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Particle-In-Cellシミュレーションを用いた異極性Spheromak合体の数値計算
Numerical Analysis of Counter-Helicity Spheromak Merging with Particle-In-Cell Simulation

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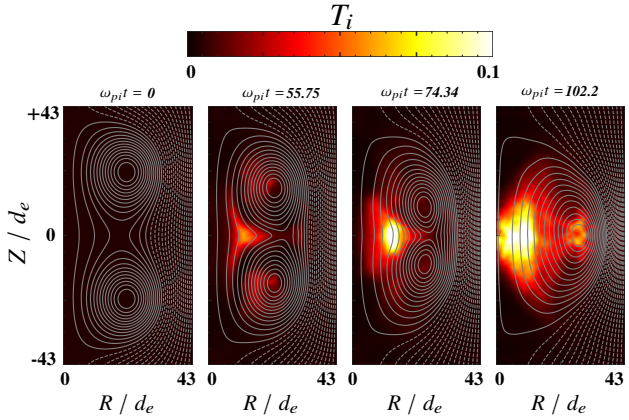
Field-reversed configuration (FRC) is an attractive configuration because of its high-β and compactness. High-β is an important factor for economical fusion reactor, and the simply-connected structure of an FRC enables to make a simple fusion reactor[1]. The Counter-Helicity Spheromak Merging (CHSM) is one of the formation techniques of FRC, and it has an advantage that it can easily generate a large-flux FRC, compared with Field- Reversed Theta Pinch (FRTP) method. Separately formed two spheromaks are collided to cancel oppositely directed toroidal magnetic fields and it relaxes into FRC. During the merging, poloidal and toroidal magnetic fields are dissipated via magnetic reconnection, and magnetic field energy is efficiently converted into kinetic or thermal energy of plasma. Although Energization mechanisms of magnetic reconnection near the X-Line are widely studied using Harris-type initial conditions, it is desired to analyze CHSM with global and cylindrical geometry. We performed two dimensional cylindrical (rz-coordinate) Particle-In-Cell simulation of CHSM in order to clarify where and how particles gain energy.

Due to its density and volume ununiformities in the cylindrical coordinate, the number of super-particles in a cell can become too large or too small to treat the particle distribution function properly. Threfore, we introduced the Adaptive Particle Refinement (APR) to control the number of super-particles in a cell (~130 particles/cell in each species). Two shperomaks (with initial β ~ 10%) are set as an initial condition in the simulation region surrounded by perfect conducting wall boundary condition.

Simulation results show electrostatic potential well are formed in the downstream region and strong electric field exists across the separatrix of the reconnection. Work done by electric field clearly shows that ion gains acceleration when it pass through potential well. As previous Hall-MHD simulation[2] reported the deformation of current sheet and flow-pattern due to the two-fluid effect, it is also found that potential well structure and ion acceleration are greatly affected by the polarity effect of the CHSM. In contrast, electrons can gain its energy near the X-Line region inductively. It is also confirmed that almost thermal and kinetic energy (> 95%) of ions and electrons are well confined inside Last Closed Flux Surface (LCFS) of the FRC. Details of the energization and distribution of thermal / kinetic energy of electrons and ions will be also discussed in the session.



[1] L.C. Steinhauer. *Phys.Plasmas*, 18(7)070501, 2011.
[2] Y.Kaminou et.al., *Phys. Plasmas*, 24(3 032508, 2017.