Modeling of Ultra-Low-Frequency Waves in Earth's Magnetoshere

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Ultra-Low-Frequency (ULF) waves, defined here to be waves with periods of 0.2 to 600 seconds, are critical in the propagation of energy and momentum throughout the Earth's magnetosphere. These waves can be described in the framework of magnetohydrodynamics (MHD), with the two dominant wave modes being the fast, or magnetosonic, mode that propagates nearly isotropically and the shear Alfvén mode that is guided along the geomagnetic field. The inhomogeneity of the Alfvén speed leads to the coupling of these wave modes as well as the formation of resonant structures such as field line resonances and the so-called ionospheric Alfvén resonator. These waves have been modeled in the inner magnetosphere by means of a finite-difference time-domain model cast in a non-orthogonal dipole coordinate system that follows the structure of the geomagnetic field. This model includes a fully height-resolved inductive ionosphere that provides a realistic inner boundary condition for the model. In addition, this model allows for a direct calculation of magnetic fields observed both in space and on the ground. The model has been applied to a number of features of magnetospheric dynamics, including the so-called Pi2 pulsations that are observed during the onset of magnetospheric substorms, the excitation of waves in the plasmaspheric resonant cavity due to sudden enhancements of the solar wind dynamic pressure, and the differences between daytime and nighttime observations due to the effects of different ionospheric conductivity. One particular focus will be on the excitation of quarter-wave modes that can be excited when one end of a magnetic field line is in daylight while the other end is in darkness.