Modulation of Auroral Electrojet Currents using Dual HF Beams with ELF Phase Offset, a Potential D-region Diagnostic

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Experiments at the ionospheric heating facility of the High Frequency Active Auroral Research Program (HAARP) involving the generation of extremely low frequency (ELF) and very low frequency (VLF) waves via modulated HF heating of the overhead ionosphere have recently focused on increasing the efficiency and directionality of generated waves. A class of techniques has taken advantage of the relative ELF/VLF phase of induced ionospheric sources to modulate current distributions that resemble horizontal ELF/VLF arrays. In the aforementioned approaches the phase offsets are created either by moving a CW HF beam to different positions in the ionosphere on the timescale of the ELF/VLF modulation period or by tilting an amplitude modulated HF beam off zenith. In both cases, an ELF/VLF phase offset as a function of position results from a delayed arrival of the HF heating flux to a given position. Here we describe a novel set of experiments employing dual AM modulated HF beams with an operator imposed ELF/VLF phase offset. The amplitude of the observed ELF/VLF is strongly dependent on the imposed ELF/VLF phase offset, the modulation waveform, and the orientation of the HF beams. Data from two ground stations are analyzed using simulations of select processes as well as a comprehensive model of the ionospheric ELF/VLF generation. Using two vertical HF beams with ELF phase offset is found to be a potential diagnostic method for the ionospheric D-region. Experiments with offset HF beams show that independent ELF/VLF sources can be induced in the ionospheric region above the heater.