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Solar energetic particle spectrum at the Sun and the Earth

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It is well accepted that high-energy solar energetic particles are accelerated at reconnection regions in a solar flare and coronal shock waves driven by a coronal mass ejection. The coronal shock waves accelerate particles through the first-order Fermi process. The original Fermi acceleration theory predicts a power law particle distribution in momentum with index depending on shock compression ratio. Solar energetic particle spectra have been well investigated and it is found that the observed spectra are represented by almost power law (with high energy rollover). This looks like natural results at first glance. However, the observed spectrum is the spectrum at the observation location not at the acceleration site, and it is not trivial if the observed spectrum is as same as the source spectrum. There are some evidences that typical observed power law index will be about 6 in ground level enhancement (GLE). If the source spectrum of accelerated particle at a coronal shock is assumed to be as same as observed one, a compression ratio of the coronal shock accelerating particles should be about 1.6 according to the Fermi acceleration theory. This shock strength may not be enough to accelerate particles to GeV energy range in a short time. This implies that the spectrum at the source may not be as same as one at the observation location. While a power law spectrum predicted by Fermi process is a steady state solution, a lot of study show that a shock accelerated particle spectrum is time dependent manner. This fact may also imply a different spectrum between at the Sun and at the Earth. In this study, we investigate an energetic particle spectrum difference between at the source region and at the observation location by the interplanetary particle transport simulations.

Keywords: Solar energetic particles, Spectra