Dispersive Alfven Waves in the High Latitude Auroral Zone

R. Rankin[1], J. Y. Liu[1], R. Marchand[1], V. T. Tikhonchuk[2], C. E. Watt[1]

[1]Department of Physics, University of Alberta, Edmonton, Canada T6G 2J1.

[2]Institut de Physique Fondamentale, Universite Bordeaux 1, France.

We describe a model that incorporates nonlinear and dispersive effects in the evolution of field line resonances (FLRs) in Earth's magnetosphere. In this model, the ponderomotive force of shear Alfven waves drives geomagnetic field-aligned density perturbations that steepen the perpendicular Alfven speed gradient. This accelerates the on-set of dispersive effects and leads to self-trapping of FLRs inside density perturbations that evolve as nonlinear acoustic waves with a characteristic timescale. The associated density depletions near the ionosphere significantly enhance parallel electric fields that are necessary to explain auroral acceleration. By including gradients in wave dispersion in our model, we are able to show that FLRs have a natural tendency to focus onto field lines where wave dispersion is initially small (close to zero). On these field lines, very short perpendicular scales are possible, with correspondingly large wave amplitudes that initiate ponderomotive forces and perpendicular profile steepening. The magnetospheric regions where wave dispersion is initially negligible, subsequently evolve nonlinearly into highly structured dispersive Alfven waves with enhanced parallel electric fields. We further demonstrate that the parallel electron dynamics in FLRs must be treated non-locally, and show how this leads to a further enhancement of parallel electric fields that is sufficient to explain the precipitation energies of electrons in FLRs. We conclude by presenting characteristic space and timescales that are useful in analyzing ground and space based observations of FLRs.