Initial Amplitude and Phase Dynamics of VLF triggered Emissions Excited by the HAARP HF Heater

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The High Frequency Active Auroral Research Program (HAARP) HF heating facility in Gakona, Alaska has been used extensively for magnetospheric wave injection to study magnetospheric amplification. ELF/VLF waves in 500 Hz - 5 kHz band are generated by modulation of the overhead ionospheric auroral electrojet currents. Amplified whistler mode echoes have been observed in the conjugate region and also in the northern hemisphere after reflection from the ionospheric boundary in the south. Recent observations allow for accurate determination of the initial amplitude and phase dynamics of 2-hop echoes triggered by ~ 2 kHz pulses. Observed dispersion of simultaneous echoes triggered by frequency-time ramps in the 1-3 kHz band allows for determination of the propagation path and cold plasma parameters using whistler dispersion techniques. The echoes are found to propagate along L ~ 5 and inside the plasmapause boundary with cold electron densities ~ 170 cm^{-3}. The amplitude and phase offset from the transmission of the pulse triggered emissions are analyzed using non-linear theory. Using equations for the electromagnetic wave fields in the presence of a cyclotron resonant current, the temporal behavior of the non-linear resonant current vector is determined. The dynamic of the non-linear current vector is compared for different observed input amplitudes. Since observed phase advance accompanies and outpaces amplitude growth, the non-linear current vector is found to rotate with respect to the circularly polarized wave fields. The observations agree with the concept of an electron phase-space hole created by trapping of particles in the wave potential well as is predicted by numerical models.