Parallel electron and perpendicular ion energisation via lower hybrid and Buneman turbulence in low beta reconnection regions

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Particle energisation to semi-relativistic energies and beyond is widely inferred to occur in magnetic reconnection regions although in situ observations are rare. Reconnection regions are typically expected to have strong parallel currents, spatial gradients, and wave levels. Here two mechanisms for electron and ion energisation via wave-particle interactions in reconnection regions are investigated with numerical simulations. The first involves lower hybrid (LH) waves driven by a drift instability (LHDI) resonantly accelerating electrons parallel to the magnetic field (some perpendicular ion heating is predicted). Simulations and analytic theory suggests that the time scales for electron acceleration to tens of background electron thermal speeds appear plausible for solar and magnetospheric applications. The second mechanism involves parallel current-driven instabilities associated with the reconnection electric field leading to current relaxation and particle energisation. Using linear theory and quasilinear simulations, we show that Buneman-stable electron distributions are unstable to LH waves that then can fully relax the electron distribution and perpendicularly heat ions. We then use PIC simulations to study this mechanism in detail, finding that parallel Buneman and LH waves can be linearly excited with similar simultaneous intensities. The intense LH turbulence has significant observational consequences including substantial parallel electron heating, perpendicular ion accelaration, and density variations (of up to about 10%) on LH scales. The LH waves allow more complete relaxation of the electron distribution than for the Buneman instability alone. We sketch the application of these mechanisms to magnetic reconnection regions with low plasma beta and substantial guide fields in the solar corona and Earth's magnetosphere.