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Ion Acceleration Mechanisms in the Exhaust Region of Magnetic Reconnection

TAKAMOTO, Makoto[1*] ; FUJIMOTO, Keizo[2]

[1]Max-Planck-Institute for Nuclear Physics, [2]National Astronomical Observatory of Japan

Magnetic reconnection is considered to be a key mechanism to convert magnetic field energy into plasma kinetic and thermal energy in various plasma phenomena, in particular, in many astrophysical systems. In collisional plasma, many works assuming magnetohydrodynamic approximation have revealed that plasma jets can be accelerated up to the upstream Alfven velocity. However, in the case of the collisionless plasma, which is common in many astrophysical phenomena, there is still no conclusive theory of the ion acceleration mechanism and the maximum plasma jet velocity because of the complexities of plasma phenomena and the associated high numerical cost.

In this study, we performed a large-scale 2D particle-in-cell simulations with adaptive mesh refinement under an open boundary condition. The simulation was performed until the MHD condition is well-satisfied in the exhausts,

which allows us to study a long-time dynamical evolution of the structure of the diffusion region and exhausts.

To analyze the detailed mechanisms of the ion acceleration in the exhausts, we also performed test particle simulations on the dynamical background plasma. We found that the ions are accelerated mainly by the electric field perpendicular to the reconnection plane. However, effects from other electric field components are not negligible;

in particular, the contribution from the electric field along the exhausts becomes significant as the ions are accelerated. We also compared the results with the velocity distribution functions inside of the exhausts.

In this talk, we present our numerical results of the particle-in-cell simulation, and discussed its physical interpretations of the structure. We also discuss the ion kinetic mechanisms leading to the formation of reconnection jets.

Keywords: magnetic reconnection, ion acceleration