Formation of butterfly pitch angle distributions of relativistic electrons in the outer radiation belt due to the drift resonance with a monochromatic Pc5 wave

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Radial transport of relativistic electrons in the inner magnetosphere can be driven by drift resonance with Pc5 Ultra Low Frequency (ULF) waves. The radial transport due to the drift resonance has been considered as one of important acceleration mechanisms of the outer radiation belt electrons. In the course of the radial transport, the energy and equatorial pitch angle of electron change under conservation of the first and second adiabatic invariants. The change in the drift period in the course of radial transport thus depends on the adiabatic process, and it can affect the radial transport rate of the electrons. In other words, the radial transport rate due to the drift resonance depends on the equatorial pitch angle and can form the characteristic pitch angle distributions (PADs). In this study, we investigate the radial transport of relativistic electrons due to the drift resonance with a monochromatic Pc5 wave and focus on formation of PADs of the outer radiation belt electrons.
We use two simulation models of the inner magnetosphere: GEMSIS-Ring Current (RC) and GEMSIS-Radiation Belt (RB). The RC simulation, which is a self-consistent and kinetic numerical simulation code, solves the five-dimensional Boltzmann equation for the ring-current ions coupled with Maxwell equations. The RB simulation calculates trajectories of guiding center of test-particles in arbitrary magnetic and electric field. We used electric and magnetic fields of a monochromatic Pc5 wave in the inner magnetosphere obtained from the RC simulation as background fields in the RB simulations. We traced an order of 10^7 of radiation belt electrons to calculate phase space density of the electrons at each position in the equatorial plane.
Simulation results show formation of characteristic PADs depending on the energy and location (L value), which can be explicable of the pitch angle dependence of resonance conditions. At some fixed location and energy range, the PADs can change from pancake-like to butterfly-like distributions, as the transport by the monochromatic Pc5 wave progresses. These butterfly distributions can be seen when electrons with small (oblique) pitch angles satisfy the resonance condition. It is also found that the small pitch angle electrons can be transported further inward because PA change to larger value through the adiabatic transport enables them to satisfy resonance condition in wider L range compared to the 90-degrees PA electrons.

Keywords: Radiation belt electrons, Drift resonance, Pitch angle distributions

