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Size scaling and bursting activity due to thermally induced cracking

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Sub-critical rupture, occurring under a constant load below the fracture strength of materials, is of fundamental importance in a wide range of physical, biological, and geological systems.
During the last decade major progress has been achieved in the understanding of the role of quenched disorder in the size scaling of materials strength. However, under sub-critical loads, the interplay of annealed disorder (thermal noise) and of the inhomogeneous stress field in the rupture process still remained an open fundamental problem.

We study sub-critical fracture driven by thermally activated crack nucleation in the framework of fiber bundle models. Based on analytic calculations and computer simulations we show that in the presence of stress inhomogeneities, thermally activated cracking results in an anomalous size effect, i.e. newline the average lifetime of the system decreases as a power law of the system size, where the exponent depends on the external load and on the temperature. We propose a modified form of the Arrhenius law which provides a comprehensive description of thermally activated breakdown.

On the microlevel, thermal fluctuations trigger bursts of breakings which proved to have a power law size distribution. We compare analytic results obtained in the mean field limit to the computer simulations of localized load redistribution to reveal the effect of the range of interaction on the time evolution. Focusing on the waiting times between consecutive bursts we show that the time evolution has two distinct forms: at high load values the breaking process continuously accelerates towards macroscopic failure, however, for low loads and high enough temperatures the acceleration is preceded by a slow-down. Analyzing the structural entropy and the location of consecutive bursts we show that in the presence of stress concentration the early acceleration is the consequence of damage localization. The distribution of waiting times has a power law form with an exponent switching between 1 and 2 as the load and temperature are varied.