Ion Gyro-harmonic Structuring in the Stimulated Radiation Spectrum during Third Electron Gyro-harmonic Heating

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Recently, there has been significant interest in ion gyro-harmonic structuring the Stimulated Electromagnetic Emission SEE spectrum due to the potential for new diagnostic information available about the heated volume and ancillary processes such as creation of artificial ionization layers. These relatively recently discovered emission lines have almost exclusively been studied for second electron gyro-harmonic heating. The first extensive systematic investigations of the possibility of these spectral features for third electron gyro-harmonic heating are provided here. Objectives include the consideration of the variation of the spectral behavior under pump power, proximity to the gyro-harmonic frequency, and beam angle. Also, the relationship between such spectral features and electron acceleration and creation of plasma irregularities was an important focus.

During experimental campaigns at the High Frequency Active Auroral Program HAARP facility in 2011 and 2012 excitation of IB waves has been observed for the first time for the pump heating of the ionosphere near the third electron cyclotron frequency. Variation of ion gyro-structures with the pump frequency sweeping near the $3f_{ce}$, the angle of pump electric field, and strength of the pump field is studied during the experiment and compared favorably with the theoretical calculations of three-wave parametric decay instabilities involving upper hybrid/electron Bernstein waves and ion Bernstein waves. It is observed that the previously observed SEE downshifted peak DP feature and the newly discovered ion gyro-structures appear simultaneously in the SEE spectra which may show that these two features are produced with the same physical process but at different altitudes. Further relationships between these features and the well known DP feature in SEE will be discussed in light of these recent observations.

Coordinated optical and SEE observations were carried out in order to provide a better understanding of electron acceleration and precipitation processes. Optical emissions were observed with multiple wide- and narrow-field imagers at HAARP during the experiment. Results for correlation between SEE gyro-harmonic features and airglow is provided for pump heating near the second electron gyro-harmonic during the campaign. The observations affirm strong correlation between the gyro-structures and the airglow.