

Dual-Beam ELF/VLF TOA Measurements as a Function of HF Power

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Dual-beam ELF/VLF wave generation experiments performed at the High-frequency Active Auroral Research Program (HAARP) observatory in Gakona, Alaska are critically compared with the predictions of an ionospheric HF heating model that accounts for the simultaneous propagation and absorption of multiple HF beams. During the May 2012 HAARP campaign, the dual-beam HF heating experiments consisted of two HF beams transmitting simultaneously: one amplitude modulated (AM) HF beam (4.5 MHz, X-mode) modulated the conductivity of the *D*-region ionosphere at ELF/VLF frequencies while a second HF beam broadcast a continuous waveform (CW) signal (3.25 MHz, X-mode), modifying the efficiency of ELF/VLF conductivity modulation and thereby the efficiency of ELF/VLF wave generation. The square-wave AM modulation format consisted of a linear frequency-time ramp between 1 and 6 kHz (with 1 kHz/sec slope), enabling time-of-arrival (TOA) signal processing to be performed. TOA analysis may be used to separate the line-of-sight (LOS) component of the received ELF/VLF signal from the ionospherically-reflected (IR) components. For each frequency-time ramp, the power of the CW beam was increased in 3-dB steps. TOA results were successfully obtained for seven different CW power levels (including CW-OFF) on multiple occasions. For all cases with good signal-to-noise ratio, the received ELF/VLF wave magnitude decreased with increasing CW power, and the TOA of the LOS component increased with increasing CW power. Observations are compared with the results of a dual-beam HF heating model, and general agreement between the experimental observations and theoretical calculations is demonstrated. We interpret these observations as another experimental validation of the dual-beam HF heating model.