Geophysical Research Abstracts, Vol. 7, 03511, 2005
SRef-ID: 1607-7962/gra/EGU05-A-03511

Alfvén waves interaction with inhomogeneous plasmas

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We study the evolution of the interaction of Alfvén waves (AW) with a plasma inhomogeneous in a direction perpendicular to the static magnetic field. This kind of inhomogeneity is, for instance, typical of the density cavities extended along the magnetic field in the auroral zone; such cavities bound plasma regions where current and field distributions, AKR emission and particle flux differ. 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). We show that ions are accelerated in the perpendicular direction (heated) as they experience the non-uniform E-field typical of these regions. The distinction between acceleration due to stochastic motion and to the localization of the electric field is presented. Finally this study shows that strongly inhomogeneous plasma regions are ideal locations for wave dissipation and particle heating/acceleration.