Statistical Mechanics of Damage

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Motivation

- In order to understand, and ultimately help prevent, catastrophic failure in materials we must understand the failure mode of the material.

The Model

- We base our model on the Olami-Feder-Christensen (OFC) model, a cellular automaton model for earthquake faults. [PRL 68, 8, 1244-1248, 1992]

(1) $\sigma_i \to \sigma_i + \delta \quad \forall \; i$

(2) If $\sigma_i > \sigma^c$

(a) $\sigma_i \to \sigma^r$

(b) $\sigma_{<j>} \to (1-\alpha)\left(\dfrac{\sigma^c - \sigma^r}{q}\right)$

(3) Return to (1)

σ_i is the stress on site i

δ is the stress added by increasing the load

$<j>$ represents a "neighbor" of site i

α is the dissipation parameter

q is the total number of neighbors of site i

Modifications

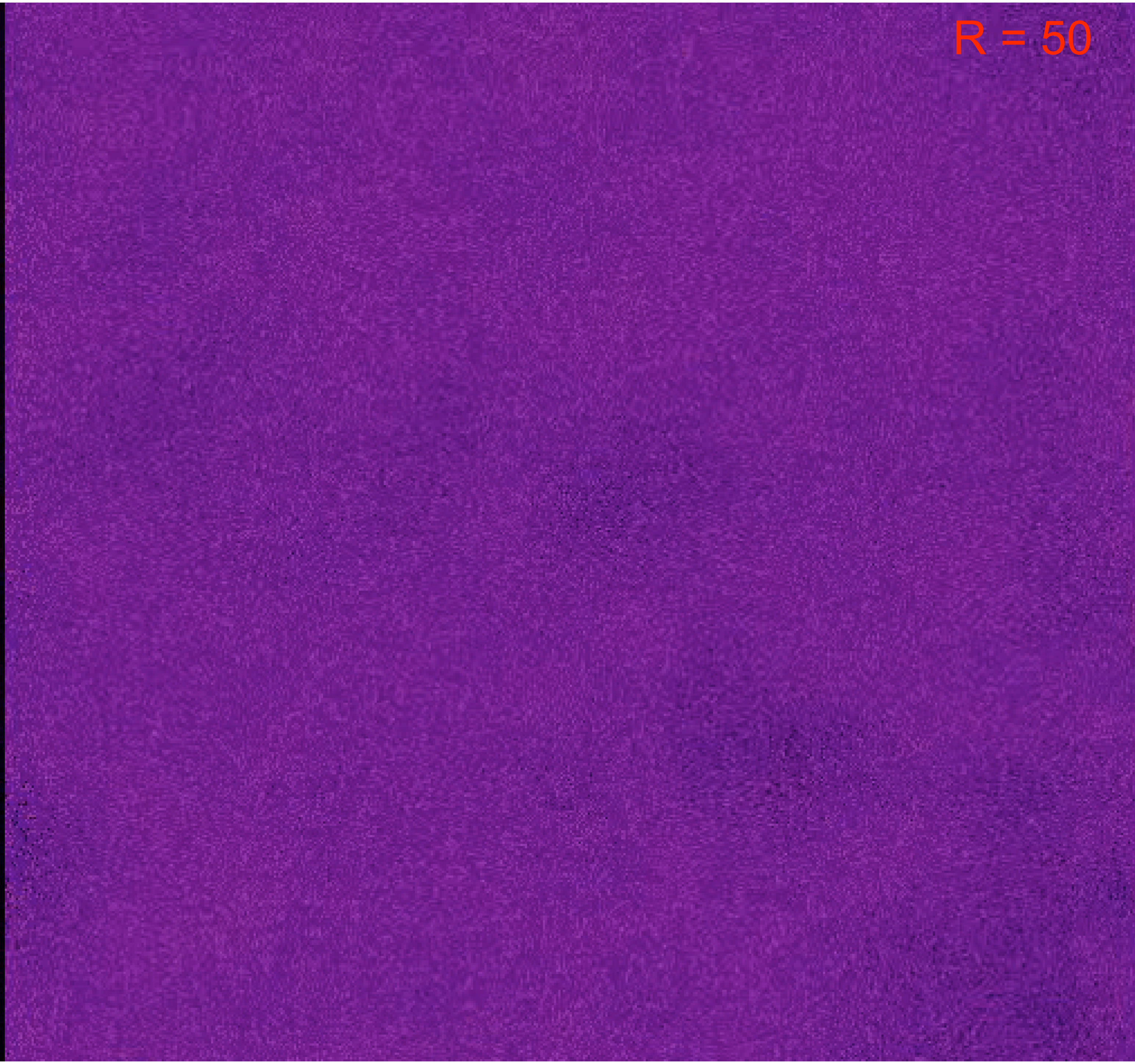
- Once a site fails F times, the site is considered dead and no longer receives stress.
- Sites interact equally with all other sites within a given radius, R.
- Catastrophic failure is defined as a percolating cluster of dead sites.

Short Range vs Long Range

- For long range interactions, we observe a nucleation-like event which results in catastrophic failure.
- For nearest-neighbor interactions, we observe a percolating cluster, prior to any nucleation-like event, which results in catastrophic failure.

Movie Parameters

- $N = L \times L = (512)^2$, (periodic BC)
- $V(r) = \theta(R - r)$
  - Long Range: R = 50
  - Short Range: R = 1
- $\sigma^c = 4$, $\sigma^r = 2$
- $\alpha = 0.1$
- $F = 5$


R = 50

R = 1