Solar Flare Model Over Rewired Magnetic Field Network

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The Lu-Hamilton model [1] is a sandpile model which was proposed to study the dynamics of solar flares. In this work, the centroids of the regions affected by the simulated flares are considered as nodes of a growing complex network [2], using the Suzuki-Abe method [3], which has been extensively used to study seismic sequences. Results show that the Lu-Hamilton model yields Gaussian distributions for the degree distribution of the network Fig. 1, which is consistent with a random process, where the probability of all locations to be centers of energy release is the same.

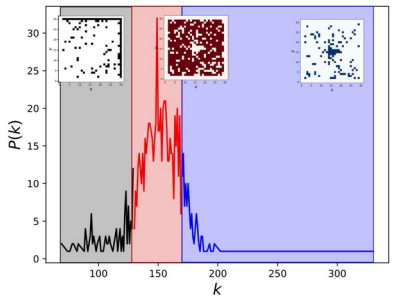

Fig 1: Gaussian Distribution for degree distribution.

Lu & Hamilton model managed to reproduce a large part of the main characteristics observed in solar eruptions but the physical interpretation of the elements constitutive of the system presented several difficulties. One way to solve this issues was presented by Morales and Charbonneau [4]. We follow that idea and modify the Lu-Hamilton such that the main element of the cellular automaton is a strand of interconnected nodes that can reconnect when a certain condition is fulfilled. Thus, we modify the Lu-Hamilton model, such that, instead of running over a regular grid as in a traditional cellular automaton, sites in the grid are reconnected, so that energy is released not to spatial neighbours, but to topological neighbours, as given by the grid network configuration.

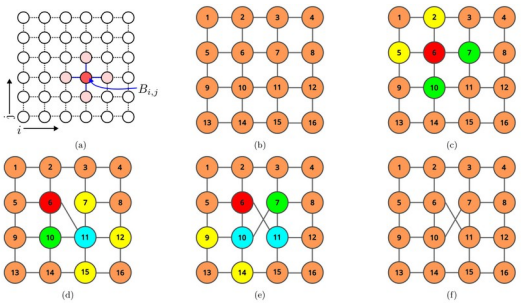

Fig. 2: Diagram of the system where a) is the original model and where is the (i,j) node, b) is the original node before the rewiring processes, c) a random node is chosen, green is the possible neighbor, and yellow cannot be selected, d) cyan is the node selected at the next rewiring step, e) using the same logic for conservation of neighbors, the system is rewired again, f) the final state after all rewiring processes.

Rewiring of the grid network is done is such a way that energy release out of the system is always possible, and the number of network edges is conserved. In this case, the Lu-Hamilton model shows a SOC state different to the regular grid case, presenting structures where the appearance of solar flares has a higher probability. Both cases, the regular grid and the rewired grid, present a power-law distribution of released energy per event Fig. 3, which is consistent with previous findings on solar flare dynamics [5].

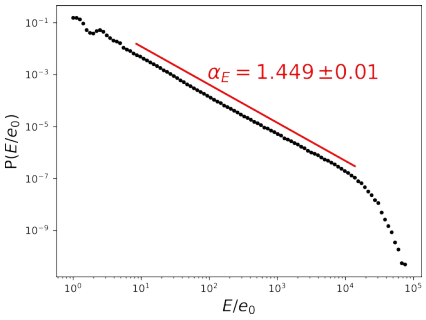

Fig 3: *Power-law distribution for energy in rewired Lu-Hamilton model.*

References

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