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Study of interaction of multiple X-lines using two-fluid simulation

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Magnetic reconnection, which converts magnetic energy into kinetic energy of plasma particles, is one of the most important processes in collisionless space plasmas. At the Earth's magnetotail current sheet, for example, a number of in-situ observations have clarified the existence of reconnection. To understand the nature of reconnection, a number of numerical studies have also been performed. Most of these numerical studies, however, have been performed using the single X-line models in which reconnection grows and matures from a single X-line. On the other hand, multiple X-lines models, in which reconnection is first triggered at multiple X-lines in a long and thin current sheet and matures with the coalescence of multiple magnetic islands, have recently been proposed. Since electrons tend to be strongly accelerated in magnetic islands, multiple X-lines model is also attracting attention regarding the electron heating. Most of numerical studies which treat multiple X-lines models, however, have been done using periodic boundary conditions, which prevent the large-scale development of reconnection.

Thus, in this study, we perform two-dimensional two-fluid simulation of multiple X-lines model using open boundary conditions. Using the same settings, it was revealed that two X-lines at the lateral-edges of the perturbed current sheet possess the intrinsic advantage to dominate and to create an inflating magnetic island between them. This study treated only the case in which the initial perturbations at both edge X-lines have the same amplitude. On the basis of this study, we examined more natural case in which both edge X-lines are unbalanced, and found that while inflating magnetic island are also observed between both edge X-lines, stronger edge X-line blows off this island toward weaker edge X-line. Since this blown-off island tends to push away the plasma existing around the weaker X-line against the inflow of the X-line, with the motion of the island the activity of the weaker X-line further weakens and thereby the island is further accelerated. Thus, once the island starts moving, the activity of the weaker X-line weakens at an accelerated rate and is eventually stopped. We also found that the amplitude of the initial unbalance of both edge X-lines and the initial distance between the both X-lines control the time it takes for the activity of the weaker X-line to be stopped.

In our presentation, we will show the results of the parametric study of the amplitude of the initial perturbation at both edge X-lines and initial distance of both edge X-lines, and discuss possible processes of development of reconnection triggered at multiple X-lines on the Earth's magnetotail current sheet.