Modeling of cavity modes and field line resonances in the inner magnetosphere

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Ultra-low-frequency (ULF) waves are a major means to transport energy through the magnetosphere and play an important role in energization and transport of radiation belt particles. In the inhomogeneous inner magnetosphere, ULF waves frequently are affected by the density structure of the magnetosphere as well as by the ionospheric boundary conditions. We have developed a three-dimensional numerical code in dipole geometry to describe the propagation of ULF waves in the inner magnetosphere. In particular, we model the response of the inner magnetosphere to impulsive compressions that occur on the dayside due to shocks impinging on the magnetosphere and on the nightside due to dipolarization fronts during substorms. These compressions can lead to the development of plasmaspheric cavity modes in the inner magnetosphere that have periods of 1-2 minutes. Furthermore, compressional waves can mode convert to shear Alfvén mode field line resonances that stand on field lines when the compressions contain wave power at the frequency corresponding to harmonics of the fundamental wave period. A special case of field line resonances occurs near the terminator during solstice conditions when one end of the field line is sunlit while the other end is in darkness. Under these circumstances, quarter-wave modes can result in which one end of the field line is a node of the electric field while the other end is an antinode. The model results compare favorably with observations from the Van Allen Probe satellites as well as fields measured by ground magnetometers.

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