Cyclic self-reformation of perpendicular shocks in two-dimensional particle-in-cell simulation

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The cyclic self-reformation of perpendicular collisionless shocks was first identified in one-dimensional (1D) kinetic particle-in-cell simulations. In early studies, the reformation was defined as the cyclic accumulation and release of ions. The release ions toward upstream (ion reflection) takes place periodically at the ion gyro period of the downstream, which forms the shock foot region. Later, the cyclic self-reformation of perpendicular shocks was also identified in two-dimensional (2D) full particle-in-cell simulations with a simulation domain shorter than the ion inertial length in the shock tangential direction. However, some of recent 2D full particle-in-cell simulations with a large simulation domain argued against the evidence of the cyclic self-reformation of perpendicular shocks due to rippled structures at the shock front. In the previous studies, the cyclic self-reformation was identified from the cyclic oscillation of the magnetic field at overshoot, since the magnetic field and the ion density are well correlated in 1D simulations and 2D simulations with a small simulation domain. In the present study, we analyze ion particle data obtained from large-scale 2D full particle-in-cell simulations with different ion-to-electron mass ratio, and discuss the effect of the mass ratio to the evidence of the cyclic self-reformation of perpendicular shocks.

Keywords: collisonless shock wave, particle-in-cell simulation

