Simultaneous Multi-angle Measurements of Plasma Turbulence at HAARP

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We report the results from a recent series of experiments employing the HAARP HF transmitter to generate and study strong Langmuir turbulence (SLT) in the interaction region of overdense ionospheric plasma. Two three-wave decays processes, the Parametric Decay Instability (PDI) and the Langmuir Decay Instability (LDI), along with the Modulational Instability, which results in cavitation of the ionospheric plasma density are studied by means of corresponding spectral observations. To study these aspects, we produced and measured Strong Langmuir Turbulence (SLT) for a variety of transmitted HAARP parameters including HF pump pointing, Modular UHF Ionospheric Radar (MUIR) UHF diagnostic look anglesand, and HF receivers to record stimulated electromagnetic emissions (SEE). Short pulse, low duty cycle experiments demonstrate control and suppression of artificial field aligned irregularities (AFAI). This allows the isolation of ponderomotive plasma turbulence effects. The versatile capabilities of the Ultra High Frequency (UHF) phased array diagnostic radar called MUIR is exploited to study the spectra simultaneously in different regions of the heated ionosphere. MUIR observed and studied a number of effects of SLT, including cascades of discrete plasma lines, collapse of Langmuir cavities (called cavitons), and outshifted plasma lines (OPL). The observed cascade lines indicates Langmuir waves. The coexistence spectra indicate that Strong Langmuir Turbulence was excited, and the strong OPL are observed as predicted by SLT theory. The ground based SEE observations exhibit frequencies of Ion Acoustic waves (IAW). This study improves upon previous studies of the aspect angle dependence of SLT in the ionosphere employing simultaneous multi-angle observations.