

# Interplanetary Magnetic Field Line Stretching by an expanding Coronal Mass Ejection: Evidence from Sequential Solar Energetic Electron Events in Extremely Low-Density Solar Wind

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Between 15–17 July 2023, ACE observed a sequence of 13 recurring <sup>3</sup>He-rich SEP and solar energetic electron (SEE) events originating from active region AR 13363 during an exceptionally low-density solar wind interval ( $n \sim 0.3 \text{ cm}^{-3}$ , roughly 3.5 below the solar cycle 25 mean). In situ signatures: a monotonic solar wind speed decrease from 425 to 325 km/s, low plasma beta ( $0.03 \lesssim \beta \lesssim 0.3$ ), cold proton temperatures, suppressed IMF variance, and bidirectional suprathermal electron strahl at STEREO-A, together with remote coronagraph observations of a prior eruption from AR 13363 on 15 July, are consistent with sustained passage through the leg of an ICME whose footpoints remain anchored at the recurrent SEP source.

Applying velocity dispersion analysis to the impulsive electron onsets, we find that the inferred path length  $L$  grows systematically from  $\sim 1.2$ – $1.3$  AU in the early events to  $\sim 1.75$  AU in the final event, far larger than can be attributed to the modest slowing of the ambient solar wind. The onset of this growth coincides with the eruption of a narrow, faster CME from the same active region, and the rate of path-length increase tracks the CME's outward propagation. We interpret this as direct evidence that the expanding CME acts as a magnetic obstacle around which the frozen-in IMF drapes and stretches, so that later <sup>3</sup>He-rich injections traverse nearly 0.5 AU of additional field line before reaching 1 AU. These observations offer support for CME-driven field-line stretching as a mechanism modifying SEP transport.