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The cosmic-ray ground-level enhancements of 29 September 1989 and 20 January 2005

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Ground-level enhancements (GLEs) of the intensity of cosmic rays are an inherent part of large cosmic-ray storms.

The GLE of 29 September 1989 was one of the largest of 71 solar energetic particle events observed by neutron monitors on Earth. It was smaller than the record-breaking GLE 5 of 23 February 1956, but by some measures it was larger than GLE 69 of 20 January 2005. It is also the most extensively studied of the 71 GLEs, and it was observed by more than 50 ground-based detectors in the worldwide network. Moraal and Caballero-Lopez, ApJ., 790:154, 2014 made another study of the event, with the main difference from previous studies that all the existing observations were employed, instead of the usual selection of stations. The main conclusion was that the event is the best example available of a "classical"GLE that has a gradual increase towards peak intensity, and does not contain multiple distinct peaks, as inferred previously.

GLE 69 of 20 January 2005 was studied earlier by McCracken et al., JGR 113, A12101, 2008. This event had entirely different characteristics, showing a very large prompt increase, merging into a much smaller gradual increase later in the event.

In combination, GLEs 42 and 69 can be understood as that in both of them there was a prompt and a gradual acceleration mechanism. The time scales of these mechanisms were a few to several minutes, and several 10s of minutes to one hour, respectively. In GLE 42 the effect of the prompt, initial acceleration was hardly observed at Earth, because the disturbance on the sun and its assumed associated flare were hidden behind the western limb. However, the ensuing CME had a very large angular extent, so that the particles presumably accelerated in its shock envelope were readily detectable at Earth. In the case of GLE 69 the flare site at ˜ 60o W was quite optimally connected to Earth via the Parker spiral magnetic field, so that the promptly accelerated particles were very well visible at Earth, while those that were accelerated by the secondary mechanism remained engulfed below these prompt particles until about an hour into the event.

The two events were so large that they provide the clearest example of this double acceleration hypothesis, this interpretation is not subject to statistical uncertainties, and it can be distinguished from the fluctuations introduced by propagation effects.

The comparison suggests that solar storms contain two acceleration mechanisms, the first, prompt one probably deep in the corona, associated with the solar flare, and the second, gradual one in the envelope of the associated CME.

Collaboration

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