

Alfvén wave interaction with inhomogeneous auroral plasmas

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Investigating the process of particle acceleration in auroral regions, we study the temporal evolution of the interaction of Alfvén waves (AW) with a plasma inhomogeneous in a direction transverse to the static magnetic field. This type of inhomogeneity is typical of the density cavities extended along the magnetic field in auroral acceleration regions. We use self-consistent Particle In Cell (PIC) simulations which are able to reproduce the full nonlinear evolution of the electromagnetic waves as well as the trajectories of ions and electrons in phase space. Physical processes are studied down to the ion Larmor radius and electron skin depth scales. We show that the AW propagation on sharp density gradients leads to the formation of a significant parallel (to the magnetic field) electric field (E-field). It results from an electric charge separation generated on the density gradients by the polarization drift associated with the time varying AW E-field. Its amplitude may reach a few percents of the AW E-field. This parallel component accelerates electrons up to keV energies over distance of a few hundreds Debye lengths, and induces the formation of electron beams. These beams trigger electrostatic plasma instabilities which evolve toward the formation of nonlinear electrostatic structures (identified as electron holes and double layers). For sufficient AW amplitude ions are stochastically accelerated in the perpendicular direction as they experience a non-uniform E-field; in the parallel direction, ions are accelerated in the direction of the E-field. These motions control the erosion/strengthening of the density gradients and, finally, the evolution and stability of the cavity. This study elucidates a possible general scenario to account for the particle acceleration and the wave dissipation in inhomogeneous plasmas. It would consist of successive phases of acceleration along the magnetic field, the development of an electrostatic turbulence, the thermalization and the heating of the plasma.