§3. MHD Simulation of Spheromak Merging

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We have investigated an MHD relaxation process where two spheromaks merge spontaneously. The two spheromaks with the same toroidal current are initially placed in a cylindrical vessel made of perfect conductor. They attract with each other because of the Lorentz force, then, start to merge via the 'driven reconnection'. Two-dimensional computer simulations carried out in the present study have revealed dynamical evolution of the merging process, such as the magnetic energy relaxation due to the driven reconnection, transport of the thermal energy generated at the reconnection point, and formation of the pressure structure (Fig.1).

Following results are obtained in this study:

1. After merging of the two spheromaks, an FRC is realized in the counter-helicity case (where the two spheromaks have anti-parallel magnetic helicity), while a larger spheromak is formed in the co-helicity case (where the spheromaks have the same magnetic helicity). The results are consistent with TS-3 experiments [1] and the previous simulations in the zero-beta limit [2].

2. In the final stage of the 2-D simulations, a force-balanced state (not force-free state) is found both in the counter- and co-helicity cases. The pressure profile after merging coincides with the flux surface.

3. In the merging process, thermal energy is transported from the reconnection point throughout the flux surface which consists of just-reconnected field lines. Poloidal flow generated by the driven reconnection plays a key role in the thermal transport. Namely, the convection and the compression are important in formation of the pressure profile.

4. In the counter-helicity case, the magnetic energy is released intermittently, when the viscosity and the resistivity are sufficiently small. This is because the driven reconnection occurs intermittently due to the finite pressure effect.

A steep pressure gradient which is naturally formed in the current layer prevents the plasma flow toward the reconnection point. Hence, the reconnection rate is decreased. After flattening of the pressure gradient due to the thermal transport, the reconnection rate is increased, then, the intermittent energy relaxation occurs.

5. As a result of the driven reconnection, intense toroidal flow is generated in the counter-helicity case. We also found that the toroidal flow caused reversal of the toroidal magnetic field as was pointed out by the TS-3 experiments [1].

Fig.1 Contours of poloidal flux (top) and pressure (bottom) at different time steps for merging of two spheromaks with anti-parallel helicity (counter-helicity case).

References