Investigation of Stimulated Electromagnetic Emission SEE during second electron gyro-harmonic heating

A. Samimi* [(1)], W. A. Scales [(1)], H. Fu [(1)], P. A. Bernhardt [(2)], S. J. Briczinski [(2)], and M. J. McCarrick [(3)]

(1) Bradley Department of Electrical and Computer Engineering, Virginia Tech, Blacksburg, Virginia, USA

(2) Plasma Physics Division, Naval Research Laboratory, Washington D.C., USA

(3) Marsh Creek, LLC, Gakona, Alaska, USA

Features in the Stimulated Electromagnetic Emission (SEE) spectrum during heating near the second electron gyro-harmonic frequency have recently attracted significant attention due to their possible connection to artificial airglow and artificially generated ionization layers. Experimentally, three new phenomenologically related spectral features within 1 kHz of the heater frequency have been recently discovered: 1) discrete narrowband spectral structures ordered by ion gyro-frequency, 2) broadband features with power spectral density maximum near 500 Hz and 3) the broadband features with embedded ion gyro-harmonic structures.

During the summer of 2011 and 2012 extensive experimental investigations were performed at the High Frequency Active Auroral Research Program HAARP facility to systematically investigate these new features. We have measured the threshold transmitter power required to excite the discrete ion gyro-harmonic structures. We have also conducted experiments to investigate the effect of the heater frequency relative to the second electron gyro-harmonic and the transmitter beam angle direction. In this presentation, the results of the experiments are provided.

Furthermore to provide a theoretical foundation for the observations, a parametric decay instability involving decay of upper hybrid/electron Bernstein (UH/EB) waves into another UH/EB wave and the neutralized ion Bernstein (IB) and/or an oblique ion acoustic (IA) waves is considered. The strength of the pump field, the angle of the electric field relative to the geomagnetic field in the interaction region and the frequency offset of the pump wave relative to the second electron gyro-harmonic frequency are the three critical parameters that determine the spectral characteristics observed. Next, the prediction of the analytical model is examined by using a fully kinetic 2.5 dimensional particle-in-cell (PIC) plasma computational model. The computational model provides insight into the nonlinear processes, in particular, associated electron heating along the magnetic field. The correlation of the gyro-harmonic spectral features and electron heating will be discussed in light of the simulation results.