Statistics of breaking bursts in a fiber bundle model of fat tailed disorder

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ABSTRACT

The fracture of heterogeneous materials proceeds in bursts of local breakings which can be recorded in the form of acoustic noise. Measuring such crackling noise is the primary source of information about the microscopic dynamics of fracture processes. The size of bursts, considering all crackling events up to failure, has been found experimentally to be power law distributed for a broad class of materials, where the value of the exponent exhibits a high degree of robustness with respect to materials features.

Here we investigate how the degree of disorder of materials affects the statistics of bursts using a fiber bundle model (FBM) of heterogeneous materials. In FBMs, materials' disorder can simply be represented by the probability distribution of the strength of single fibers. In our study we consider fat tailed distributions over a finite range, where the amount of disorder can be tuned by varying the upper cutoff of strength values and the power law exponent of the distribution [1,2].

Analytical calculations and computer simulations, performed in the limit of equal load sharing, revealed that the bundle exhibits a transition from brittle to quasi-brittle behaviour [1,2]. In the quasi-brittle phase macroscopic failure is approached through a sequence of bursts of fiber breakings. The size of bursts is found to be power law distributed, however, the value of the exponent depends on the disorder parameters: In the limit of infinite upper cutoff a universal exponent 3/2 is obtained, independent of the disorder exponent, however, for finite upper cutoffs a crossover occurs to a higher exponent 5/2. Analysing the statistics of avalanches we demonstrate that the transition between the quasi-brittle and brittle phases occurs analogously to continuous phase transitions as the disorder exponent is varied.

REFERENCES

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