First Demonstration of HF-Driven Ionospheric Currents

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Abstract

Ionospheric heaters located in Polar Regions (EISCAT, HAARP, HIPAS) have been used extensively to generate electromagnetic waves in the ULF/VLF/ELF frequency range and this concept has been referred as the Polar Electrojet (PEJ) antenna. A major problem with the PEJ is its reliance in the presence and strength of the electrojet current. This restricts not only the location of the heater but makes their generation highly unpredictable.

A new concept of using HF heating to generate a virtual antenna in the ionospheric Hall region at ULF/ELF frequencies without relying in the existence of electrojets, was advanced recently by Papdopoulos et al. (2010). The current drive and the creation of a virtual ELF antenna are accomplished in two steps. First, F region heating generates a diamagnetic current with a field aligned magnetic moment. Second, the electric field of the magnetosonic wave radiated by the F region magnetic moment drives a Hall current when it reaches the bottom of the ionosphere. In a fashion similar to the PEJ the HAARP driven virtual antenna excites the Earth-Ionosphere Waveguide (EIW) as well as injects helicon and Shear Alfven (SA) waves upwards into the radiation belts.

The paper presents the first experimental demonstration of the ICD concept using the HAARP facility. Strong signals at frequencies between .5-50 Hz have been detected at sites near HAARP as well as far sites located at Homer and Poker Flat in the absence of electrojet currents. While during electrojet modulation the maximum signal occurs in the vicinity of 2-4 kHz, during ICD the peak fields occur at a frequency of 12 Hz and the maximum frequency is limited to 50 Hz by the slow response time of the F-region ionosphere. During strong ICD generation the 2kHz signal, used as a proxy for the presence of electrojet currents remains below .1 pT, more than 30-40 dB smaller than the 1-10 Hz signals. A comparison of the waveforms between the PEJ and ICD waves generated at 20-40 Hz frequency shows that while the former are characterized by the usual sequence of overshoots due to temperature saturation at .2 msec times and the associated reflection of the signals every .5 msec, these features are completely absent from the ICD waveforms as theoretically expected. A diagrammatic representation that shows the measured signals at 1-50 Hz frequencies normalized to simultaneously measured kHz signals has been used to clearly distinguish ICD from PEJ generated waves. Furthermore, the paper presents the first simultaneous ground and DEMETER satellite measurement of ICD generated shear Alfven waves at frequencies 2-5 Hz.

The paper concludes with suggestions of similar ICD experiments using the Arecibo heater and the advantages of a heater located at deep equatorial latitudes

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