TESTS OF THEORY FOR ELECTROMAGNETIC RADIATION FROM SHORT DIPOLES IN SPACE PLASMA

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ABSTRACT

Data from the double OEDIPUS-C (OC) rocket payload have been used to test antenna radiation theory for various electromagnetic wave modes. The experiment geometry imposes ray directions a few degrees away from the axis of the Earth's magnetic field. We report on the fast Z and the whistler modes, corresponding to CMA regions 4 and 8, respectively. Both regions have only one cold-plasma mode, which simplifies tests of theory. These two modes have the additional feature of refractive-index surfaces with points of inflection. The electric fields predicted by a short-dipole theory are generally in good agreement with the OC observations.

TEXT

In the OC experiment, waves were emitted from a double-V dipole on a transmitting subpayload and received at a distance of about 1200 m on a similar dipole connected to a synchronized receiver. Radiation theory was tested in the frequency range 0.025 – 8. MHz, which corresponds to various wave modes, since a considerable range of values of f_c, the electron gyrofrequency, and f_p, the plasma frequency, were observed. The dipole data come from about 400 frequency sweeps recorded during the flight down leg in the auroral night-side ionosphere.

We consider wave-vector directions close to the axis of the Earth's magnetic field vector. Two modes recently examined are the left-hand polarized Z mode at wave frequencies f in $max\{f_c, f_Z\} < f < f_p$ and the right-hand polarized whistler mode in $f_{lh} < f < min\{f_Z, f_c, f_p\}$, corresponding to CMA regions 4 and 8, respectively. Here, f_Z is the Z-mode cutoff frequency $f_Z = (-f_c + (f_c^2 + 4f_p^2)^{1/2})/2$, and f_{lh} is the lower-hybrid-resonance frequency. Both of the CMA regions have only one cold-plasma propagating mode and thereby offer the advantage of simpler tests of theory. These two modes have refractive-index surfaces with points of inflection, meaning that, at a given frequency, there can be up to three different wave-vectors that correspond to a desired ray direction

The Z-mode transmitted signals are strong compared with those in neighboring modes. This is attributed to the inductive nature of the dipole impedance. An analysis of absolute strengths showed that observations are in good agreement with the predictions of the EM radiation theory [1].

The magnitudes of transmitted whistler-mode signals predicted by the same theory for short dipoles have also been found to be in good agreement with observations [2]. The agreement is very good in the top two thirds of the frequency range where $f > f_c/2$ and the dispersion relation plus geometry provide only one saddle-point solution with the required ray direction. In this part of the parameter space studied, the transmitter-receiver separation is at least 10 wavelengths.

This condition does not hold at the lowest frequencies, where the computed strengths disagree with the observations. The effects of interference of multiple saddle-point rays, one of which is close to the oblique resonance cone, are also expected to complicate the analysis. This relates to previous reports from OC of strong transmission of 25-kHz waves propagating along the lower oblique resonance cone. A new formal approach to the calculation of the effective length of a receiving dipole, invoking the reciprocity principle, can explain the unexpectedly high received amplitudes[3].

REFERENCES

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