Structure of the Dissipation Region During Collisionless Magnetic Reconnection

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ABSTRACT. Collisionless magnetic reconnection is studied using a 2 1/2-dimensional hybrid code including Hall dynamics and electron inertia. The simulations reveal that the dissipation region develops a two-scale structure: an inner electron region and an outer ion region. Close to the X line is a region with a scale of c/ω_{pe}, the electron collisionless skin depth, where the electron flows completely dominate those of the ions and the frozen-in magnetic flux constraint is broken. Outside of this region and encompassing the rest of the dissipation region, which scales like c/ω_{pi}, the ion inertial length, is the Hall region where the electrons are frozen-in to the magnetic field but the ions are not, allowing the two species to flow at different velocities. The decoupling of electron and ion motion in the dissipation region has important implications for the rate of magnetic reconnection in collisionless plasma: the ions are not constrained to flow through the very narrow region where the frozen-in constraint is broken so that ion flux into the dissipation region is large. For the simulations which have been completed to date, the resulting rate of reconnection is a substantial fraction of the Alfvén velocity and is controlled by the ions, not the electrons. The dynamics of the ions is found to be inhererently nonfluid-like, with multiple ion beams present both at the X line and at the downstream boundary between the inflow and outflow plasma. The reconnection rate is only slightly affected by the temperature of the inflowing ions and in particular the structure of the dissipation region is controlled by the ion inertial length c/ω_{pi} and not the ion Larmor radius based on the incoming ion temperature.