Numerical Investigation of Reflection Process of FRC

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Many translation experiments of field-reversed configuration (FRC) plasma [1] have been performed intensively to establish the convenient way of separating formation, heating, and burn regions in a fusion reactor design. On the FRC Injection experiment (FIX) machine [2] at Osaka, the FRC translation has been successfully accomplished by empirically adjusting a magnetic guide field in a confinement region. However, it is observed in the first reflection from the downstream magnetic mirror field imposed at the end of the confinement region that the separatrix radius of the FRC expands excessively, and that more energy of the translated FRC is lost in the case where the translation velocity is larger and the magnetic mirror ratio is smaller. Details concerning how such a reflection process of a FRC plasma is performed by interaction with the magnetic mirror field remain unclear. Under this experimental background, the purpose of this study is to investigate the fundamental physics of reflection dynamics of a FRC plasma by means of an axisymmetric numerical simulation. In particular, we will focus our attention to examine the time evolution of the poloidal flux contours and the plasma pressure distribution. For this purpose, we have developed the two-dimensional (r, z) MHD simulation code [3]. In this code, the full set of MHD equations are solved on a rezoned Lagrangian mesh which employs an adaptive algorithm to concentrate the grid in regions of sharp plasma pressure gradients. As the initial value for the simulation, we use a MHD equilibrium configuration such as is typically observed in the FIX experiment. We give an appropriate initial velocity for this equilibrium configuration. It is shown from the simulation results that during the reflection process the FRC still maintains most of its closed magnetic filed configuration even when injected with supersonic velocity into the magnetic mirror region, showing the robustness of the FRC against external perturbations. Also, it is found from time evolution of the average axial velocity on the midplane that the formation of the discontinuous front may be caused by a shock wave when the FRC with supersonic velocity is reflected by the magnetic mirror.

[1] M. Tuszewski, Nucl. Fusion **28**, 2033 (1988).

[2] H. Himura *et al.*, Phys. Plasmas **2**, 191 (1995).

[3] T. Kanki *et al.*, Phys. Plasmas **6**, 4612 (1999).