

Origin of Power Law Distributions of Geomagnetic Disturbances

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Several recent papers have reported that various phenomena in space (solar flares, pulsar glitches, etc.) feature probability distributions (PDs) that have a power law form. In this paper, geomagnetic disturbances as quantified by the AL index are examined. We show that the PD of their peak values has a power law form and two possible explanations are considered. One involves processes in the magnetosphere, which may reflect self organized criticality (SOC). The other involves the solar wind which provides energy for geomagnetic disturbances and whose key parameters also feature a PD with a power law form. We conclude that the power law form of the PD of peak values of geomagnetic disturbances is a consequence of processes within the magnetosphere and is not of solar wind origin.

A number of recent papers have reported that the probability distributions of various solar and geophysical disturbances have a power law form. These include the sizes of solar flares, pulsar glitches, earthquakes and solar wind parameters. The scale-free property of disturbances that follow a power law distribution can be considered as a consequence of the relevant system being driven into a state of self-organized criticality (SOC). In this process, systems evolve naturally into a (critical) state with no characteristic length or time scale. In this paper, events are defined as geomagnetic disturbances which exceed a specified threshold in AL (AL being an index of geomagnetic activity). We demonstrate that the probability distribution of the peak values of these events follows a power law form with exponential decay. In the search for why the probability distributions have this form, we consider two possible reasons. The first of these involves magnetospheric processes which may be driven into a state of SOC while the second would involve solar wind processes which provide the energy for the geomagnetic disturbances. We conclude that the power law form of the probability distribution of peak values of geomagnetic disturbances is a consequence of processes within the magnetosphere and is not of solar wind origin.