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Achievement of the switch-off condition through Rotational Discontinuity structures in PIC simulations of collisionless magnetic reconnection with guide field

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In Petschek's model for magnetic reconnection, switch-off (SO) condition is achieved through back-to-back slow mode shocks (SS). No rotational discontinuity (RD) is needed, unless in specific cases detailed in [Vasyliunas 1975]. Decades of simulations with different models (MHD, Hall MHD, hybrid, PIC) have yielded contradictory results regarding the achievement of the SO condition during magnetic reconnection events.
It has been recently argued that the formation of Petschek's SO-SS is inhibited by the development of the firehose instability, which provokes the flapping of the magnetic field in the reconnection exhausts (Liu et al., 2012). We report here on the formation of localized switch-off areas in simulations of collisionless magnetic reconnection in extremely large domains (hundreds of ion skin depths) for extremely long times (hundreds of inverse ion cyclotron frequency). A guide field (a magnetic field in the direction perpendicular to the reconnection plane) prevents the development of the firehose instability. The switch-off areas are marked by magnetic field line bending (in a way closely resembling the textbook description of RDs), by the formation of a nozzle-like structure in the in-plane projection of the ion and electron velocities perpendicular to the magnetic field direction and by a reduced rate of plasmoid formation. We use Rankine-Hugoniot conditions to characterize the transitions as Rotational Discontinuities and we comment on their origin.

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