DIAGNOSTICS OF THE PLASMASPHERE AND PLASMAPAUSE USING ULF WAVES

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Ultra-low frequency (ULF; f~1-100 mHz) plasma waves distribute energy of solar wind origin throughout the Earth's magnetosphere and down to the ground, where they are recorded as pulsations of the geomagnetic field. The waves propagate through the magnetosphere in the fast magnetosonic mode and may couple to shear transverse mode field line eigenoscillations. The frequency of these field line resonances (FLRs) is determined by the field geometry and the plasma mass density near the equatorial plane. The FLRs occur during the local daytime and can often be observed for several hours. Ground-based measurements of the resonant frequency can therefore provide information on the plasma mass density near the field line apex in the dayside magnetosphere. An array of latitudinally-separated ground magnetometers allows the plasma density profile to be monitored throughout the magnetosphere. This may be compared with ground-based VLF electron density measurements, and satellite-borne particle and imager observations.

The average properties of the magnetospheric plasma are well established. However, case studies demonstrate that the magnetosphere exhibits density features that have only been partially described and which are far from understood. Regions of particular interest are in the vicinity of the plasmapause, where complex structures and temporal variations are frequently observed, and the outer plasmasphere, where small-scale density perturbations may occur. These regions may be examined by ULF FLR techniques on a time scale of 30-60 min and a spatial resolution in the range 0.15-0.4 R_E.

We describe two separate studies of the magnetospheric plasma using FLRs, and compare the observed mass densities with VLF and in situ measurements. The first study examined two months of data from the IMAGE and SAMNET magnetometer arrays, spanning $2.5<L<15$. The resonant frequency was measured between 29 stations using cross-phase and related techniques, and the mass density was then determined on the assumption that the density varies with altitude as R^{-p}, where p is typically 3-4. We present illustrative examples of the plasmapause profile for the following cases: (1). Quiet conditions, when only a vestigal plasmapause is present; (2). Several days after a moderate magnetic disturbance; (3) Disturbed conditions; and (4). Cases when there are sudden changes in solar wind pressure. In addition to observing the erosion and refilling of the plasmasphere, we can detect small localized depletions and enhancements, and monitor the effect of heavy ion contributions.

The second study presents results from a unique experiment that monitors plasma conditions along an L=2.5 flux tube. This uses (a) closely-spaced ground magnetometers to record the field line resonance frequency and hence provide mass density information, (b) co-located VLF receivers that simultaneously monitor the electron density, (c) RPI and EUV data from the IMAGE spacecraft, providing in situ electron and helium density information, and (d) mathematical modelling of the constituent densities and temperatures for this flux tube. These measurements provide the first intercalibration of different ground-based and in situ techniques and lend new insight on plasma dynamics within the plasmasphere. We present examples illustrating the diurnal variation in heavy ion and electron density under moderately disturbed conditions.