EFFECTS OF DENSITY STRUCTURE ON TRANSIONOSPHERIC HF PROPAGATION

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ABSTRACT

One goal of the ePOP/RRI experiment will be to image ionospheric density structures using transionospheric propagation. In 1978, propagation from a transmitter at Ottawa to the ISIS sounder receivers was investigated at 9.3 MHz. Characteristics of transionospheric propagation were identified in the resulting data. Pulses propagating equatorward occasionally exhibited periodic fades with periodicities around 1 Hz. Two- and three-dimensional ray-tracing has been applied to investigate the features of the observed waves. Fading in a single mode (O or X) is attributed to interference between focused rays. Where O and X mode pulses overlap, Faraday effect explains the observed fade frequencies.

TEXT

The enhanced Polar Outflow Probe (e-POP) is a scientific payload to be launched in late 2007 into an elliptical polar orbit with 80° inclination, 325-km perigee and 1500-km apogee. An overview of the radio-science experiments with e-POP is presented elsewhere at this meeting [1]. One of the scientific objectives of e-POP is to quantify meso-scale plasma processes in the high-latitude ionosphere, through the study of the effects of plasma structures on radio propagation. The suite of eight scientific instruments in the e-POP payload includes a Radio Receiver Instrument (RRI). This receiver will measure the HF electric fields of waves from ground transmitters such as ionosondes, HF radars and ionospheric heaters. One goal will be to image ionospheric density structures with this transionospheric propagation tool.

In 1978, an experiment on transionospheric propagation was carried out at 9.3 MHz using a transmitter on the ground at Ottawa and the sounder receivers of the ISIS-I and ISIS-II spacecraft. A survey of the resulting data has allowed the identification of some reproducible characteristics of transionospheric propagation[2], and has thus helped to prepare the e-POP/RRI mission. A simple square-wave amplitude modulation of the 9.3-MHz carrier was used with a frequency of 180 Hz. Pulses received on waves propagating equatorward from the transmitter were comparatively sharp and occasionally exhibited periodic fades with beat frequencies between about 1 and 4 Hz. Magnetoionic dispersion partially resolved the O- and X-mode pulses through the differences in their group delays. Periodic fades were observed both in the O-only and X-only parts of received pulses (self fades), and in the middle part of the pulses where the O and X parts overlapped (Faraday fades).

Periodic self fades are better explained by focusing of rays than by diffraction. Two- and three-dimensional tracings of transionospheric rays have been used to investigate some of the observed features of the waves received on ISIS. For equatorward rays, propagation directions at the spacecraft come to within about 10° of the axis of the magnetic field **B**. Circular polarization is then expected, providing the necessary condition for a linear total electric field at the spacecraft and hence Faraday fades. F-region structure aligned along **B** focuses or defocuses equatorward rays, and helps to explain the observation that self fades are confined mostly to the equatorward parts of ISIS passes.

REFERENCES

[1] H.G. James, P.A. Bernhardt, R.B. Langley, C.L. Siefring and A.W. Yau , Radio frequency experiments with the Enhanced Polar Outflow Probe satellite payload using its RRI, GAP, and CERTO instruments, Proc. URSI 28th General Assembly, New Delhi, 2005.

[2] H.G. James, Effects on transionospheric HF propagation observed by ISIS at middle and auroral latitudes, Adv. Space Res., in press, DOI: 10.1016/j.asr.2005.03.114, 2005.