Particle-in-cell simulation of enhanced incoherent scatter radar spectrum

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A particle in cell (PIC) approach is presented and utilized to simulate Natural Enhanced Ion Acoustic Line (NEIAL). NEIALs can be found occasionally in incoherent scatter radar (ISR) spectra at high latitudes and have been associated with some types of aurora. An explanation to those enhancements in the ion acoustic line proposes that an electron beam of low energy can destabilize the ion acoustic waves via a two-process mechanism. The first process is started when a beam of electrons interacts with the background plasma which produces an enhancement on a Langmuir wave through the bump on tail instability. The second process starts when the electric field amplitude of the enhanced Langmuir wave overcomes a threshold which produces a decay of the enhanced Langmuir wave in other two waves: an ion acoustic wave and another Langmuir wave. The nonlinear coupling between Langmuir waves and ion-acoustic waves is studied through this fully kinetic simulation as well as the ISR spectrum produced by this unstable plasma. In particular, a two-dimensional simulation is performed of a small, unmagnetized, F region plasma volume bombarded with low energy beams of electrons. Simulated ISR spectra obtained for different beam parameters are presented and the temporal and spatial incoherent scatter spectra signature is discussed in light of these beam parameters. The simulation also allows the direct comparison of a modeled ISR spectrum which includes the beam parameters to simulated ISR spectra to study possible inversion techniques. The simulation results are also used to explain observed NEIALs spectra collected in early 2007 with the Advanced Modular Incoherent Scatter Radar (AMISR).