MFP37

Simulating Magnetohydrodynamic instabilities with Conservative Perturbed MHD Model

J. Ma[1,a)], W. Guo[1,b)], Z. Yu[1]

[1]*Institute of Plasma Physics, Chinese Academy of sciences, Hefei 230031, China*

[a)]*E-mail: junma@ipp.ac.cn*

[b)]*E-mail: wfguo@ipp.ac.cn*

Numerical simulation of magnetohydrodynamics (MHD) system is always an important subject in magnetically confined plasma research. One of the critical challenging issues of simulating laboratory plasma system is the macroscopic instability analysis in complex geometry, e.g. tokamak and stellarator. We derive the perturbed MHD model equations in conservative form, then numerically solve them by using conservative numerical approaches as Discontinuous Galerkin (DG) method [1], and flux vector splitting (FVS) based high order of accuracy finite difference method [2]. Several numerical examples are tested in 2D geometry, such as linear and nonlinear Kelvin-Helmholtz (KH) instability, Coalescence instability, double tearing modes(DTM). The results validated our model and numerical approaches for both small and large perturbations, and show higher resolution and accuracy of our model comparing with original conservative MHD model while perturbations are small. As applications of our model and numerical code, plasmoids formation during nonlinear evolution of 2D DTM with higher Lundquist number(up to 10^5) are numerically studied [2]. We also find that while symmetry is well preserved during the simulation, a new quasi-stationary state with two pairs of islands can form after the explosive stage. For larger distance between rational surfaces two fast reconnections during one evolution can take place.

In our recent work, we extend our numerical capability to 3D Cartesian and cylindrical geometry, aiming for MHD instability simulation in toroidal geometry for tokamaks. A first-step test of 3D cylindrical nonlinear KH instability validates our approaches for ideal MHD model, and then we test a DTM simulation in 3D cylindrical geometry as validation for the resistive MHD model.

References

[1] J. Ma*, W. Guo*, Z. Yu, Comunn. Comput. Phys. 21(5), 1429 (2017).

[2] W. Guo*, J. Ma*, Z. Yu, Phys. Plasmas 24, 032115 (2017).