A statistical study of geomagnetic disturbances in terms of probabilistic nonlinear processes

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The magnetosphere is a nonlinear system, in which energy from the solar wind is being transformed into energy in the ionosphere and the inner magnetosphere. In this presentation, we report the results of a statistical study of the long-term (1978-1994) AL data. It is found that the parameters characterizing the probability distribution show obvious seasonal variations. Using solar wind parameters, probability distributions of solar wind events are derived. The distributions have, similar to those of the AL index, power-law forms with exponential decay. It is contended that the power laws in the probability distributions of the AL events against the duration and the peak value are produced through two different processes.

The magnetosphere is a nonlinear system, in which energy from the solar wind is being transformed into energy in the ionosphere and the inner magnetosphere. Recently, a number of papers have reported that there are various phenomena showing the power-law dependence of their probability distributions against the magnitude of the disturbances. This scale-free (the power-law) property can be considered as a consequence for a system being driven in a state of self-organized criticality (SOC). The SOC system evolves naturally into a critical state with no characteristic length or time scale. In this presentation, geomagnetic disturbance events are defined in terms of a threshold in the AL time series. It is demonstrated that the probability distribution against the magnitude (both for the time of duration and the peak value) follows a power-law form with an exponential decay. This result is consistent with a stochastic model such as the SOC.

To test whether the power-law originates from processes in the magnetosphere or those in the solar wind, seasonal variations of the distributions of certain characteristics of AL are examined. It is found that the parameters characterizing the distribution show obvious seasonal variations, implying that the distribution of geomagnetic disturbances is determined through magnetospheric processes. Using solar wind parameters, probability distributions of solar wind events are derived. The distributions have, similar to those of the AL index, power-law forms with exponential decay. The similarity between these probability distributions indicates a possibility that the power-law forms originate from solar wind processes.

It is contended that the power laws in the probability distributions of the AL events against the duration and the peak value are produced through two different processes. The power laws in the "duration" distributions would result from solar wind conditions. This may be attributed to the directly driven process associated with the magnetospheric convection. The power laws in the "peak-value" distributions, on the other hand, would be produced through intrinsic processes in magnetosphere. This result suggests (1) that there exists a state of SOC in the magnetosphere producing the power law forms, or (2) that the power law forms of geomagnetic disturbances do originate from the solar wind but there must be a system in the magnetosphere controlling the slopes of the power law distributions.