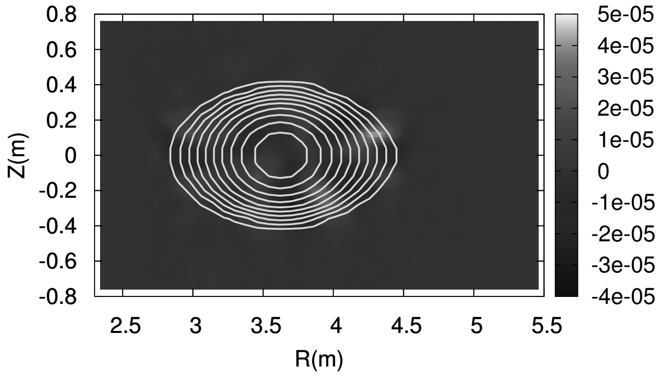

Fig. 2. perturbed pressure profile on the horizontally elongated poloidal plane at the linear stage (t = 80) .

1) Watanabe, K. Y., et al.: Fusion Sci. Technol. **46** (2004) 24.
2) Xiao, F., et al.: Comput. Phys. Commun. **94** (1996) 103.
3) Huamo, W., Shuli, Y.: IMPACT Comput. Sci. Eng. **1** (1989) 217.