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The "Impenetrable Barrier"Revisited: Bursting the VLF Bubble

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In a recent paper, Baker et al. (Nature, 2014) reported the observation of an "impenetrable barrier"to the inner edge of the ultra-relativistic electron radiation belt. These authors demonstrated that this barrier location was not coincident with the location of the plasmapause nor any other identifiable magnetospheric boundary; nor could it be explained by the scattering of ultra-relativistic electrons into the loss cone by ground-based VLF transmitters. Here we show that the transport and energization timescales depend on gradients in the phase space density and not simply by timescales derived from the magnitude of the radial diffusion coefficient alone. Using these correctly formulated transport timescales, we show how the location of the "impenetrable barrier"can be explained in terms of radial diffusion, including the impacts of dynamical variations in phase space density gradients. Contrary to the suggestion by Baker et al., 2014 there does not appear to be any need for active local wave particle acceleration between the plasmapause and the edge of the barrier at L˜2.8 since the radial diffusion rates appear to be sufficient to transport particles there during the most active times. The "impenetrable barrier"is explained as being the location where phase space density gradient and the diffusion coefficient combine to effectively block further inward ULF wave radial transport. During more active times the timescale for transport around L˜2.8 can be increased allowing penetration of electrons into the slot. However, under typical conditions the activity does not remain high enough for a sufficiently long time to enable electron penetration below L˜2.8. Overall, the "impenetrable barrier"is explained as a simple and natural consequence of the activity-dependent rates of ULF wave diffusive transport and significantly no local acceleration processes are required to explain how the particles reach the inner edge of the "barrier"at L˜2.8.

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