COMPARATIVE STUDY OF DYNAMICAL CRITICAL SCALING IN THE SPACE STORM INDEX VERSUS SOLAR WIND FLUCTUATIONS

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We provide a new example of a natural system exhibiting statistical signatures of complex scaling behavior predicted by the contemporary theory of nonequilibrium phase transitions. We examine statistical properties of bursty multiscale energy dissipation in the inner magnetosphere of Earth based on the dynamics of the SYM-H index, a global marker of low-latitude geomagnetic fluctuations. We show that on average, and for time scales shorter than 2 hours, temporal development of SYM-H bursts follows an algebraic form consistent with the predictions from the theory of nonequilibrium phase transitions. Probability distributions of sizes and lifetimes of the activity bursts reveal no characteristic scales other than the scales imposed by technical limitations of the analysis. This behavior is observed for a wide range of SYM-H burst durations starting from about 5 minutes up to 10-15 days. The power-law exponents describing the probability distributions suggest that the main energy dissipation in the inner magnetosphere takes place due to large activity bursts such as major space storms as opposed to smaller activations whose contribution is less significant despite their much higher relative occurrence. The results obtained provide statistical evidence that the energy dissipation mechanisms associated with magnetospheric activity in the inner magnetosphere are essentially scale-free, displaying dynamical and statistical self-similarity. Our results can also be used for validating existing and future ring current models in terms of their ability to correctly represent the cross-scale coupling effects in this system. They show what could be the first quantitative evidence for the same universality class as directed percolation in a natural system.