EMERGENT SPACETIME FROM RANDOM NETWORKS

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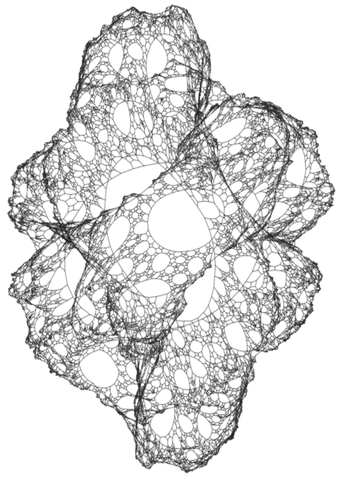
Question: **Can a discrete model of spacetime be built out of a ‘fundamental’ random network evolving in time?**

Introduction

Can a discrete data structure model the initial state of the physical universe such that both quantum theory and gravity emerge out of this structure as effective theories? Motivated by the ideas of cellular automata, there have been attempts to define ‘laws’ to evolve networks such that fundamental particles emerge as repeating ‘clumps’ in the evolving network [*Requardt 1999*] . A more recent work [*Kleftogiannis 2022*] starts with an initially complete random network and evolves via a single edge deletion per quanta of time.



Data

Complete random networks with n=100, n=500, n=800, n=1000 were evolved from a complete configuration to a completely disconnected configuration and the radius of the largest connected component, the entropy, and the dimension of the network were computed at each time step starting from R=10 to R=0, where R, the ratio between #edges and #nodes is twice the average degree.

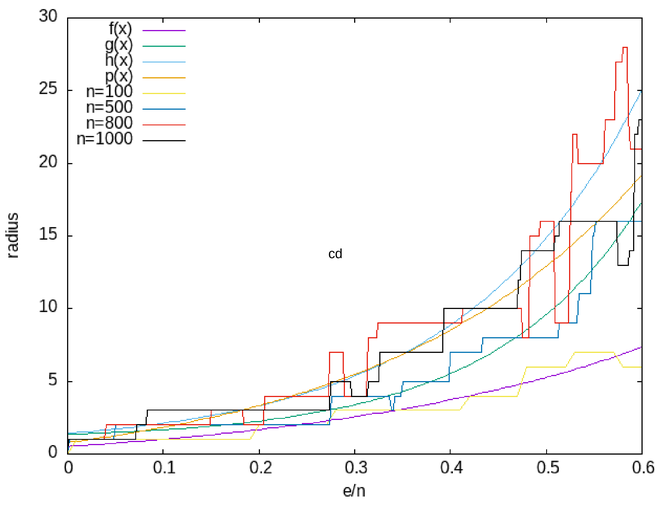
Observations

The monotonic entropy requirement constrains us to only one half of the network evolution, when the entropy is monotonic. We define an ambient dimension D for a network to exist in by the number of nodes at a distance L from a center being equal to L^D. We see that the ambient dimension evolves as well, and reaches the value D=3 as R approaches 1. Hence, this network model predicts an evolving dimension and converges to a metric space with 3 spatial dimensions only in a pocket around R=1. Moreover, as R increases, there is a better asymptote to D=8. However, the region of R between 0 and 1 is special because within this interval we have an exponential growth in the radius of our network. For R>1, most of the network is included in the giant connected component and the small worlds phenomenon takes over and the network radius drops down.

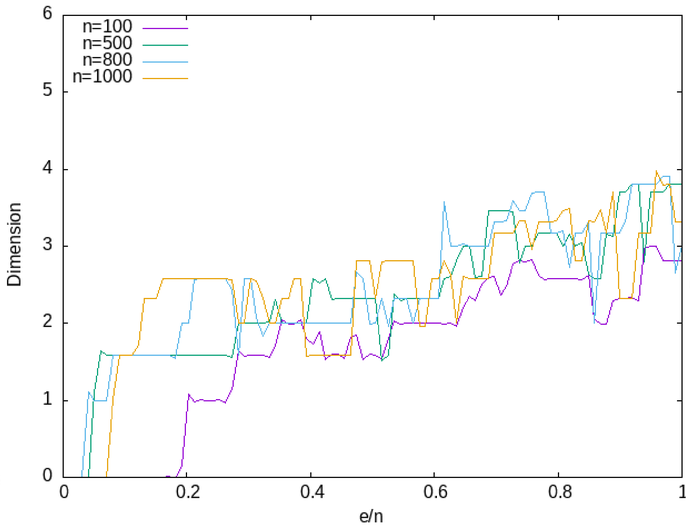
Results

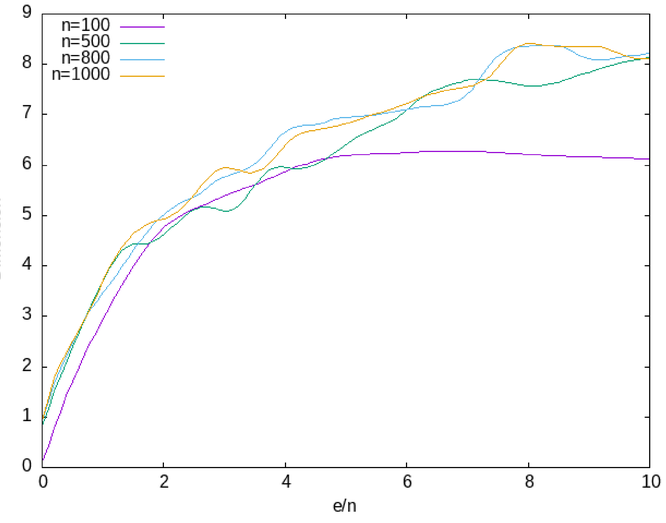
A random network could model our current universe in the infinite n limit, with R≈0.5, when the radius of the network is exponentially increasing.

Radius



Dimension





References

https://arxiv.org/abs/2210.00963

https://arxiv.org/abs/gr-qc/9912059