Scaling-law for early-stage development of magnetic reconnection

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A scaling-law for early-stage development of magnetic reconnection has been found from comparing two-dimensional particle simulation results of anti-parallel magnetic reconnection (asymptotic field denoted by B_0) with different current sheet thicknesses (D) and different ion-to-electron mass ratios (M). In these runs, magnetic reconnection is initiated by adding non-zero magnetic field normal to the current sheet. When the reconnected flux (in the B_0 D unit) at various times is plotted versus re-scaled reconnection electric field E_{rx} $D^{1/2}$ (E_{rx} in the V_A B_0 unit, where V_A is the relevant Alfven speed) obtained simultaneously, by which procedure a curve is obtained from each run, the curves obtained from the early development phases (reconnected flux < 2) of various runs are found to overlap among themselves. The spatial structures of some quantities around the X-lines determine the reconnection rates. Sampling the spatial profiles obtained when the same amount of magnetic flux is reconnected from different runs, we confirm that the non-dependence on M and the $D^{1/2}$-scaling of the reconnection rate are consistent with how the spatial scales vary according to M and D.

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