# Influence of Open Boundary Conditions on Kinetic Simulations of Magnetic Reconnection

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In recent years, most kinetic simulations of undriven magnetic reconnection have employed periodic boundary conditions for both the particles and the fields. Although a great deal has been learned from these efforts, the simulations are only physically meaningful for the relatively short period of time before the reconnection jets collide and the island saturates. Although this is also an issue with fluid calculations, the problem is even more severe in full PIC due to the intense electron flows that are generated along the separatrices. These flow velocities can easily exceed the electron thermal speed and are thus rapidly re-circulated through the system along the separatrices and back to the diffusion region. With periodic boundary conditions, it is simply not possible to reach a true steady state, nor is it possible to examine a range of other interesting questions (i.e. structure of the separatrix, shock formation, intermittency, etc).

To address this problem, we have recently developed a set of open boundary conditions to model undriven magnetic reconnection in a large system. The inflow and outflow boundaries are treated symmetrically and are open with respect to particles, magnetic flux and electromagnetic radiation. Particles that reach a boundary are permanently lost, while new particles are injected in a manner to approximately enforce a zero normal derivative condition on the moments up through the full pressure tensor for each species. The field boundary condition allows electromagnetic radiation to leave the system while enforcing a zero normal derivative condition on the magnetic field over longer time scales. On the ion time-scale, these boundary conditions are conceptually similar to the open boundary conditions that have been used previously to study undriven reconnection in MHD[1] and Hall MHD[2] simulations.

This new open boundary model is used to examine the problem of reconnection in a neutral sheet. The structure of the diffusion region and resulting reconnection rates are carefully compared between open and periodic boundary conditions for a range of system sizes.

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[2] Huba, J.D. and L.I. Rudakov, *Phys. Rev. Lett.* **93**, 175003, 2004; Huba, J.D., *Phys. Plasmas* **12**, 012322, 2005