Finite Difference Simulation of Magnetospheric EMIC and Whistler mode Waves

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The Earth's magnetosphere hosts a large number of wave modes, which interact with high energy particles of the Van Allen belts. These interactions can lead to pitch-angle scattering of these energetic particles where a portion of the particles would fall into the loss cone lowering the altitude of their mirror point to a level where they are absorbed by the atmosphere. Additionally, particles can be accelerated and lead to wave growth in a nonlinear feedback process.

Two important processes involving energetic electrons are resonant wave-particle interactions driven by electromagnetic ion cyclotron (EMIC) and whistler mode waves. While propagation in the background cold plasma is analytically tractable, resonance interactions make the problem inherently nonlinear requiring numerical modeling. Although in the general case, these waves can propagate at oblique angles to the geomagnetic field, field aligned propagation is associated with the greatest growth rates and minimal wave damping. Accurate modeling of field aligned interactions and the coexistence of multiple waves is thus important. A 1-dimensional fully broadband finite difference numerical simulation has been developed to investigate simultaneous EMIC and whistler mode waves propagation in the magnetosphere. The model is based on fundamental fluid equations for electrons and ions solved simultaneously with Maxwell's equations. Nonlinear feedback can be included via a particle-in-cell or Vlasov module to make the model self-consistent.