§17. MHD Stability Analysis in Peripheral Magnetic Field Region of LHD

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In the recent campaign of the 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 LHD.

The linear MHD code based on the real coordinate system has been developed to investigate the magnetic fluctuation in the peripheral region. In this code, the time evolution of the vector potential instead of the magnetic field itself to satisfy div$\boldsymbol{B}$ = 0 condition. In addition, to describe the plasma-vacuum boundary, "density function" is introduced. The density function is equal to 1 inside the plasma and 0 outside the plasma (in the vacuum region). As the computational techniques, we adopt the 4th order Runge-Kutta method for time, the 4th order finite difference method for space and the Constrained Interpolation Profile (CIP) method[2].

The developed code is applied to LHD. The initial velocity perturbation (n = 1-10) is added in the peripheral region of the equilibrium magnetic field with $\beta_0 = 2\%$. The time evolution of the perturbed magnetic field energy and the growth rate are shown in Figs. 1 and 2, respectively. It can be seen from Figs. 1 and 2 that the magnetic perturbations in peripheral region grow and that the growth rates are comparable with that in the core region.

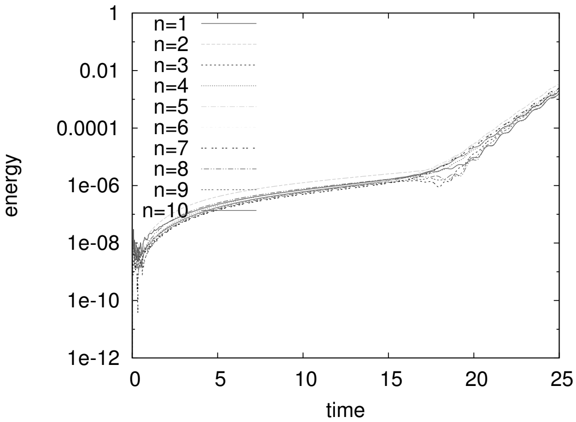

Fig. 1. Time evolution of the perturbed magnetic field energy.

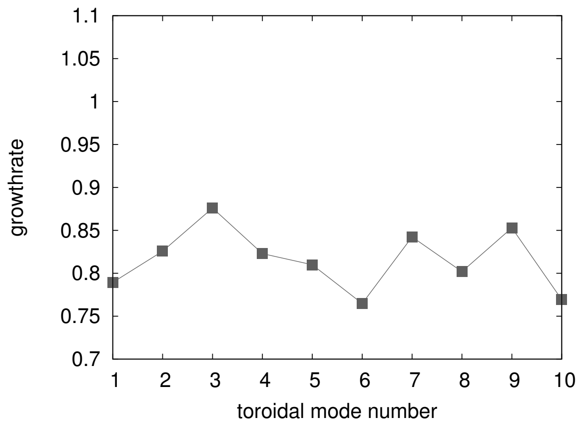

Fig. 2. Growth rate of the magnetic perturbation in the peripheral region.

We have also developed the non-linear MHD code based on the above-mentioned linear code. In this code, the MHD equations are split into two phases. One phase called non-advection phase is solved by the same computational techniques. The rational CIP method[2] is adopted to the other phase called advection phase since the advection phase has strong non-linearity. At present, this non-linear code has been applied to LHD, as is the case of the linear code.

In order to analyze the MHD modes in the peripheral magnetic field region, the magnetic-like coordinate system based on the Boozer coordinates is developed. The quasi-magnetic surface is constructed in the peripheral region by use of the field line tracing and the Radial Basis Function (RBF) expansion method[3]. The obtained quasi-magnetic surface is used as the input parameter of the VMEC code. As a result, the magnetic-like coordinate system can be constructed in the peripheral region. By use of the three-dimensional real coordinates MHD code MIPS (MHD Infrastructure for Plasma Simulation)[4], the MHD instabilities with the low mode numbers have been analyzed.

1) Watanabe, K., *et al.*, Phys. Plasmas, **18**, 056119(2011).
2) Yabe, T., *et al.*, J. Compt. Phys., **169**, 556(2001).
3) Itagaki, M., *et al.*, Plasma Phys. Control. Fusion, **54**, 125003(2012).
4) Todo, Y., *et al.*, Plasma Fusion Res., **5**, S2062(2010).