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Bipolar-field electrostatic turbulence during magnetic reconnection

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Bipolar electrostatic field structures parallel to B are often measured by spacecraft during reconnection in the magnetopause and magnetotail. Implicit PIC simulations now show that parallel bipolar structures appear on the reconnection separatrix over a wide range of conditions,
• from reconnection with zero guide field (anti-parallel) to reconnection with guide fields as strong as the reconnecting magnetic field (component)
• over a wide range of mass ratios, including the hydrogen mass ratio
• in reconnection simulations with box sizes ranging from tens of ion inertial lengths to hundreds
For 2-D reconnection with guide-field equal to the reconnecting field and a mass ratio of 256. we show that parallel bipolar structures occur near one "diagonal" of the separatrix and correspond to "holes" in parallel-electron-phase-space, driven non-locally by electron beams at the separatrix. The bipolar fields are on magnetic field lines just inside the separatrix and move towards the x-line when they are a few ion inertial lengths from it, while they move out from the x-line when they are further removed from it. The strength of the bipolar fields is generally greater than the strength of the parallel accelerating field on the same magnetic field line.