

Galactic Cosmic Rays variations not clearly related to heliospheric structures

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Cosmic ray variations

Cosmic rays interact with large-scale interplanetary structures; these structures can cause variations in the intensity of cosmic rays detected at ground-level detectors.

- A. Occurrence of a coronal mass ejection (CME) on Sun.
- B. CME arrives on Earth. Cosmic rays decrease suddenly a *"Forbush Decrease"*.
- C. Another CME on Sun. This one accelerates high-energy particles that reach Earth minutes later. The sudden increase recorded by the neutron monitor is a "Ground-level enhancement."
- D. CME arrives on Earth. Cosmic rays decrease again. This CME produces the most significant geomagnetic storm in years.



John W. Bieber, University of Delaware, Bartol Research Institute.

Forbush Decrease

EJECTA

SUN

SHOCK

 The primary and best-known relationship between cosmic rays observed on our planet and the passage of these interplanetary structures is the Forbush Decrease (FD).

• They are typically classified into two main categories: (I) non-recurrent and (II) recurrent Cane (2000).

 As a result, the intensity of cosmic rays reaching the Earth's atmosphere decreases <u>temporarily</u>. The Forbush decrease can last <u>for a few days to a few</u> weeks, depending on the strength of the CME.



The Forbush decrease occurs when a large eruption of solar material occurs from the Sun, creating a shock wave in the solar wind and a stream of charged particles flowing from the Sun. This shock wave can cause the Earth's magnetic field to become more efficient at blocking cosmic rays from entering the Earth's atmosphere.

Solar wind structures and depressions in the intensity of cosmic rays

Forbush's decrease morphology, amplitude, and duration depends on the type of disturbance that caused the decrease.

 Unlike ICMEs, CIRs / SIRs and mixed events exhibit unique characteristics during the recovery phase of the decrease, including increased fluctuations.

This could indicate different mechanisms involved in cosmic ray modulation by ICMEs and CIRs / SIRs.



The different characteristics of interplanetary magnetic structures, whether ICME- or CIR-induced, result in distinct patterns of GCR suppression.

+ information: Dumbović, M., Vršnak, B., Čalogović, J., and Župan, R.: 2012, Astron. Astrophys. 538, A28.

"Phantom" Decreases



- Occasionally, decreases in cosmic ray intensity occur for which there is no readily associated solar wind structure in near-Earth space, the so-called Phantom Forbush (PFDs).
- STEREO-A (B) can identify large solar wind structures responsible for such structures using heliospheric imagers.

The study of "*Phantom" Decreases* urgently needs to be improved because consistent observational data are required, and isolating these events from more conventional FDs is difficult.

+ information: Thomas, et.al. (2015)



Heliospheric Imagers allow us to observe the region between the Sun and Earth in a manner that was never followed by imaging cameras continuously, allowing us to determine enhancements in density observed by heliospheric imagers that may explain cosmic ray decreases.



Heliospheric Imagers Advantage: we get a global perspective. *In-situ* measurements Disadvantage (Limitation): a tiny scale, we need to catch the global perspective.





NO ICMEs reported on

Jian's Catalog (STEREO-A)

We observe a clear structure near (2008-01-22) in the J-map, but we don't have any signature in in-situ data from STEREO-B.

Interaction between 2 SIRs ??





STEREO-B (in-situ)









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SIRs observations from STEREO-B (February 2008)

800 والأ . ٤ الماليسينان وأ والمحافظ أأأل والمراجب والم $B_{\rm x}({\rm R}) \; [{\rm nT}]$ -10 $B_{y}(T)$ [nT] -10 $B_z(N)$ [nT] ومحقق والقصاف ألرجح وليجزئ ويصوط الأطلا القرا -10 Whe $B_{\rm Total} \left[{\rm nT} \right]$ Feb 2008 Datetime

Instrument: Plastic / Impact, STEREO-B

STEREO-B (in-situ)

To sum it up

- Only the images from HIs observations can identify this structure candidate (a SIR), which is not observed in situ by any other missions.
- Features in the GCR can be closely related to structures in the local solar wind observed by spacecraft observations.
- Give a more global view of the physical mechanism of Forbush Decreases or GCR depressions.

Remote sensing of solar wind structures using STEREO from different angles allows for a more comprehensive analysis of how large-scale solar and interplanetary structures interact and influence cosmic ray propagation.

Thanks for your attention !

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