Overestimation of Plasma Mass Density in the Plasmasphere due to Quarter-Wave Mode Oscillations

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Measurements of the eigenfrequency of geomagnetic field lines can provide information on the plasma mass density near the equatorial plane of the magnetosphere. Data from an extended meridional array of ground magnetometers therefore allows the radial density distribution, and its temporal variation, to be remotely monitored. Many authors have used these measurements and reported spatial-temporal variations of the plasma mass density in both quiet and disturbed conditions.

To our knowledge, all previous studies have assumed half-wave modes to infer plasma mass density from field line eigenfrequencies. However, the mode structure and hence field line eigenfrequency also depends on the ionospheric conductance. Allan and Knox [1979] showed that when the ionospheric Pedersen conductance is strongly asymmetric between both ends of the field line, quarter-wave mode standing oscillations may be produced, with longer periods at a given L-value compared with the more usual half-wave mode. If some quarter-wave mode events were detected and mistaken for half-wave mode events than the inferred mass density would be over-estimated.

We have used a simulation model and found that quarter-wave modes can be produced under realistic conditions, and then be detected by cross-phase analysis, which is commonly used to detect the eigenfrequency from geomagnetic data. We further examined the diurnal variation of the local field line eigenfrequency using cross-phase analysis of ground magnetometer array data. On several days the eigenfrequency was remarkably low near the dawn terminator, when one end of the field line was in a dark ionosphere and the other end in a sunlit ionosphere. Later in the morning the eigenfrequency gradually increased to the normal daytime value. Our results therefore suggest that quarter-wave mode waves are generated when the ionospheric conductivities are asymmetric, reverting to a half-wave mode as the dawn terminator passes both conjugate points.

In this paper, we will discuss the probability of over-estimation of mass density due to quarter-wave mode oscillations.