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An Impenetrable Barrier to Ultra-Relativistic Electrons in the Van Allen Radiation Belt

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Early observations indicated that the Earth's Van Allen belts could be delineated into an inner zone dominated by high energy protons and an outer zone dominated by high energy electrons. Subsequent studies showed that moderate-energy electrons ($E \lesssim 1$ MeV) often populate both zones with a deep "slot" region between them. This two-belt structure was explained as being due to strong electron interactions with plasmaspheric hiss just inside the plasmapause boundary with the inner edge of the outer zone corresponding to the minimum plasmapause location. Recent Van Allen Probes observations have revealed unexpected radiation belt morphology, especially at ultra-relativistic ($E > 5$ MeV) kinetic energies. Here we discuss an exceedingly sharp inner boundary exists for ultra-relativistic electrons. Concurrent data reveal that this barrier for inward electron radial transport is not due to a physical boundary within Earth's intrinsic magnetic field nor is it likely that scattering by human-generated electromagnetic transmitter wave fields would inhibit inward radial diffusion. Rather, we suggest that exceptionally slow natural inward radial diffusion combined with weak, but persistent, wave-particle pitch angle scattering deep inside the Earth's plasmasphere can conspire to create an almost impenetrable barrier through which the most energetic Van Allen belt electrons cannot migrate.