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Time series analysis of diverse extreme phenomena: universal features

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The field of study of complex systems holds that the dynamics of complex systems are founded on universal principles that may used to describe a great variety of scientific and technological approaches of different types of natural, artificial, and social systems. We suggest that earthquake, epileptic seizures, solar flares, and magnetic storms dynamics can be analyzed within similar mathematical frameworks. A central property of aforementioned extreme events generation is the occurrence of coherent large-scale collective behavior with very rich structure, resulting from repeated nonlinear interactions among the corresponding constituents. Consequently, we apply the Tsallis nonextensive statistical mechanics as it proves an appropriate framework in order to investigate universal principles of their generation.

First, we examine the data in terms of Tsallis entropy aiming to discover common "pathological" symptoms of transition to a significant shock. By monitoring the temporal evolution of the degree of organization in time series we observe similar distinctive features revealing significant reduction of complexity during their emergence.

Second, a model for earthquake dynamics coming from a nonextensive Tsallis formalism, starting from first principles, has been recently introduced. This approach leads to an energy distribution function (Gutenberg–Richter type law) for the magnitude distribution of earthquakes, providing an excellent fit to seismicities generated in various large geographic areas usually identified as seismic regions. We show that this function is able to describe the energy distribution (with similar non-extensive q-parameter) of solar flares, magnetic storms, epileptic and earthquake shocks.

The above mentioned evidence of a universal statistical behavior suggests the possibility of a common approach for studying space weather, earthquakes and epileptic seizures.