Nontrivial collective behaviour induce by heterogeneity in dynamical recurrent networks

Complex Systems

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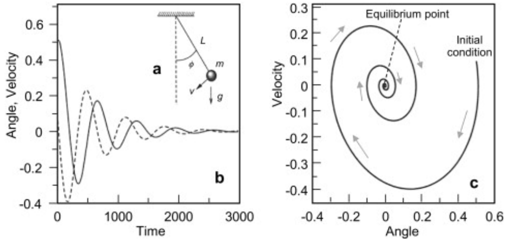
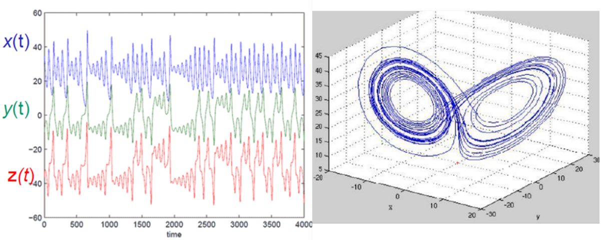
Chaos dynamics

Simple pendulum



Lorenz equations



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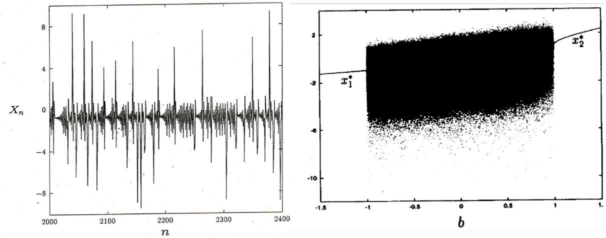
Robust chaos

Logarithmic map

$$x_{t+1} = F(xt) = Ln|xt| + b$$



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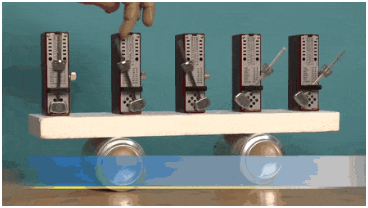
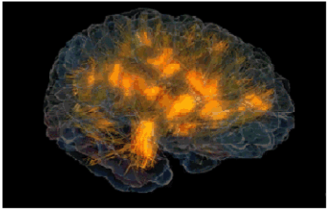
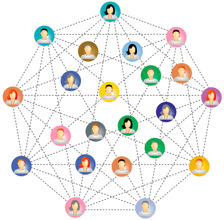
Collective behaviours

Coupled map Lattices







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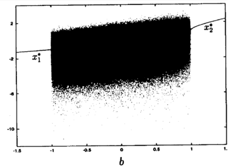
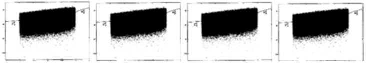
tive behaviours

$$x_{t+1} = F(x_t) = Ln|x_t| + b$$



$$x_{t+1}(i) = (1-\epsilon) f(x_t(i)) + \frac{\epsilon}{N} \sum_{j=1}^{N} f(x_t(j)),$$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Collective behaviours

Progress of Theoretical Physics, Vol. 100, No. 1, July 1998

Synchronization and Collective Behavior in Globally Coupled Logarithmic Maps

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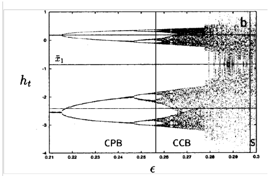
Centro de Astrofísica Teórica, Facultad de Ciencias, Universidad de Los Andes A. Postal 26 La Hechicera, Mérida 5251, Venezuela

(Received October 27, 1997)

The collective phenomena arising in a system of globally coupled chaotic logarithmic maps are investigated by considering the properties of the mean field of the network. Several collective states are found in the phase diagram of the system: synchronized, collective periodic, collective chaotic, and fully turbulent states. In contrast with previously studied globally coupled systems, no splitting of the elements into different groups nor quasiperiodic collective states occur in this model. The organization of the observed nontrivial collective states is related to the presence of unstable periodic orbits in the local dynamics. The role that the properties of the local dynamics play in the emergence and characteristics of nontrivial collective behavior in globally coupled systems is discussed.



STATISTICAL COMPLEXITY AND NONTRIVIAL COLLECTIVE BEHAVIOR IN ELECTROENCEPHALOGRAPHIC SIGNALS

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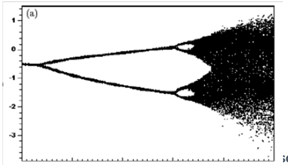

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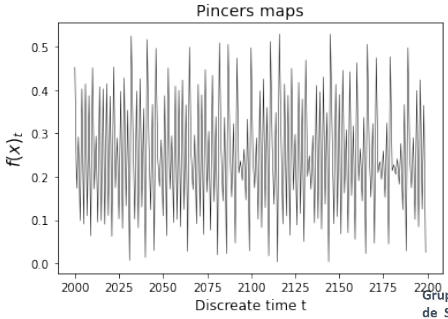
Homogeneous network

$$F(x_t) = |tanh(s(x_t - c))|$$



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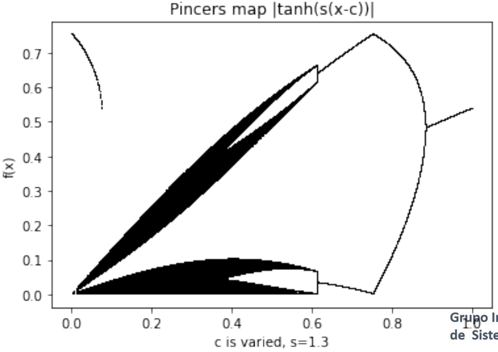

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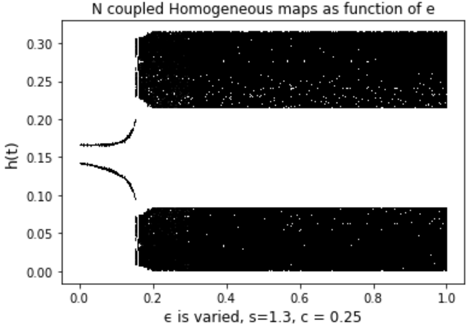
Homogeneous network

$$x_{t+1}(i) = (1-\epsilon)f(x_t(i)) + \frac{\epsilon}{N}\sum_{j=1}^{N} f(x_t(j)),$$

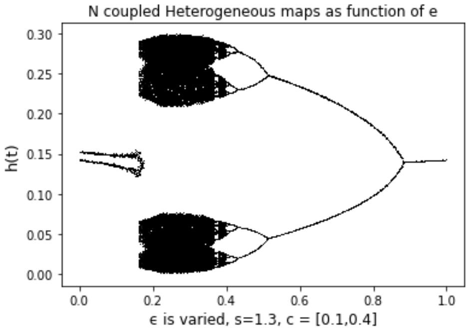
$$F(x_t) = |tanh(s(x_t - c))|$$



Heterogeneous network

$$x_{t+1}(i) = (1-\epsilon) f(x_t(i)) + \frac{\epsilon}{N} \sum_{j=1}^{N} f(x_t(j)),$$

$$F(x_t) = |tanh(s(x_t - Random[c_1, c_2]))|$$



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From homogeneous to heterogeneous

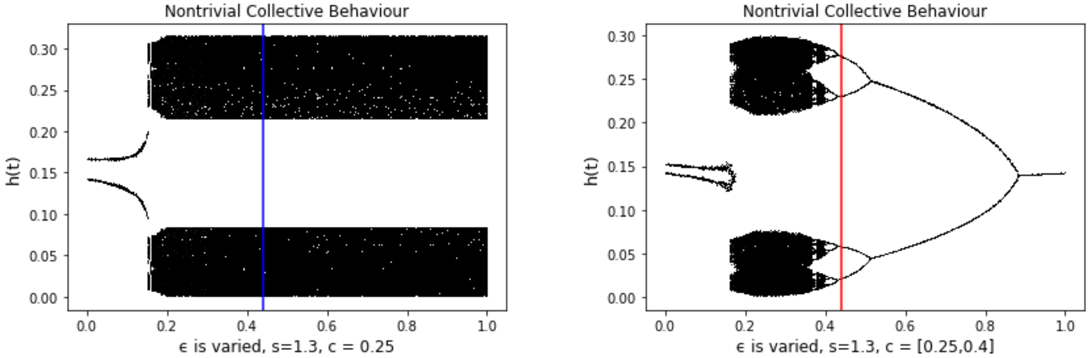

Figure: Pincers Maps Network

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Collective behaviour induced by Heterogeneity

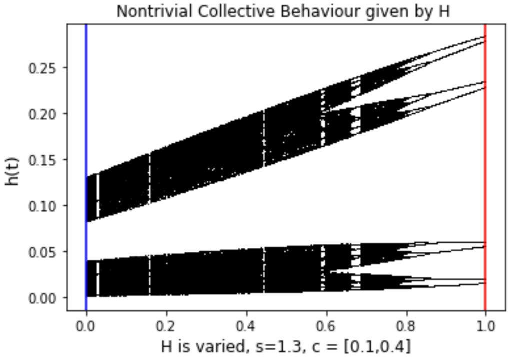
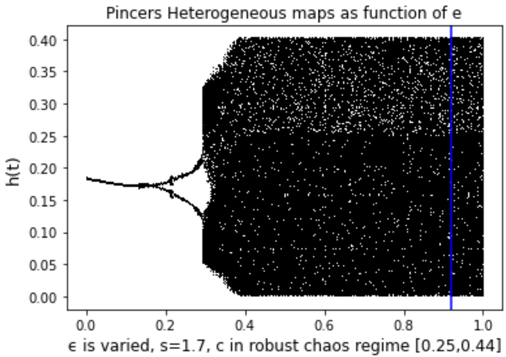


Figure: H from 0 to 1

from homogeneous to heterogeneous



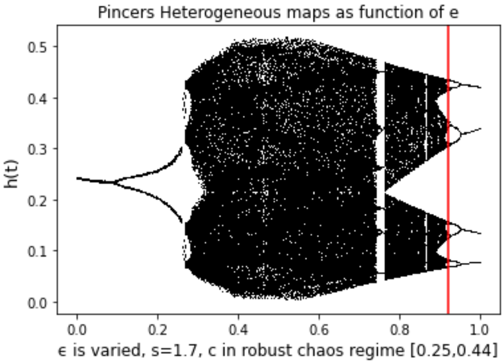


Figure: Pincers maps networks

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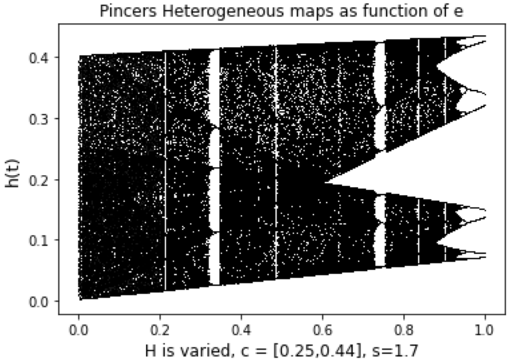

Figure: heterogeneity from 0 to 1

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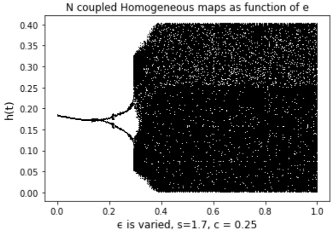
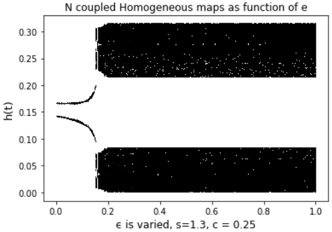
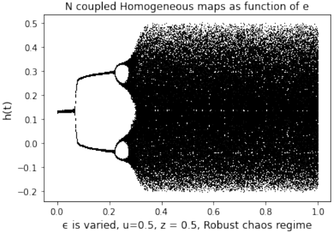
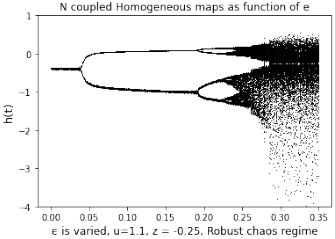
Homogeneous Networks









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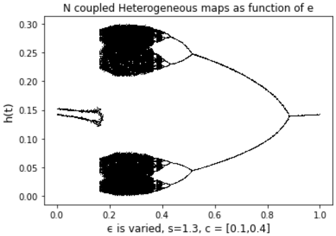
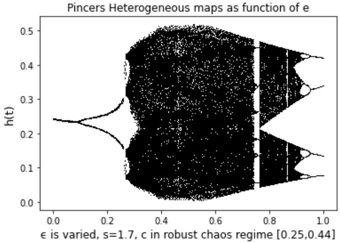
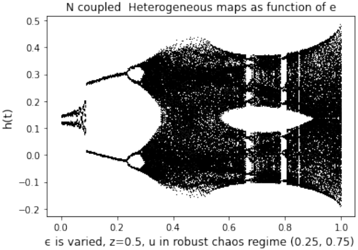
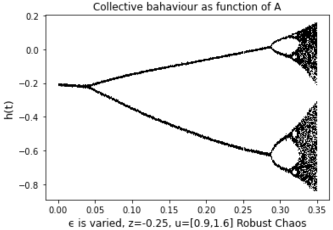
Heterogeneous Networks









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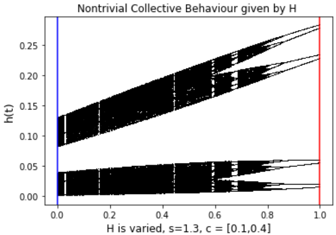
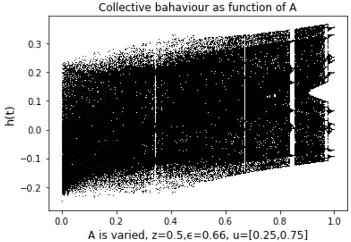
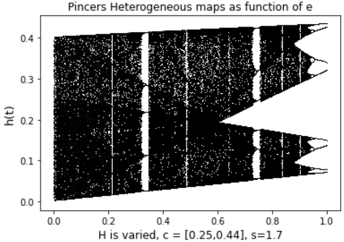
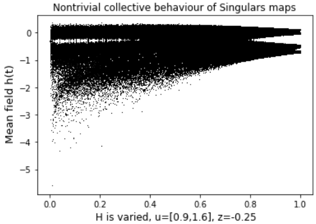
Collective behaviour induced by Heterogeneity









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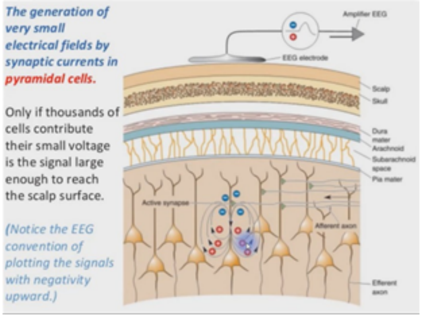
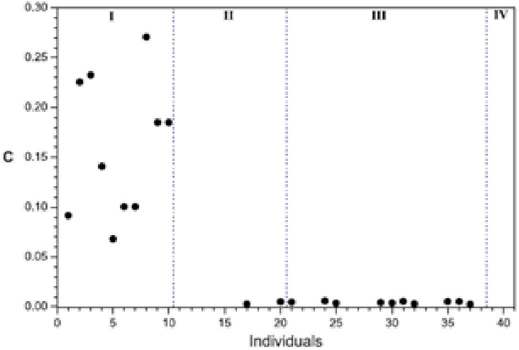
Applications

Neuroscience





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Future work
Neuroscience

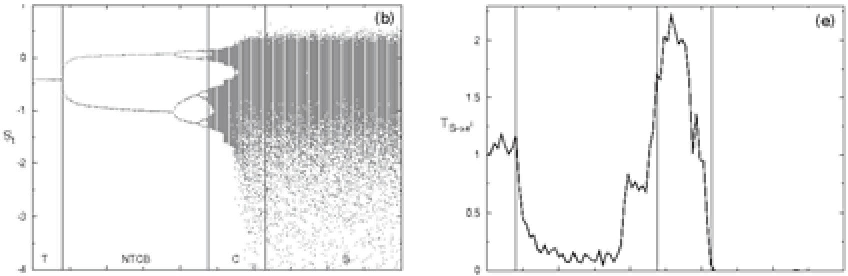

Figure: Transfer information from variables to global field

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Conclusions

1. 1) Collective behaviors of recurring dynamic networks are studied within the interval of robust chaos
2. 2) Non-trivial collective behaviors in the average field are given by varying the amount of heterogeneity of the network
3. 3) A theoretical model is established that allows to quantify the collective behavior in terms of the random varieties in all local parameters bi of the network, this let us to define this heterogeneity parameter as a bifurcation parameter of the network ("heterogeneity parameter")
4. 4) More research is needed to generalize the collective behavior associated with a family of sigmoid functions in terms of the heterogeneity parameter.

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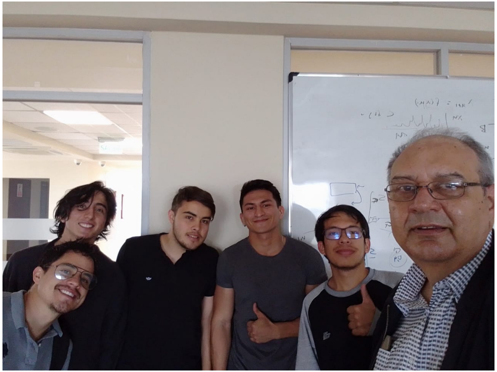
acknowledgment



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Questions?

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