Dynamics of energetic electrons interacting with sub-packet chorus emissions in the outer radiation belt

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Our preceding study examined the efficient electrons acceleration processes called Relativistic Turning Acceleration (RTA) and Ultra-relativistic Turning Acceleration (URA), and the mechanism how the outer radiation belt is formed. This time, we undertake an update of the chorus wave model used in the preceding simulation in order to reflect the observational data more precisely. By referring to the latest observations by Van Allen Probes (Foster et al. 2017), we update the chorus wave source model excited around the equator whose amplitude was assumed to grow monotonically in the preceding simulation. The new wave model in the current simulation represents the sub-packet structure in its amplitude variation. Sub-packet amplitude structure is such that when the wave amplitude nonlinearly grows to reach the optimum amplitude, it starts decreasing until crossing the threshold. Once it crosses the threshold, the wave dissipates and a new wave arises to repeat the nonlinear growth and damping in the same manner. The multiple occurrence of these wave generation to dissipation processes forms a saw tooth-like amplitude variation called sub-packet. This sub-packet structure is one of the most distinctive features of chorus waves we can find from the observations and hence should be carefully included in the simulation wave model. Due to the rapid variation of amplitude sub-packet structure, however, the wave frequency as a function of amplitude also undergoes a fluctuation in time variation. This fluctuation is assumed to decrease the duration and efficiency of wave-electron resonance and resultant electron acceleration. We examine the electrons acceleration processes including RTA and URA by the sub-packets and analyze the formation mechanism of a highly energized radiation belt. First we insert 36 test particles assigned with different gyro-phases for 3 different initial energy levels: 500keV, 1MeV and 2MeV with the pitch angle of 85 degrees. The simulation results here are compared with those from the preceding study to well understand the acceleration mechanism of individual electrons. Based on this, we next conduct a statistical analysis how these accelerated electrons collectively form the outer radiation belt. We apply the Green’s function method covering a sufficient number of electrons with the initial energies from 10keV to 2MeV and the initial pitch angles from 10 to 90 degrees. By the overall simulations, we reach a conclusion on how in detail the individual electron is sufficiently accelerated by the sub-packet chorus waves, and how the accelerated electrons collectively form the outer radiation belt.

