Electron Densities Inferred from Plasma Wave Spectra Obtained by the Van Allen Probes EMFISIS Waves Instrument

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The twin Van Allen Probes spacecraft, launched in August 2012, carry identical scientific payloads. The Electric and Magnetic Fields Instrument Suite and Integrated Science (EMFISIS) includes a plasma wave instrument (Waves) that measures three magnetic and three electric components of plasma waves in the frequency range of 10 Hz to 12 kHz using triaxial search coils and the Electric Fields and Waves (EFW) triaxial electric field sensors. The Waves instrument also measures a single electric field component of waves in the frequency range of 10 to 500 kHz. A primary objective of the higher frequency measurements is the determination of the electron density n_e at the spacecraft, primarily inferred from the upper hybrid resonance frequency $f_{uh}^2 = f_{ce}^2 + f_{pe}^2$ where f_{ce} and f_{pe} are the electron cyclotron and electron plasma frequencies, respectively. The Van Allen Probes orbits are inclined to the geographic equator by about 10 degrees and the apoapses are near 5.8 R_E. The density profiles observed fall under two broad categories. First, on many orbits, the spacecraft do not leave the plasmasphere and the electron density remains relatively high throughout the orbit. Second, the spacecraft leave the plasmasphere during the apoapsis portion of the orbit. This typically occurs during active times when the plasmapause is pushed into smaller L shells.

Considerable work has gone into developing a process for identifying and digitizing the upper hybrid resonance frequency in order to infer the electron density as an essential parameter for interpreting not only the plasma wave data from the mission, but as input to various magnetospheric models. Good progress has been made in developing algorithms to identify f_{uh} and create a data set of electron densities. However, even using the EFW potential data as a guide, it is often difficult to interpret the plasma wave spectrum during active times to identify f_{uh} and accurately determine n_e. In some cases there is not a clear signature of the upper hybrid band and the low-frequency cutoff of the continuum radiation is used. In this case, it is assumed that the continuum is at least partially propagating in the ordinary mode and the cutoff is at f_{pe}. This cutoff, however, may not be local to the spacecraft, hence, this can only be used to determine an upper limit to the electron density. In other cases, the spectrum can be confused by multiple bands at $(n + ½)f_{ce}$ (Bernstein modes), f_q resonances, or harmonics related to clipping of strong signals in the Waves instrument. We describe the expected accuracy of n_e and issues in the interpretation of the electrostatic wave spectrum.