Fixed-Energy Sandpile Model on Random Networks

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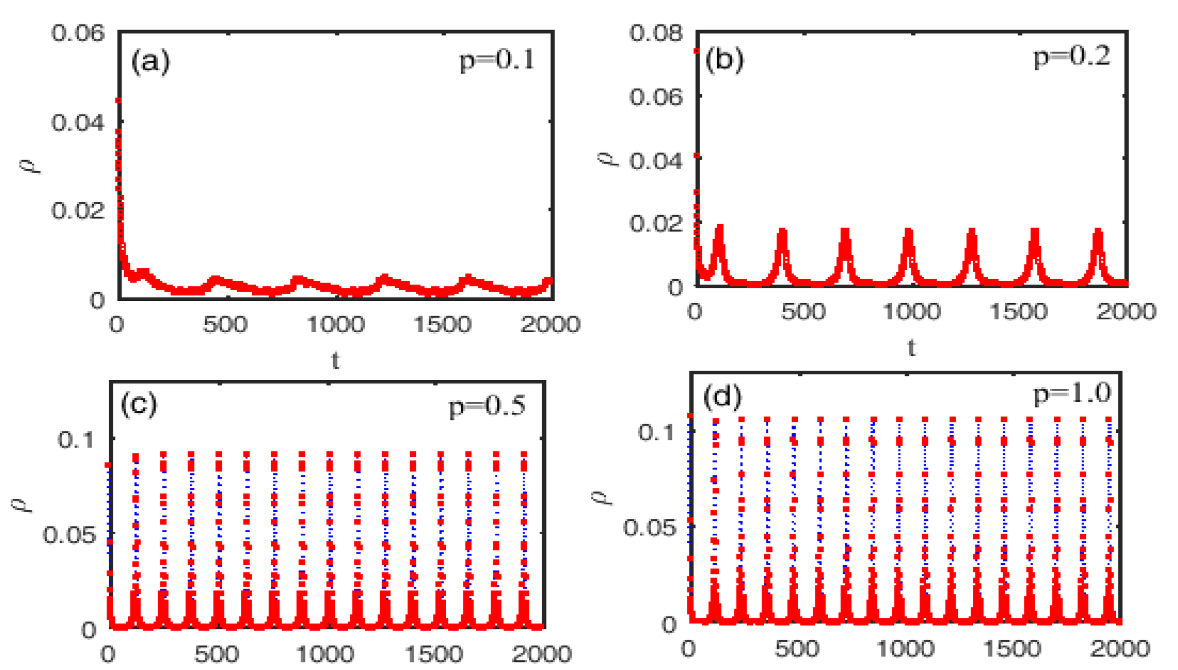
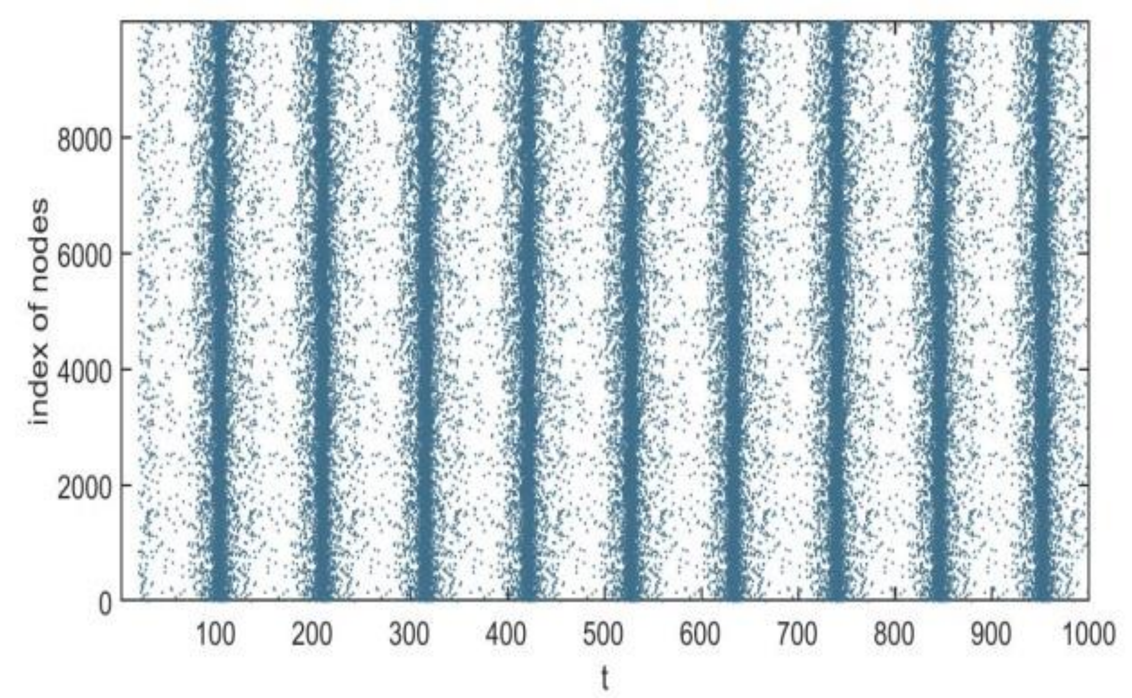
Introduction

The BTW sandpile model is the simplest well-studied model wich displays self-organized criticality (SOC) behavior. The model is simply defined on a square lattice .At each step a grain of sand is added to a randomly chosen site. If the height of a site reaches its threshold value, that node becomes active, topples and loses some grains of sand, redistributed among its nearest neighbours. Avalanches that reach the boundaries allow sand to exit the boundaries. In the fixed-energy sandpile (FES) model driving and dissipation are set to zero, such that the total number of sands is constant.



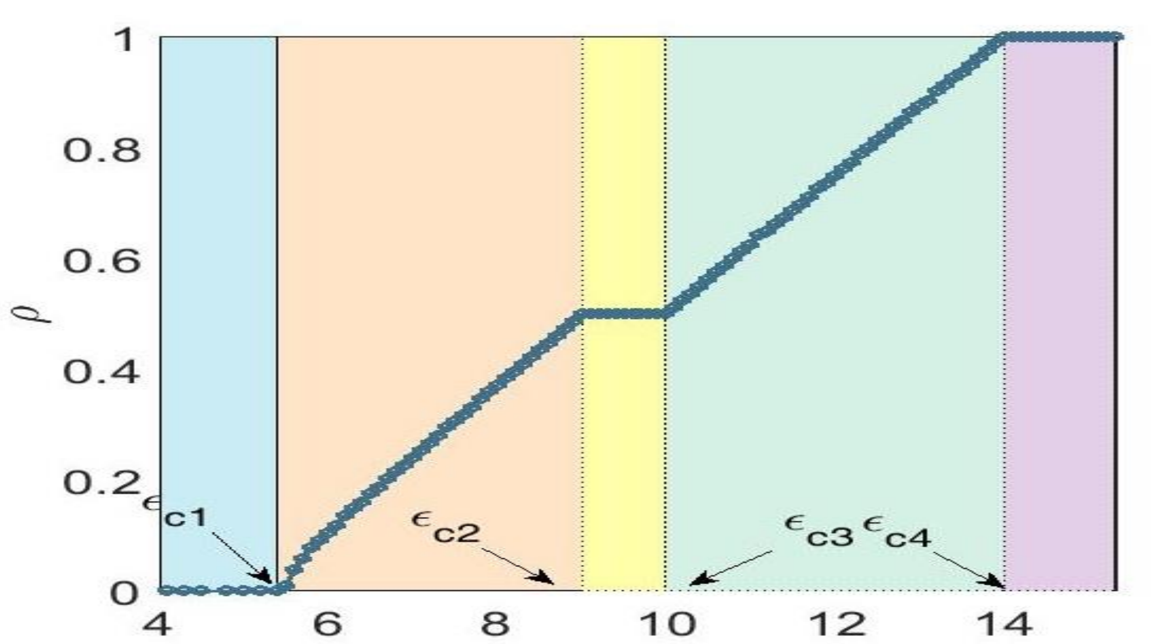
Active-site density, ρ, in surviving trials vs time



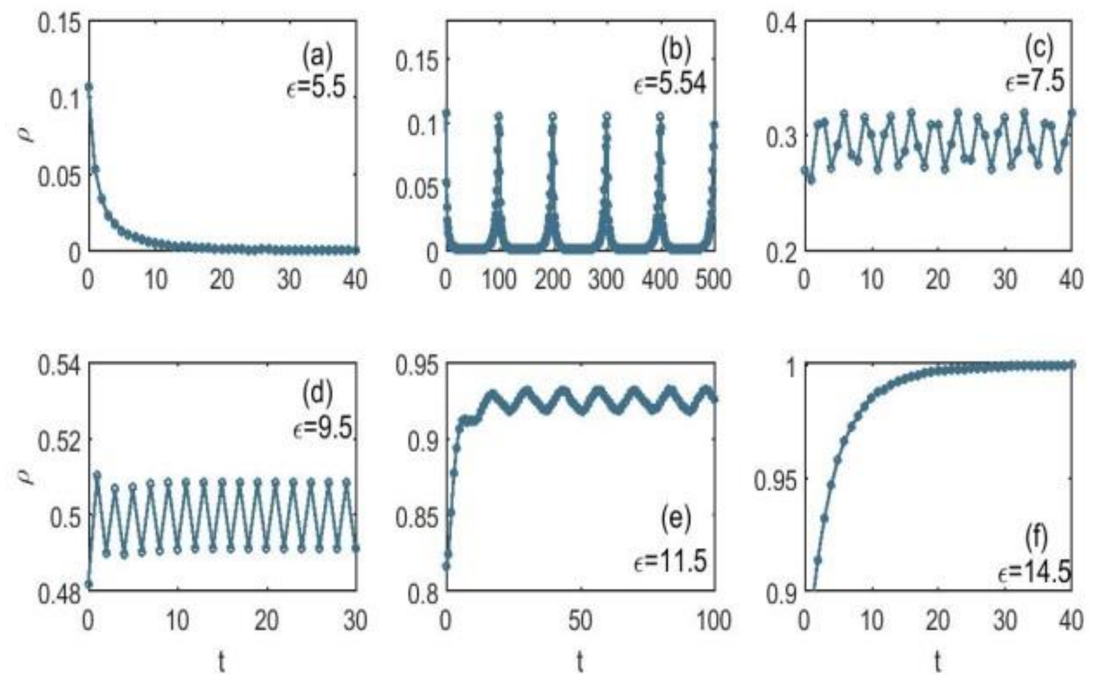
Raster plot for the activation of nodes

Model and Simulation Details

Using Watts–Strogatz algorithm we start with a ring having N nodes such that each node is connected to its m nearest neighbors on each side. Then rewire links with probability p randomly and start FES dynamic on this network.



Stationary values of the density of active nodes as a function of ϵ.

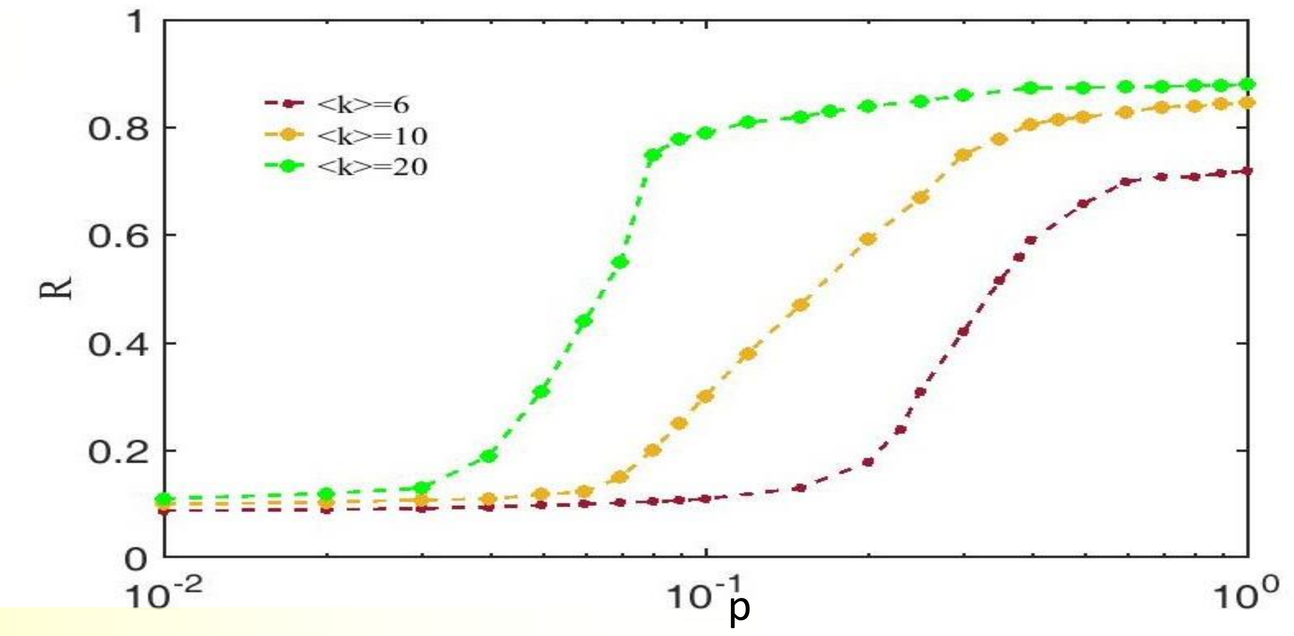


Time evolution of the density of active nodes, $\rho(t)$, for different values of sand density

Sandpile and Synchronization

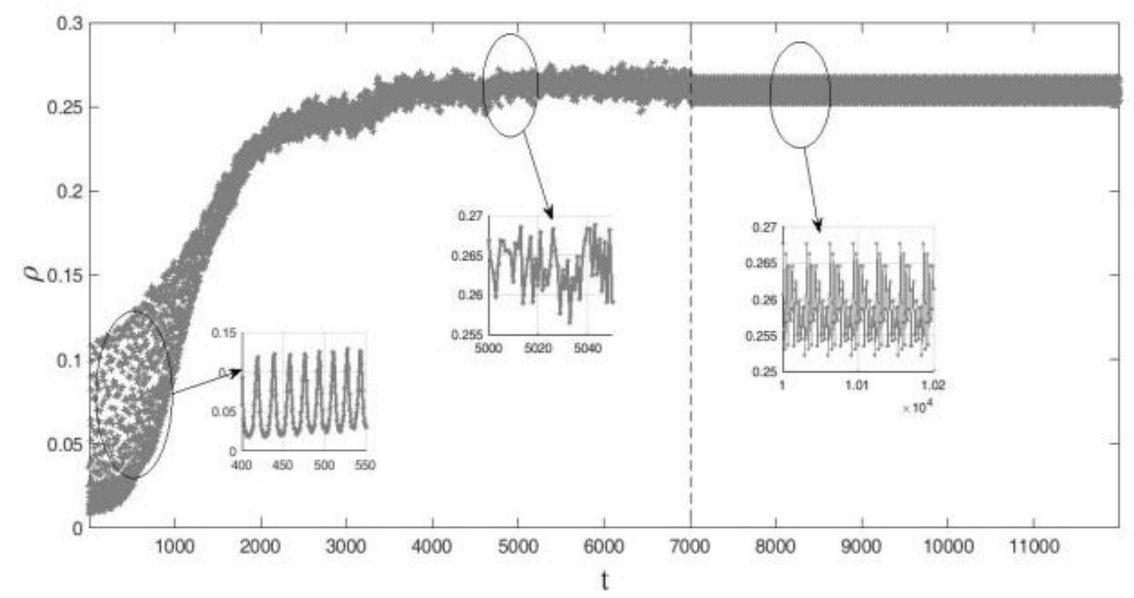
$$R(t) = \left|\frac{1}{N}\sum_{j=1}^{N} e^{i\varphi_j(t)}\right|$$

Synchronization order parameter R as a function of p .

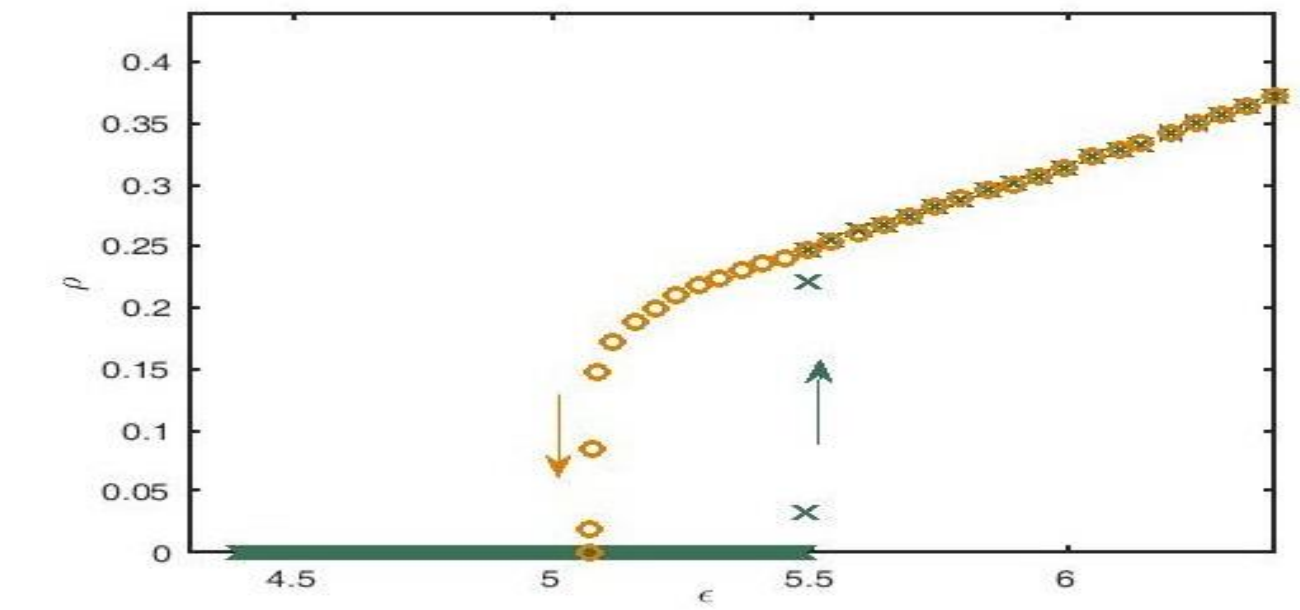


Activity dependent rewiring

we studied the Fixed-Energy Sandpile model on adaptive network: an active edge is randomly chosen and from one of its active end nodes, it is disconnected and rewired to a randomly chosen inactive node in the network. During rewiring the density of active nodes increases. This leads to the emergence of a bistable region with a first-order transition between the



Time evolution of the density of the active nodes



Phase transitions of the BTW-FES model on an adaptive network

CONCLUSION

The model undergoes an absorbing phase transition from a fixed point with zero density of active nodes to an oscillatory synchronized active phase. It seems that the small-world effect results in qualitatively similar behaviors between the BTW-FES model with the cyclic three-state models. However finding an exact equivalence of the FES models and the cyclic three-state models is a challenge for future work

References

[1] R. Dickman R, A. Vespignani, S. Zapperi, Phys. Rev. E 57, 5095 (1998).

[2] D.Fazli,N.Azimi-Tafreshi, Phys. Rev. E. 105, 014303 (2022).