Extremely large solar energetic particle events: occurrence probability and characteristics

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The probability of occurrence of extremely large SEP events is determined by both the general properties of the distribution function, and the character of this function in the region of large fluxes (fluences and peak fluxes) of particles. The analysis of experimental data has shown that the distribution function describing a set of events, divided by the sum of Wolf numbers during the measurement of this set, is identical for any period (phase) of solar activity. This means that the probability of occurrence of SEP events for the identical sum of Wolf numbers is the same for any phase (maximum or minimum, ascending or declining) of solar activity.

In any case, the probability of appearance of extremely large events is determined by the form of the distribution function in the region of large events, where the statistical accuracy of experimental data is low, and also by extrapolation of the distribution function beyond the limits of the region of already recorded events. In this case of great significance is the fact, how authentic is the form of the function approximating the experimental data in the region of extreme values of particle fluxes.

The major characteristic of extreme events is their energy spectrum. The most authentic experimental data on fluxes of particles, measured in last decades in wide energy ranges, testify that for energies higher than 30 MeV the energy spectra of fluences and peak fluxes represent the power law functions of rigidity (or impulse) for protons and of a impulse per a nucleon – for heavy ions. This indicates that the energy spectra of extreme events, measured in earlier years and approximated as exponents of rigidity, are, most likely, poorly authentic in the range of high energies (Å $>$ 100 MeV). It is sufficient, that the indices of power law energy spectra in rigidity of protons, both their mean value, and the form of their distribution do not depend either on the solar activity, or on the size of the event.

The laws set forth above form a basis for forecasting both the probability of occurrence of extreme SEP events and the values of fluxes of particles corresponding to them for any period of solar activity.