

Kinetic plasma turbulence generated by accelerated particles in 3D current sheets with magnetic islands

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We present simulations of particle acceleration during a magnetic reconnection in 3D current sheet affected by tearing instability using particle-in-cell (PIC) approach. The model utilises a strong guiding field that leads to separation of the particles of opposite charges, generation of a strong polarisation electric field across the RCS and suppression of kink instability in the 'out-of-plane' direction. The accelerated particles of the same charge entering an RCS from the opposite edges are shown accelerated to different energies forming the 'bump-in-tail' velocity distributions that, in turn, can generate plasma turbulence in different locations. The turbulence-generated waves produced by either electron or proton beams can be identified from the energy spectra of electromagnetic field fluctuations in the phase and frequency domains. From the phase space analysis we gather that the kinetic turbulence may be generated by accelerated particle beams, which are later found to evolve into a phase-space hole indicating the beam breakage. This happens at some distance from the particle entrance into an RCS, e.g. about $7d_i$ (ion inertial depth) for the electron beam and $12d_i$ for the proton beam. In a wavenumber space the spectral index of the power spectrum of the turbulent magnetic field near the ion inertial length is found to be -2.7 that is consistent with other estimations. The collective turbulence power spectra are consistent with the high-frequency fluctuations of perpendicular electric field, or upper hybrid waves, to occur in a vicinity of X-nullpoints, where the Langmuir (LW) with high growth rates can be generated by accelerated electrons, while further from X-nullpoints or on the edges of magnetic islands, where electrons become ejected and start moving across the magnetic field lines, Bernstein waves can be generated. The frequency spectra of high and low-frequency waves are explored in the kinetic turbulence in parallel and perpendicular directions to the local magnetic field showing noticeable lower hybrid turbulence occurring between the electron's gyro- and plasma frequencies seen also in the wavelet spectra. Fluctuation of the perpendicular electric field component of turbulence can be consistent with the oblique whistler waves generated on the ambient density fluctuations by intense electron beams