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Generic Multifractality in Exponentials of Long Memory Processes: a mechanism for extreme events based on long-range correlations with applications to finance, material rupture and earthquakes.

Parisi and Frisch [1985] and Halsey et al.[1986] have introduced the extended concept of scale invariance, called multifractality, motivated by hydrodynamic turbulence and fractal growth processes respectively. Use of the multifractal spectrum as a metric to characterize complex systems is now routinely used in many fields to describe hierarchical structures in space and time. However, the origin of multifractality is rarely identified. This is certainly true for earthquakes and rupture for which the possible existence of multifractality is still debated. After a general introduction of the fundamental concepts and their general applications, we will discuss a a physically-based "multifractal stress activation" model of earthquake interaction and triggering based on two simple ingredients: (i) a seismic rupture results from thermally activated processes giving an exponential dependence on the local stress; (ii) the stress relaxation has a long memory. The interplay between these two physical processes are shown to lead to a multifractal organization of seismicity in the shape of a remarkable magnitude-dependence of the exponent p of the Omori law for aftershocks, which we observe quantitatively in real catalogs. The generalization of this research to other systems finds that multifractal scaling is a robust property of a large class of continuous stochastic processes, constructed as exponentials of long-memory processes. The general mechanism for multifractality found here will also be highlighted in finance by asking: are large market events caused by exogenous shocks or can they occur endogenously? We ask this question for large stock market events and conclude that endogenous crashes do exist by testing a remarkable prediction of the MRW (multifractal random walk) model of volatility without adjustable parameters, in which multifractality reveals itself in the time domain rather than in the statistical moments.

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