Scaling Theory for the Process Zone of Quasibrittle Materials

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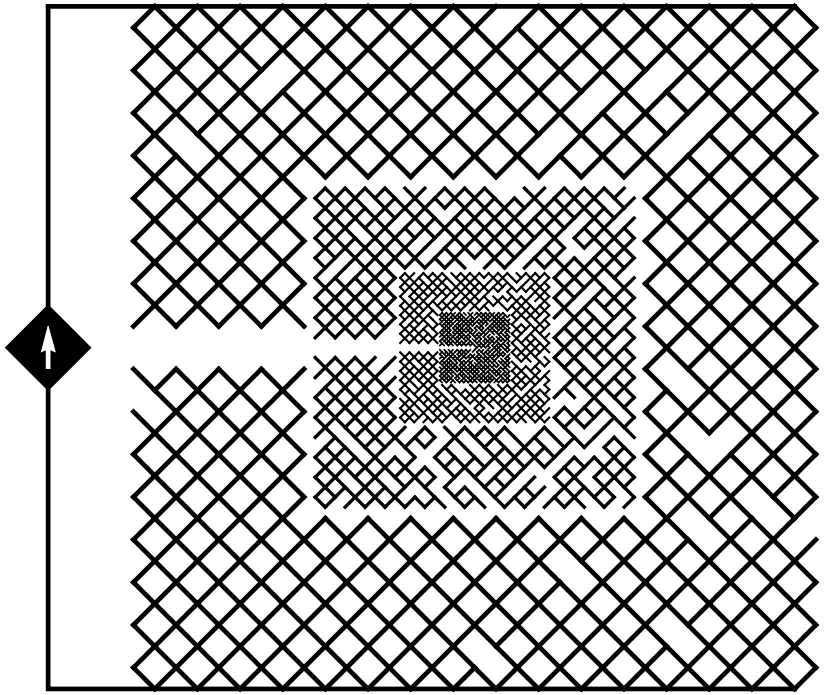
Introduction

Overview

- we use RG ideas to model the scaling of stress and damage near a disordered crack, or in the crack's *process zone*
- developing a numerical strategy using 2D fuse networks with variable boundary conditions



Introduction

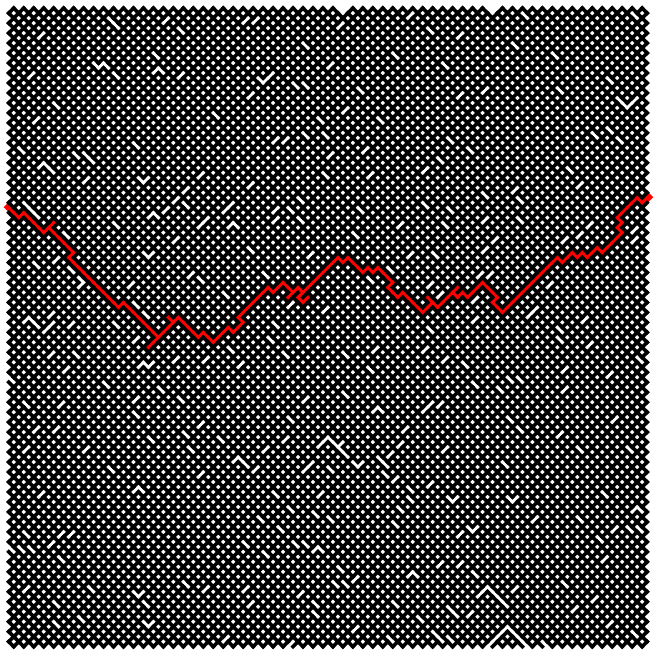
Fracture Mechanisms in Concrete

- mechanism of fracture is size-dependant
- stress relief at crack tip by nonlinear process zone characterized by microcracking
- no consistent geometry-independent characterization of material strength

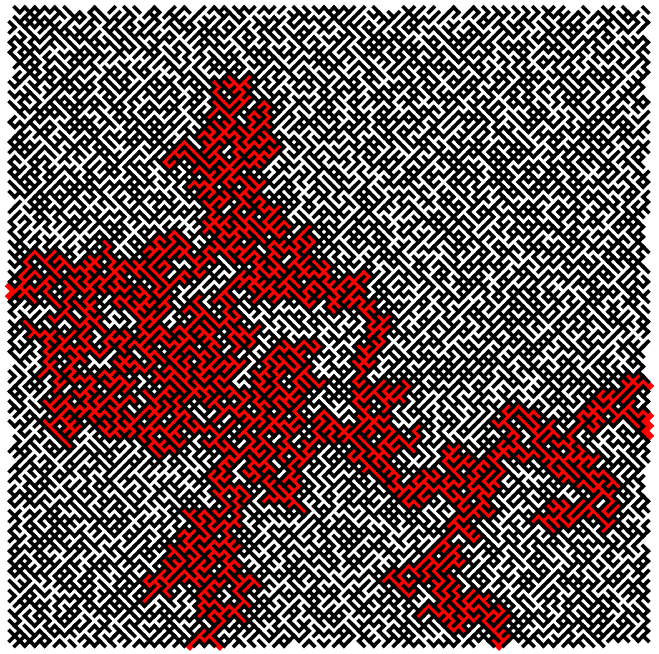
Introduction

Fracture Mechanisms in Fuse Networks

- **fuse network: diamond grid of equally resistive fuses with failure threshold cumulatively distributed as x^β**



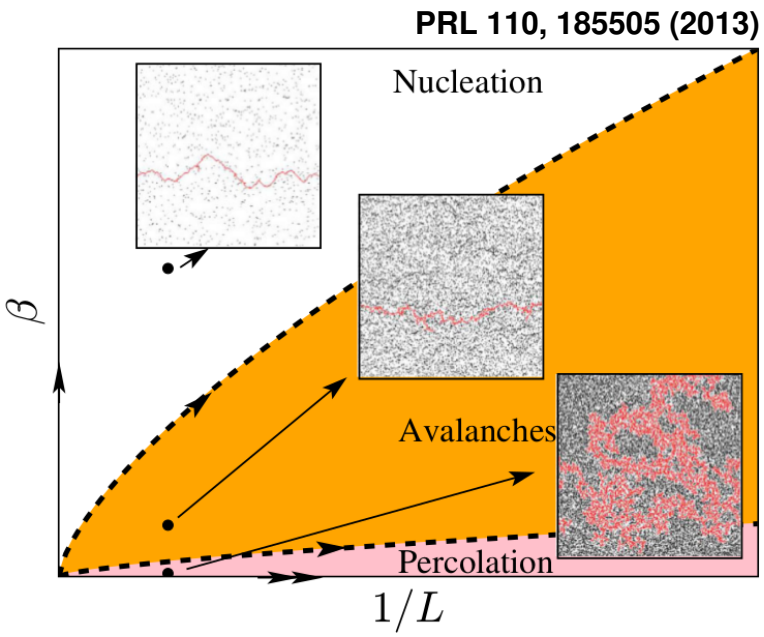
$\beta = 3.00$



$\beta = 0.03$

Introduction

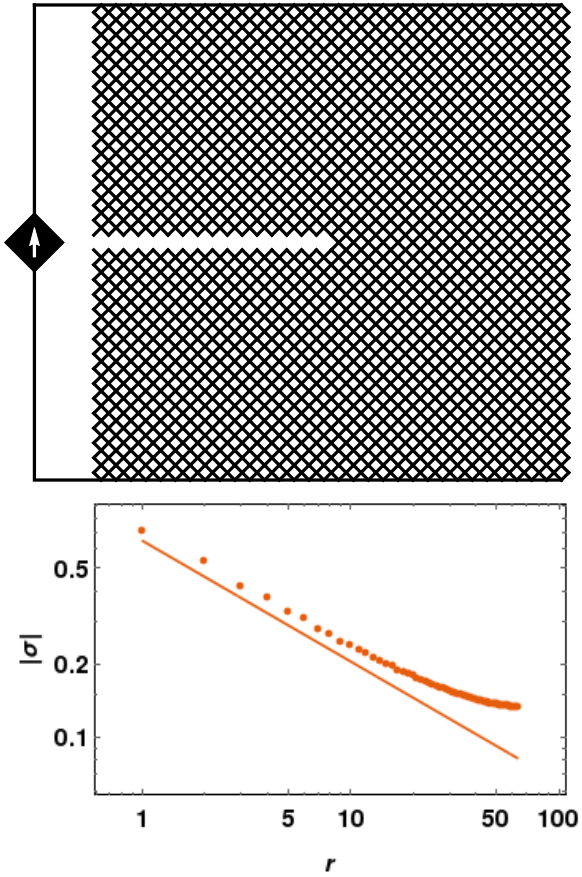
Avalanche Crossover in Fuse Networks



- Shekhawat and collaborators found smooth crossover transition between two mechanisms characterized by mean-field avalanches scaling
- percolation fixed point at infinite disorder unstable, any finite disorder flows to zero-disorder, nucleation-like fixed point
- however, crossover size is typically extremely large

Studying the Process Zone

The Problem



- stress analysis dominated by finite-size effects
- those effects become far more important with greater disorder

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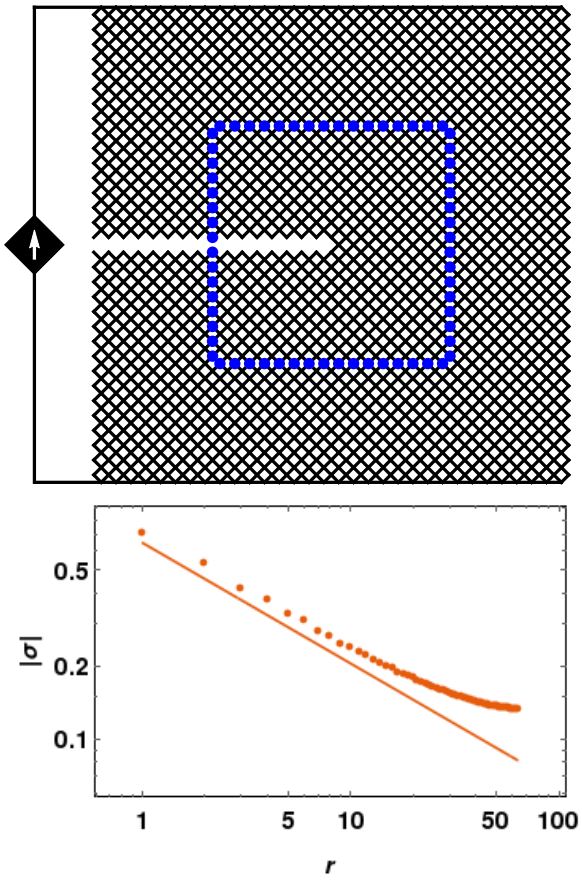
The Problem



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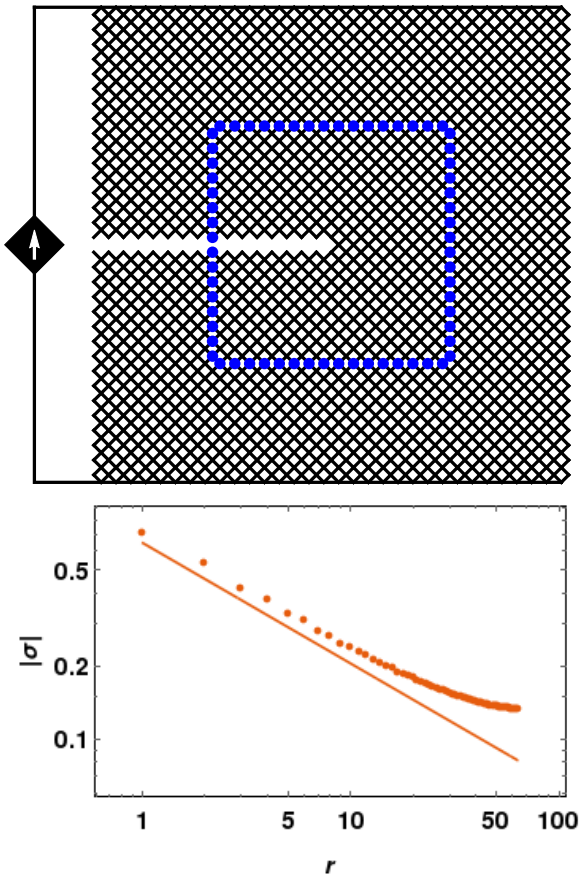
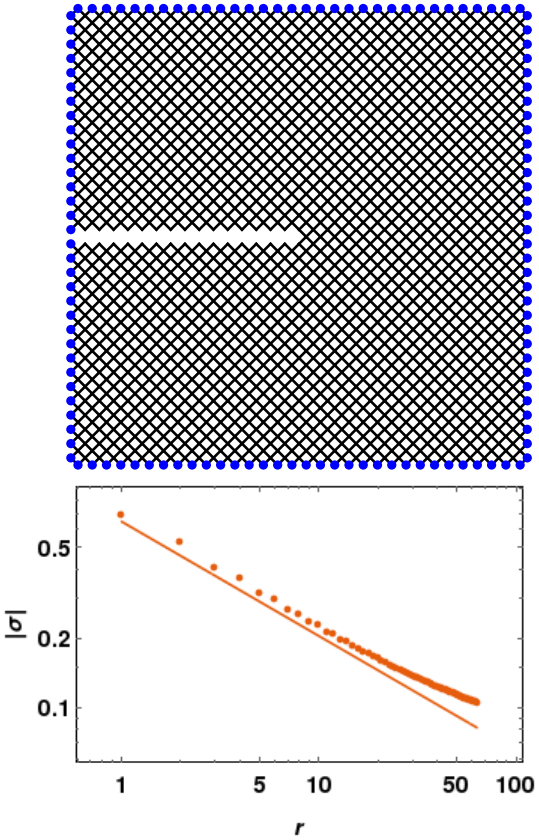
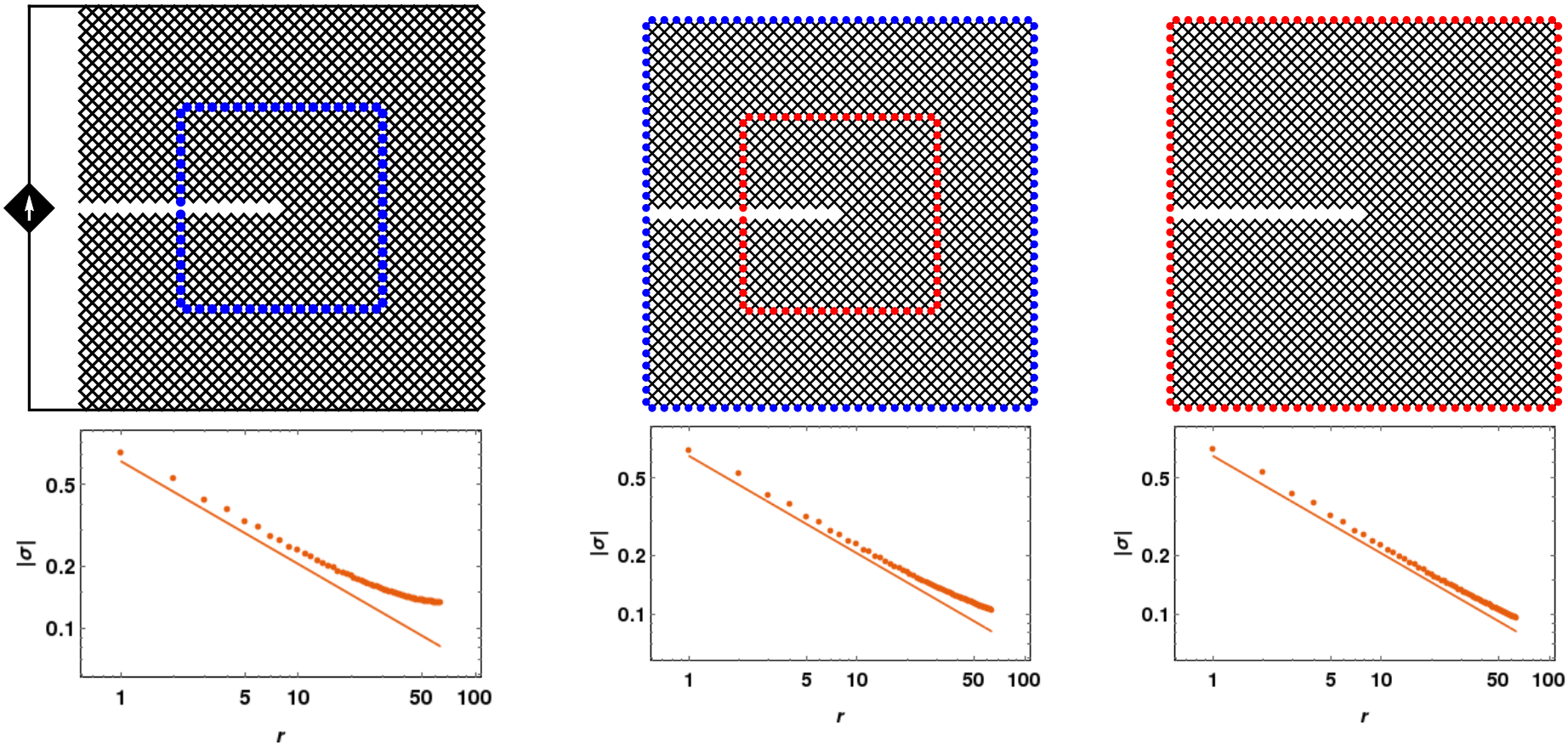




Studying the Process Zone

The Problem



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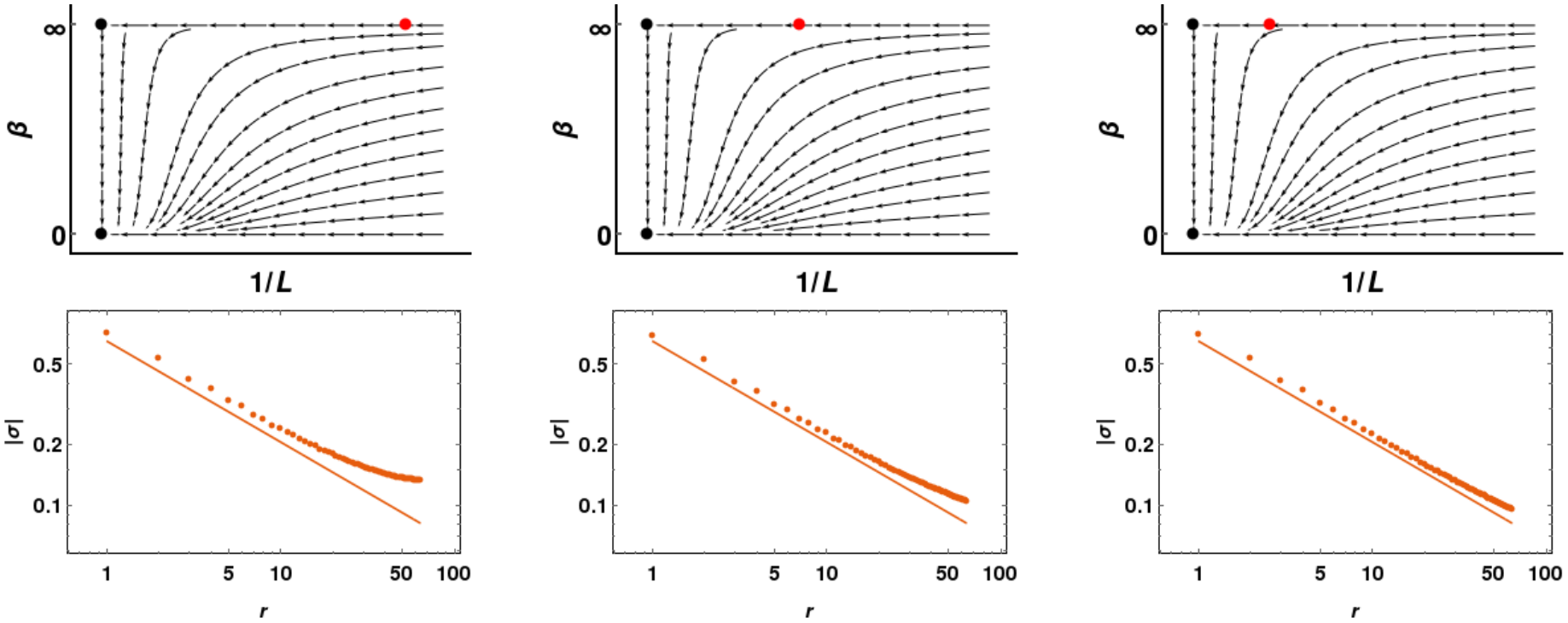

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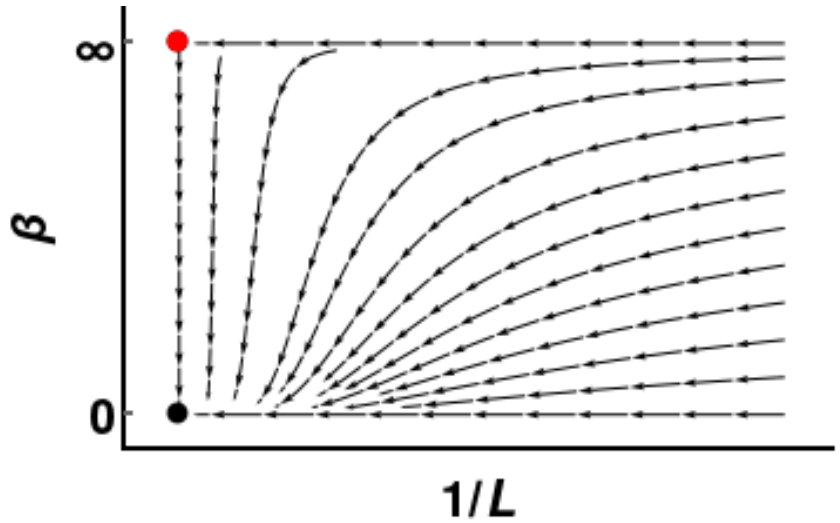
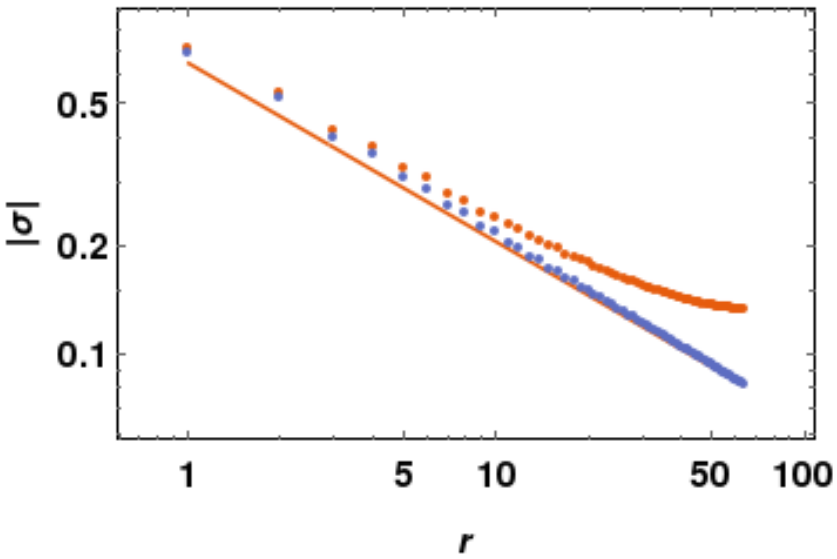
The Linear Elastic Fixed Point



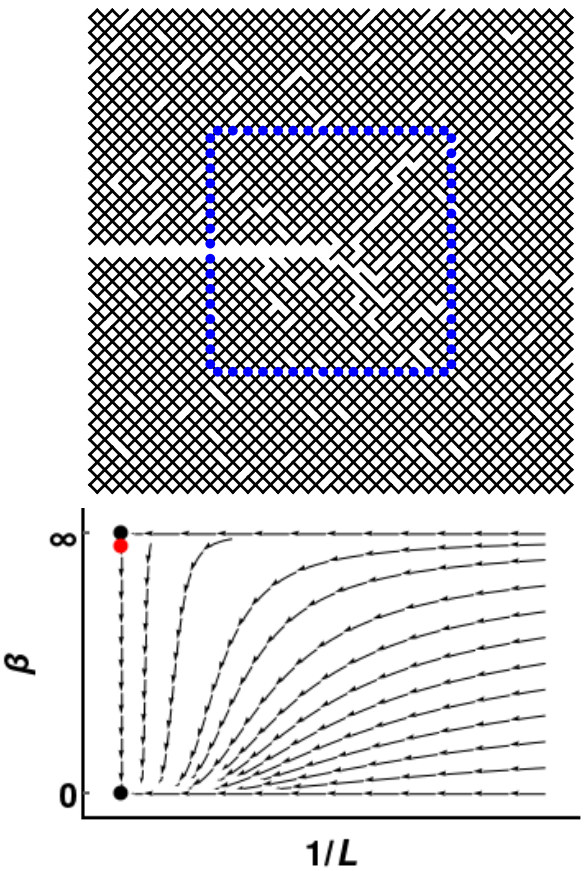


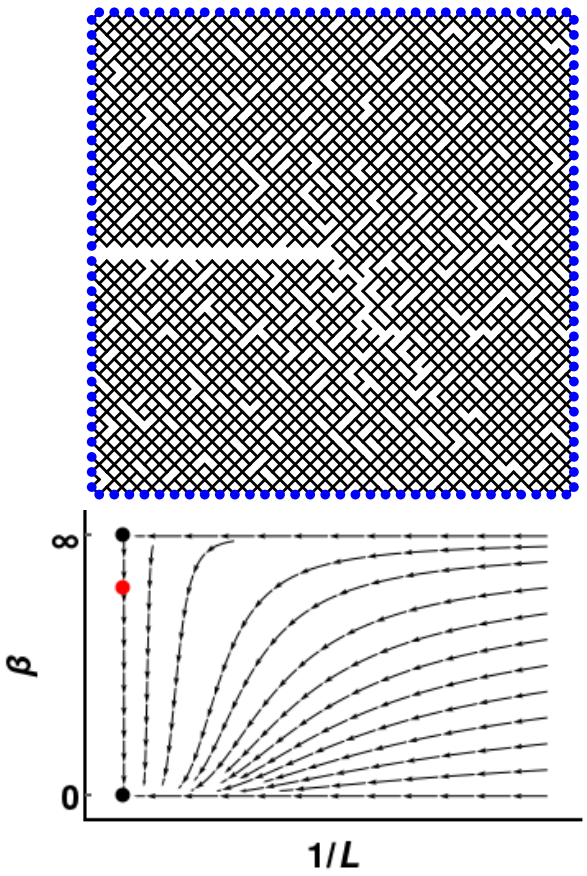
- after many (500 in blue) iterations, the stress asymptotically approaches the linear elastic result
- at zero disorder ($\beta = \infty$), linear elastic theory is a fixed point on an infinite lattice

Studying the Process Zone

Probing the Disordered Region

- the linear elastic theory is unstable to disorder
- rescaling inward for finite disorder should rescale β towards $\langle\sigma\rangle \sim$ constant, $\beta = 0$ fixed point





Studying the Process Zone

Open Questions

- how to self-consistently scale β?
- should β scale with the same exponent as it does for finite-size scaling as found by Shekhawat?
- what happens when you consider a realistically rough crack?

Questions?