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Temporal and spatial evolution of crackling bursts in a fiber bundle model

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The fracture of heterogeneous materials proceeds in bursts which can be recorded by acoustic or electromagnetic techniques. Although crackling noise is the major source of information about the microscopic dynamics of fracture, its analysis mainly focuses on the statistics of crackling events considering fracture as a stochastic point-process.

Here we investigate the temporal and spacial evolution of single bursts emerging in heterogeneous materials under a constant external load. Based on a fiber bundle model we demonstrate that the average temporal shape of burst pulses encodes information about the range of load redistribution following failure events: when the load redistribution is localized along a propagating crack front the average temporal shape of pulses has a right handed asymmetry due to the gradual acceleration of bursts. For long range interaction, however, a symmetric shape with parabolic functional form is obtained. The degree of asymmetry is found to depend on the pulse duration revealing a load dependent characteristic time scale of the avalanche dynamics of fracture.

In spite of the compact internal structure, the external frontier of bursts proved to be a fractal with dimension $D_f = 1.25$. Our analysis revealed that the pulse shape and spatial evolution of bursts are correlated which can be exploited in materials' testing.