Substorm Injections as a Source of Relativistic Electrons in Earth’s Outer Radiation Belt

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Earth’s magnetotail plasma sheet plays a crucial role in the variability of Earth’s outer electron radiation belt. Typically, injections of energetic electrons from Earth’s magnetotail into the outer radiation belt and inner magnetosphere during periods of substorm activity are not observed exceeding ~300 keV. Consistent with that, phase space density radial distributions of electrons typically indicate that for electrons below ~300 keV, there is a source of electrons in the plasma sheet while for electrons with energies above that, there is a local source within the outer radiation belt itself. However, here we ask the question: is this always the case or can the plasma sheet provide a direct source of relativistic (> ~500 keV) electrons into Earth’s outer radiation belt via substorm injection? Using phase space density analysis for fixed values of electron first and second adiabatic invariants, we use energetic electron data from NASA’s Van Allen Probes and Magnetospheric Multiscale (MMS) missions during periods in which MMS observed energetic electron injections in the plasma sheet while Van Allen Probes concurrently observed injections into the outer radiation belt. We report on cases that indicate there was a sufficient source of up to >1 MeV electrons in the electron injections in the plasma sheet as observed by MMS, yet Van Allen Probes did not see those energies injected inside of geosynchronous orbit. From global insight with recent test-particle simulations in global, dynamic magnetospheric fields, we offer an explanation for why the highest-energy electrons might not be able to inject into the outer belt even while the lower energy (< ~300 keV) electrons do. Two other intriguing points that we will discuss concerning these results are: i) what acceleration mechanism is capable of producing such abundance of relativistic electrons at such large radial distances (X-GSE < -10 RE) in Earth’s magnetotail? and ii) during what conditions (if any) might injections of relativistic electrons be able to penetrate into the outer belt?
