MHD Simulation of Relaxation to a Flipped ST Configuration in Helicity-driven Systems

Y. Kagei, M. Nagata, T. Uyama
Himeji Institute of Technology, Himeji 671-2201, Japan

Y. Suzuki, Y. Kishimoto
Japan Atomic Energy Research Institute, Naka 311-0193, Japan

T. Hayashi
National Institute for Fusion Science, Toki 509-5292, Japan

In order to understand the $n = 1$ relaxation activity in helicity-driven systems comprehensively, the dynamics of low aspect ratio toroidal plasmas has been investigated by Helicity Injected Spherical Torus (HIST) experiments and by one-fluid three-dimensional MHD numerical simulations. In result, it has been found that when the external toroidal magnetic field (TF) is decreased to zero and then increased in the opposite direction, a spherical torus (ST) plasma relaxes to a flipped ST state. According to the helicity-driven relaxation theory, we can confirm the existence of the force-free flipped relaxed state. During the transition from the ST to the flipped ST, not only the paramagnetic toroidal field but also the poloidal field reverses polarity spontaneously. Such self-reversal of these fields suggests the global helicity conservation during relaxation in helicity-driven systems.

In our simulation result, the detailed relaxation dynamics to the flipped ST state is revealed. After the ST plasma collapses because of the growth of the $n = 1$ mode in the open flux region and the following magnetic reconnection event, the flipped ST configuration is self-organized. The force-free parameter $\lambda = \boldsymbol{j} \cdot \boldsymbol{B} / B^2$ is calculated to discuss the origin of the unstable $n = 1$ mode. It shows that the enhanced λ in the open flux region due to the reversal of TF is responsible for the growth of the $n = 1$ mode, which is ensured by the stability analysis in helicity-driven systems. It is concluded that the transition behavior to the flipped ST is consistent with the relaxation of the plasma in open flux region to a low λ state.

- *Subject Area: B2 (Macroscopic equilibrium and stability)*