8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Inflow Crossover and Parallel Outflow during Collisionless Magnetic Reconnection: A Particle-Labelling Particle-In-Cell Study

Theerasarn Pianpanit[1], Piyawat Suetrong[2], Kittipat Malakit[3], Pakkapawn Prapan[4], **Peera Pongkitiwanichakul**[2], Paul Cassak[5], Michael Shay[6], and David Ruffolo[4]
e-mail (speaker): peera.po@ku.th
[1]Department of Applied Radiation and Isotopes, Faculty of Science, Kasetsart University, Thailand
[2]Department of Physics, Faculty of Science, Kasetsart University, Thailand
[3]Department of Physics, Faculty of Science and Technology, Thammasat University, Thailand
[4]Department of Physics, Faculty of Science, Mahidol University, Thailand
[5]Department of Physics and Astronomy, West Virginia University, USA
[6]Department of Physics & Astronomy, University of Delaware, USA

Labeling particles in particle-in-cell simulations by their initial regions, we have revealed that the bulk flow of the plasma at a collisionless magnetic reconnection exhibits a flow-crossover feature, meaning the plasma from an inflow side flows through the midplane to the other side before turning into an outflow, implying that the plasma from an inflow side can affect the physics of reconnection on the other side. In the fluid sense, we can attribute the crossover feature to the generation of parallel flow, which is different for ions and electrons. Ion parallel flow is mostly generated within the ion diffusion region, while electron parallel flow is mostly created outside the electron diffusion region. As a result, the crossover patterns for ions and electrons are different. Importantly, the flow crossover and parallel flow generation is so significant that the reconnection outflow is more parallel rather than perpendicular to the magnetic field. Finally, the flow crossover can be found not only in simple anti-parallel symmetric reconnection but also in complicated guide-field asymmetric reconnection, suggesting that the flow crossover is a general feature in collisionless reconnection.

The left and the right panels of the figure show ions and electrons from simulation region 1 flowing across the current sheet, where the magnetic field changes sign. Ion inflow exhibits a flow crossover directly to the outflow region. The electrons also have a flow crossover, mostly flowing inward along a magnetic field line and then flowing out from the middle along the outflow. All labeled flows contribute to the electric current that influences the physics of magnetic reconnection.

This work was supported by grants RTA5980003 and grant MRG6180176 from the Thailand Research Fund and grant RTA6280002 from Thailand Science Research and Innovation and the Kasetsart University Research and Development Institute (KURDI). This research is partially supported in Thailand by the National Science and Technology Development Agency (NSTDA) and National Research Council (NRCT): High-Potential Research Team Grant Program (N42A650868), and from the NSRF via the Program Management Unit for Human Resources & Institutional Development, Research and Innovation (B39G670013).

References

[1] Zeiler, A., Biskamp, D., Drake, J. F., et al. 2002, Journal of Geophysical Research: Space Physics, 107, SMP 6
[2] Malakit, K., Shay, M. A., Cassak, P. A., & Bard, C. 2010,170 Journal of Geophysical Research: Space Physics, 115.

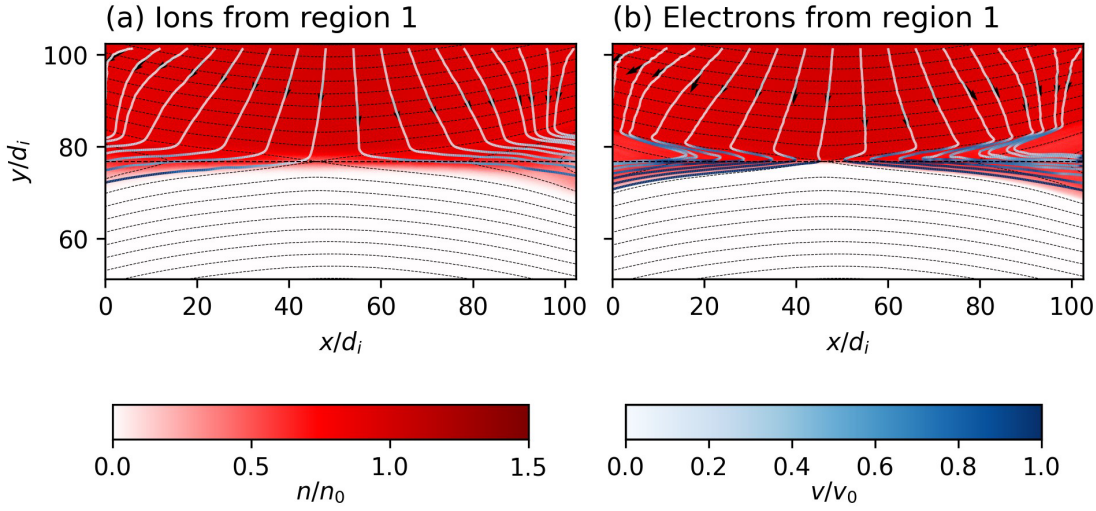

Figure 1. Streamlines of particle flux during symmetric magnetic reconnection overplotted on the magnitude of particle number density flux for particles from the upper upstream region as identified by particle labeling.