Interaction of multiple X-lines in an open system: Two fluid simulations with finite electron inertial effects

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Multiple magnetic islands formed via magnetic reconnection at multiple X-lines are known to coalescence to one large island. This result, however, has been obtained in simulations using periodic boundary conditions. To reveal how multiple X-lines interact in an open system, and further to see in what shape via the interaction a matured reconnection region will be, we take a sufficiently large simulation domain and open boundary conditions and investigate the dynamics and the subsequent structure using two-dimensional two fluid simulations including finite electron inertia. X-lines are imposed initially by adding corresponding magnetic field perturbations. For instance, when there are three X-lines in the system and if the initial perturbations are the same at the three X-lines, the two X-lines at the ends grow faster and the X-line in the middle is terminated by a pair of converging flows from both sides. Then the two X-lines stay active while the magnetic island in between expands. The X-line in the middle can dominate eventually only when the initial perturbation is enhanced by a factor of 1.3. When the number of the X-line is increased to five, the two X-lines at the ends dominate until the initial perturbation at the middle X-line is enhanced by a factor of 1.3. These results suggest that, while the single X-line is the standard picture for a matured reconnection region, if the reconnection region is to grow out of a laterally extended thin current in which large number of X-lines forms, there is a good possibility that the matured state of the reconnection region puts on the inflating magnetic island geometry, in which two active X-lines are retreating from each other. Via numerical experimental approach, we have found more variation in the final states of a reconnection region, which will be shown in the paper.