Record breaking bursts in a discrete element model of compressive failure

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An accurate understanding of the interplay between random and deterministic processes in generating extreme events is of critical importance in many fields, from forecasting extreme meteorological events to the catastrophic failure of materials and in the Earth. Here we investigate the statistics of record-breaking events in the time series of crackling noise generated by local rupture events during the compressive failure of porous materials. Bursts of local breaking events are generated by computer simulations of the uniaxial compression of cylindrical samples in a discrete element model [1,2].

We show that the number of records grows as a decelerating power law of the number of events followed by an acceleration immediately prior to failure. The size of records has a power law distribution with an exponent significantly smaller than the one of the complete burst size distribution. The lifetime of records proved to be also power law distributed with a relatively low exponent [3].

Analyzing the behavior of average quantities of records we show the existence of a characteristic record rank k^* which separates two regimes of the time evolution of the fracture process: the beginning of the failure process is characterized by the slow-down of record breaking due to the effect of disorder. Then record breaking accelerates as macroscopic failure is approached when spatial and temporal correlations dominate [3].

Scaling analysis revealed that the size distribution of records of different ranks has a universal form independent of the record rank. Sub-sequences of bursts enclosed by consecutive records are characterized by a power law size distribution with an exponent which decreases as failure is approached. Our analysis revealed that records have a strong effect on the structure of the surrounding time series: high rank records are preceded by bursts of increasing size and waiting time between consecutive events and they are followed by a relaxation process [3].

In principle the results could be used to improve forecasting of catastrophic failure events, if they can be observed reliably in a single experiment in real time.

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