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Kinetic turbulence generated by accelerated particles in a reconnecting current sheet with magnetic islands

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The kinetic turbulence generated by accelerated particles in a reconnecting current sheet (RCS) with X- and O-nullpoints is considered. The simulations of magnetic reconnection using particle-in-cell (PIC) approach is carried out in a thin current sheet with 3D magnetic field topology affected by tearing instability that leads to a formation of two large magnetic islands . 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 generates plasma turbulence in different locations. The turbulence produced by either electron or proton beams is identified from the energy spectra of electromagnetic field fluctuations in the phase and frequency domains.

The spectral index of the power spectrum In a wavenumber space of the turbulent magnetic field near the ion inertial length approaches -2.7. 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, with the Langmuir waves generated by accelerated electrons which can be converted to Bernstein waves when electron beams become moving across the magnetic field lines. 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. The implication of finding for observations is also discussed.