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極低アスペクト比逆磁場ピンチプラズマにおける
抵抗不安定性の磁気流体解析

Simulation study on resistive instabilities in a small aspect ratio reversed field pinch

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A reversed-field pinch (RFP) plasma is the result of a self-organization process, which is produced by a dynamo effect due to magnetohydrodynamic (MHD) instabilities. In the recent progress of the RFP study, improvement of the confinement properties by the transition to a single-helical-axis state is observed in the large experimental device. Also recent numerical simulations show the possibility of reproducing such single-helical-axis states [1]. As for a low aspect ratio RFP with A≈2, formation and rotation of the helical structure such as quasi-single-hericity states have been observed in experiments [2]. Towards the understanding of this structure formation mechanism, analysis using the detailed three-dimensional MHD simulation through the comparison with the experiment has been conducted [3].

In this study, from an analogy with the spherical tokamak (ST), we focus our attention on the RFP configuration having an elongated cross section with a small aspect ratio A < 2, in other words, spherical RFP. The basic characteristics of the equilibrium configuration and dynamical behavior of resistive instabilities are examined by using the MHD simulation model. Regarding the spherical RFP concept, its characteristic already has been introduced briefly in the first theoritical study on the spherical tokamak [4].

As a numerical simulation model, a simple visco-resistive nonlinear 3D MHD model is used here. This model is successful in qualitatively reproducing the recent experimental findings in the RFP. The negligible-pressure, constatnt-density approximation is assumed in the model, however the full torus geometry is treated to adopt an effect of the aspect ratio correctly in this study. Also for numerical simplicity, the torus with rectangular cross-section is assumed. The finite difference scheme for the (r, z) plane and the pseudo-spectral method for the angular ϕ-direction are applied to the numerical discretization. The Runge-Kutta method is used for the time integration. Preliminary calculations show that the growth of the dominant mode in instabilities can be confirmed.

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