Magnetic reconnection with multiple X-lines in a long current sheet: Two-fluid simulations including electron inertial effects

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To understand large-scale development of magnetic reconnection, it is necessary to consider reconnection triggered at multiple X-lines in a long current sheet and associated coalescence process of magnetic islands. While a number of numerical simulations have been performed to study magnetic reconnection at multiple X-lines using a periodic boundary condition, a periodic system restricts the spatial scale of reconnection region and hinders the long time evolution of reconnection region. Thus, in this study, we have performed two-fluid simulations of magnetic reconnection at multiple X-lines in an open system. Here the X-lines are triggered by adding magnetic perturbations in a finite segment of an extended thin current sheet. The distance between each initial X-line is set to be 12D, where D is the half thickness of the current sheet.

When the initial perturbations are of the same amplitude at every X-line, two X-lines at the edges preferentially survive and continue to remain active. This is because only the two edge X-lines can retreat after the reconnection jets collide in magnetic islands. Furthermore, we have confirmed that even when the initial perturbation at the middle X-line is moderately enhanced, the advantage of the edge X-lines mentioned above make them dominate eventually.

Traditionally the single X-line picture has been the model for large-scale reconnection geometry. Here we propose a new model in which large-scale magnetic reconnection involves two X-lines with an expanding magnetic island in between them. These results may, for example, apply to the Earth's tail current sheet, where plasmoids (magnetic islands) are frequently observed.