

Quantification of *D*-region Absorption using HF Cross-Modulation

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An HF cross-modulation technique is employed to probe the *D*-region ionosphere during modulated HF heating experiments at the High-frequency Active Auroral Research Program (HAARP) observatory. The presented technique is a modified version of a more typical pulsed HF cross-modulation experiment, based on Fejer's method, in which a low-power pulsed wave probes the *D*-region modulated by a second high-power pulsed wave. During the modulated heating experiments discussed herein, the ionosphere is heated, not with pulsed waves, but with amplitude modulated (AM) waves and continuous waves (CW) at high- and low-power levels.

It has previously been established that careful measurements of the amplitude and phase of pulse cross-modulated signals can be used to quantify the HAARP-modified characteristics of the *D*-region ionosphere (e.g., the modified *D*-region conductivity) using pulsed HF cross-modulation experiments. This new technique applies the same concept, but implements a modified transmission schedule that can be used to quantify the change in absorption and phase of low-power pulsed waves during AM and CW heating experiments. This modulation of *D*-region characteristics can be measured as a function of heating time, which quantifies transient and steady-state behavior with high time resolution – something unattainable using previous pulsed modulation experiments. Comparisons are made between experiment runs performed with different heating power levels, different AM waveforms (i.e. sinusoidal, square wave, and CW), and different AM modulation frequencies. Furthermore, a comparison can be made between the steady-state modified absorption of probing pulses generated by the HAARP HF heating array and the HAARP digisonde. Experiments were performed during HF heating campaigns at HAARP in September 2011 and February 2012.