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New insights on the high reconnection rate and diminishment of ion outflow in reconnection

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The recently discovered electron-only reconnection has abnormal features like lack of ion outflows, high reconnection rates, and peaked electric fields near the current sheet center. Using particle-in-cell simulations, we investigate their physical mechanisms. The reconnection rate, when normalized by ion parameters (R_i), may appear anomalously high, whereas that normalized by electron parameters (R_e) remains ~0.1. The essence of high R_i is insufficient field line bending outside the electron diffusion region, indicating an incomplete development of the ion diffusion region. The high R_i may be transient occurring in the electron-only phase of thin current sheets, due to the inconsistent pace between the developments of the reconnection rate and the diffusion region structure; or R_i can be steadily high for small system sizes. The ion outflow diminishes at high β_i when the gyroradius (ρ_i) exceeds the system size, manifesting high-velocity ions that experience random accelerations from different electric fields across ρ_i. We further understand the peak electric field features as indications of the current sheet evolution, and look for supporting evidence in space observations. Our study advances the understanding of the basic reconnection structure and its evolution, providing unified pictures for puzzling reconnection phenomena.

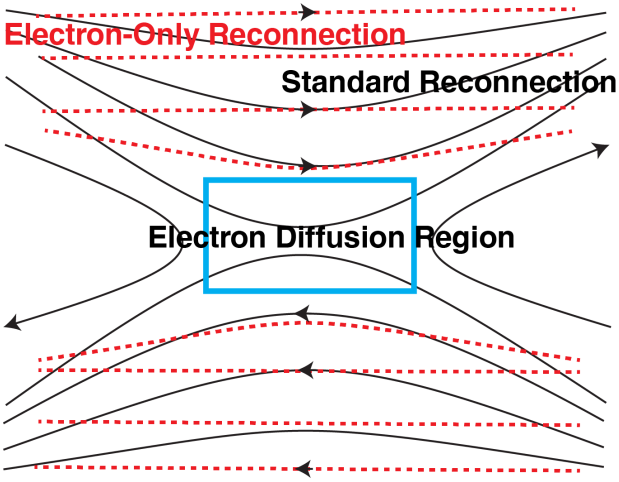

Figure 1. Illustration of magnetic field line structures for the electron-only status of reconnection (red). Compared to standard reconnection (black), field lines outside of the central electron diffusion region are insufficiently bent.