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The time structure of cosmic-ray ground-level enhancements

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Seventy-one ground-level enhancements (GLEs) in the counting rates of cosmic-ray detectors, due to outbursts of solar energetic particles, have been observed since 1942.
It is well-known that these events are associated with solar flares and coronal mass ejections (CMEs), and that they originate primarily from western longitudes on the surface of the sun. In addition, studies of the time structure of these events generally classify them as "prompt"or "gradual". The spectral shape and anisotropy of these events provide signatures of the acceleration mechanism and the subsequent propagation conditions. McCracken et al., ApJ, 761:101, (2012) described a data base of all these 71 events, including observations of all the detectors that recorded them. These observations are used in this paper to study the time structure of the GLE pulses in greater detail than before. For each event we record the maximum increase, the time-to-maximum, the time to decay to 50% from the maximum, and the longitude of the inferred origin of the event. We then interpret these properties in terms of a simple diffusive model. The results indicate that there is a continuous range of pulses ranging from prompt to gradual, that the most prompt ones come from the latitude range 30 to 60 degrees west solar longitude, that the relationship between rise and decay time of the pulses confirms their diffusive propagation, and that reasonable estimates of the cosmic-ray diffusion mean free path between the sun and earth can be derived from this.
The details of the diffusive model indicate that the injection phase makes up a significant fraction of the duration of the events, and that they cannot be described as simple point-explosions.

Collaboration

– not specified –

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