Multi-Mission Observations of Relativistic Electrons and High-Speed Jets Linked to Shock Generated Transients

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What is the science question?

How do energetic electrons get accelerated from upstream to downstream of the quasi-parallel bow shock, and how do upstream transient events modify the downstream magnetosheath plasma during this process?

What were your findings?

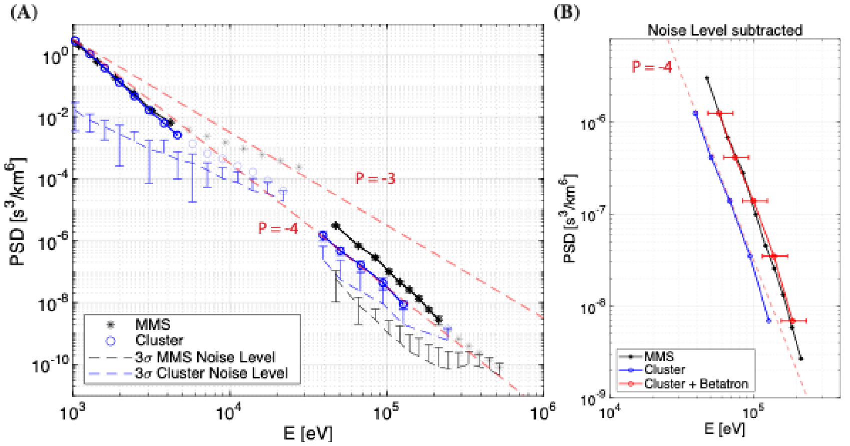
Our study shows that shock-generated transients can pass through Earth's bow shock while retaining their key features. They accelerate electrons to relativistic energies both upstream and downstream, with additional energization via betatron acceleration occurring in compressed regions. Multi-spacecraft data from MMS and Cluster confirm that these energetic electrons remain confined within the transients, sustaining high fluxes. We also found that the compressive edges form high-speed jets with elevated dynamic pressure.

What was the impact?

Our findings offer a new understanding of quasi-parallel shocks as efficient particle accelerators driven by upstream transients. These insights refine planetary magnetospheric models and broadens our understanding of astrophysical shocks. Our work also paves the way for future multi-scale studies and supports upcoming missions.

Why does it matter to non-scientists?

Understanding particle acceleration using in-situ measurements is vital as it is our only way to robustly formulate models and expand our understanding to other planetary and astrophysical system. Furthermore, energetic particles can drive space weather events that can disrupt satellite communications, GPS, and power grids. High-energy particles can affect technologies that millions depend on every day. Improved knowledge of these processes leads to better forecasts and more resilient infrastructure.



***(A)** Electron phase space density versus energy for upstream (Cluster) and downstream (MMS) measurements, with error bars and instrument noise levels indicated. **(B)** A zoomed view of the energetic tail after noise subtraction, comparing observed data with a betatron acceleration model (with energy gain uncertainty shown). Observations are during a shock-generated transient crossing the Earth's planetary bow shock.*

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