Recent Observations and Modeling of Narrowband Stimulated Electromagnetic Emissions SEEs at HARP

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There has been significant interest in so-called narrowband Stimulated Electromagnetic Emission SEE over the past several years. Narrowband SEE is defined here as spectral features in the SEE spectrum typically within 1 kHz of the transmitter (or pump) frequency. The stimulated emissions are due to nonlinear processes leading to re-radiation at frequencies other than the pump frequency during heating the ionospheric plasma with high power radiowaves. The first observations at the High Frequency Active Auroral Research Program HAARP facility showed discrete narrowband emissions ordered by the primary background ion (O^+) gyro-frequency for heating at the second electron gyro-harmonic. Subsequent systematic observational investigations at HAARP have shown that narrowband SEE exhibits a more richly complex structure including broadband as well as narrowband discrete features ordered by O^+gyro-frequencies . It has also now been discovered that this spectral structuring exists for heating at higher electron gyro-harmonics.

This presentation will first provide a very brief overview summary of the recent experimental observations at HAARP. It will emphasize the newly discovered narrowband SEE features that are related to background ion gyro-harmonic structuring. The relationship to previously observed and related SEE features such as Magnetized Stimulated Brillioun Scatter MSBS will also be discussed. However a principal emphasis here will be on newly discovered gyro-harmonic structuring potentially related to the minority ion (H^+). These new emissions are particularly intriguing for several reasons. The first is due to the expected low density of this minority species in the heated volume. The second is the great potential for interrogating minority species density during heating experiments. First the experimental evidence will be provided for these new H^+ minority gyro-harmonic related features. These tend to be very narrowband (50 Hz or less) and shifted roughly within 100 Hz of the H^+ gyro-frequency. Second, theory of parametric decay instability in a multi-ion component plasma is presented to access the possibility of the observations having relationship to parametric decay of upper hybrid/electron Bernstein modes into appropriate low frequency modes in a multi-ion component plasma. Finally discussions are provided on possibilities for accessing the density ratio of the minority species from the experimentally observed spectra during hearing experiments.