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Kinetic Simulations of Fast Magnetosonic Wave Excitation in the Radiation Belts

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Fast magnetosonic waves are enhanced waves at frequencies close to the proton cyclotron frequency and its harmonics (up to the lower hybrid frequency) observed near the geomagnetic equator in the terrestrial magnetosphere. They can pitch-angle scatter as well as energize radiation belt electrons. The waves arise from the ion Bernstein instability driven by ring-like proton velocity distributions with a positive slope with respect to the perpendicular velocity. In the present work, particle-in-cell simulations are performed to investigate the excitation and propagation of fast magnetosonic waves in the radiation belts. An observed partial shell velocity distribution of energetic protons is used to excite the waves. The simulations are performed in a dipole background magnetic field, first with an one-dimensional configuration along the radial direction and then extended to a two-dimensional configuration in the equatorial plane (adding the azimuthal dimension). Following the prediction of local linear theory analysis, wave growth occurs at harmonics of the local proton cyclotron frequency. However, in the one dimensional configuration, the excited waves quickly propagate along the radial direction away from the locations where they are unstable. So the overall convective wave growth is much weaker than the case with a uniform background magnetic field. The two-dimensional simulations allow wave propagation in the azimuthal direction along which the background magnetic field strength does not change. The waves, therefore, experience more rapid convective growth in the azimuthal direction. Thus, the waves propagate and grow preferentially in the azimuthal direction compared to the radial direction. The effects of plasmapause on the wave excitation and propagation are also investigated.