Quasi-Electrostatic Z-Mode Propagation Observed in the Two-Point OEDIPUS-C Experiment

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The OEDIPUS-C rocket double-payload experiment was carried out in the auroral night-side ionosphere. 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. Z-mode waves were observed at frequencies f in $max\{f_c, f_p\} < f < f_{uh}$, where f_c is the electron gyrofrequency, f_p the plasma frequency, and f_{uh} the upper-hybrid-resonance frequency. The separation vector between the transmitter and receiver lay along a direction at about 5° from the axis of the Earth's magnetic field **B**. In addition to ordinary (O) mode pulses with group speeds close to c, strong, highly dispersed Z-mode waves were transmitted at frequencies just below f_{uh}. These measurements are related to similar observations of strong, highly delayed echoes seen on the ISIS sounders at the same frequencies. An investigation of the quasi-electrostatic Z mode propagation has been carried out using solutions of the complete electromagnetic hot-plasma dispersion. It is found theoretically that there are no solutions at the working frequency with the observed group delays and group directions. So the original assumption of rectilinear propagation from an emitting dipole has been discarded.

A explanation based on incoherent radiation from sounder-accelerated electrons (SAE) has been investigated. Previously published reports [James et al., *Phys. Plasmas, 6(10)*, 4058, 1999; Huang et al., *J. Geophys. Res., 106(A2),* 1835, 2001] show that the transmitting dipole produces strong SAE at energies from 10 eV up to 10 keV when the transmitting frequency sweeps through the above mentioned frequency range. This model supposes that a field-aligned tube centered on the transmitter confines SAE moving helically downward in the general direction of the receiver. At every instant, each SAE particle creates radiation that obeys the resonance condition $f - mf_c = (nf/c)\cos\theta\, V\cos\alpha$, where m is an integer, n is the Z-mode refractive index, θ is the angle between the direction of propagation of the radiation and **B**, V is the electron speed and α its pitch angle. Using the reported SAE energies, it is found that the time delays like those observed can be explained with Z-mode n and θ values, for m = 0, 1or 2. The resonance condition and dispersion relation together require θ values near the upper-oblique resonance cone. Incoherent radiation theory [e.g. McKenzie, *Phys. Fluids, 10(12)*, 2680, 1967] is used to compute the theoretical radiation level created by the SAE flux, for comparison with the observed levels.