Solar Energetic Particle Events: Prediction, SOC and turbulence.

S B Gabriel
Astronautics Research Group, University of Southampton, UK,
(email sbg2@soton.ac.uk)

Solar energetic particle events can cause major disruptions to the operation of spacecraft in earth orbit and outside the earth's magnetosphere and have to be considered for EVA and other manned activities. They may also have an effect on radiation doses received by the crew flying in high altitude aircraft over the polar regions.

Little has been done to try to predict these events in real-time with nearly all of the work concentrating on statistical modelling. Currently our understanding of the causes of these events is not good. But what are the prospects for prediction? Can artificial intelligence techniques be used to predict them in the absence of a more complete understanding of the physics involved? The paper briefly reviews the results of neural network prediction techniques and discusses the conjecture that the underlying physical processes might be related to self-organised criticality and turbulent MHD flows.

Intermittent or bursty behaviour of the proton fluxes is very prominent. Even if we cannot predict these events can we learn something about the processes involved in their production from examining certain characteristics of their distributions? Examination of this type of behaviour in other phenomena, such as X-ray flares and laboratory plasmas has concluded that it could be indicative of self-organised criticality (SOC) or perhaps turbulence in the MHD equations describing the plasmas. To further examine the applicability to SEPEs, we derived the distributions for 3 of the characteristics of these events, size (or fluence), waiting times and durations. At high fluences the distribution is well described by a power law, but at lower values seems to flatten out. The waiting times and durations seem to be well described by a Levy function. These analyses suggest that the underlying physical processes involved in the production of SEPEs are close to SOC (fractal) or are indicative of turbulent plasma behaviour (cf. magnetic reconnection, multi-fractal).

If the process is in a state of SOC, one could conclude that the events are not predictable, at least based on time series analysis (rather than using pre-cursors). However, more work is needed in this area to be able to make this very significant and fundamental conclusion. The prospects for a more detailed quantitative analysis, based on the shell model for fluid turbulence, and the possibilities of modelling the tail of the probability distribution function, will also be discussed.