



The evolutionary Kuramoto's dilemma

Alessio Cardillo

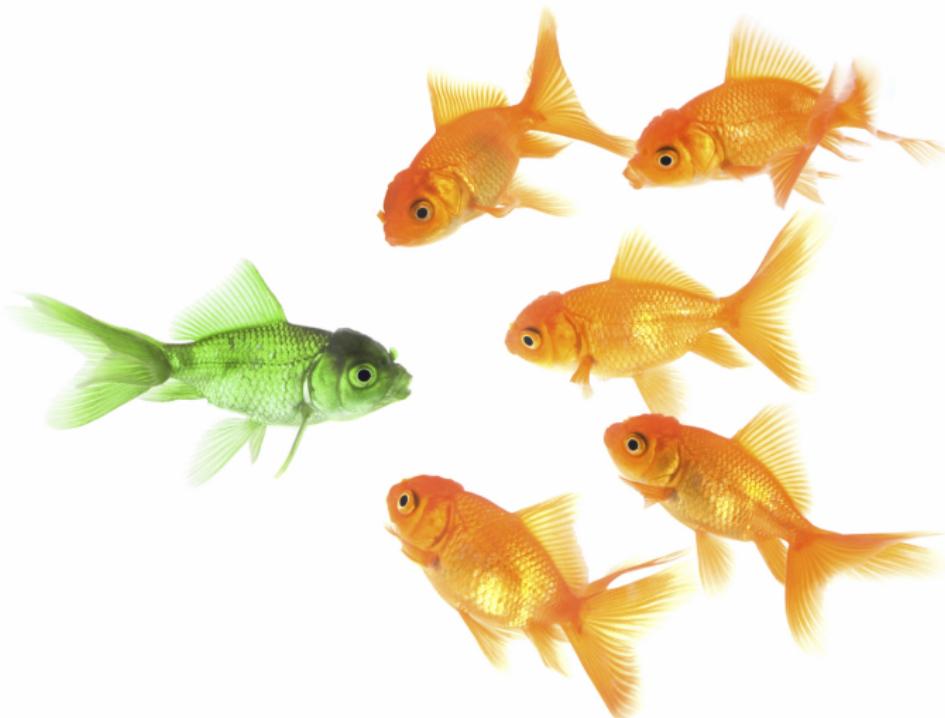
École polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

Thursday 24 March 2016, Complenet 2016, Dijon, France

A group of men in white athletic gear are running on a wet, sandy beach. The water is shallow and reflects the overcast sky. The men are wearing white zip-up shirts and white shorts. Some have small red and white patches on their shirts. The scene captures a sense of movement and determination.

CHARIOTS OF FIRE

Kuramoto's Dilemma



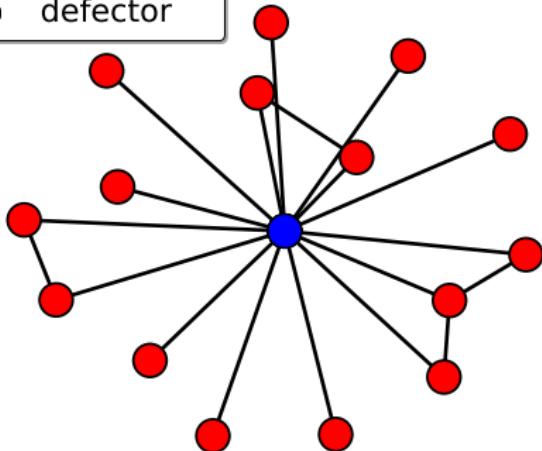


Motivation

Question:

What happens to the synchronization when the interactions are regulated by the cost/benefit ratio?

cooperator
defector

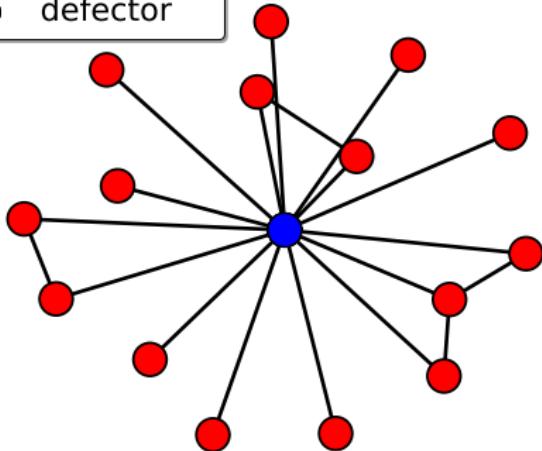
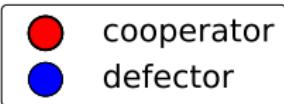


Strategy

$$s_I = \begin{cases} 1 & \text{if } I \text{ is cooperator} \\ 0 & \text{if } I \text{ is defector} \end{cases}$$

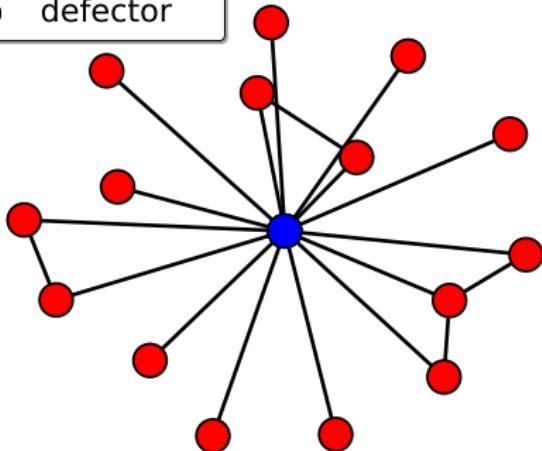
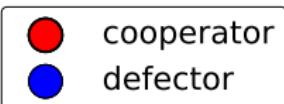
Phase

$$\theta_I \in [0, 2\pi]$$



Kuramoto

$$\dot{\theta}_I = \omega_I + \underbrace{s_I \lambda}_{\text{interaction}} \sum_{j=1}^N a_{ij} \sin(\theta_I - \theta_j).$$



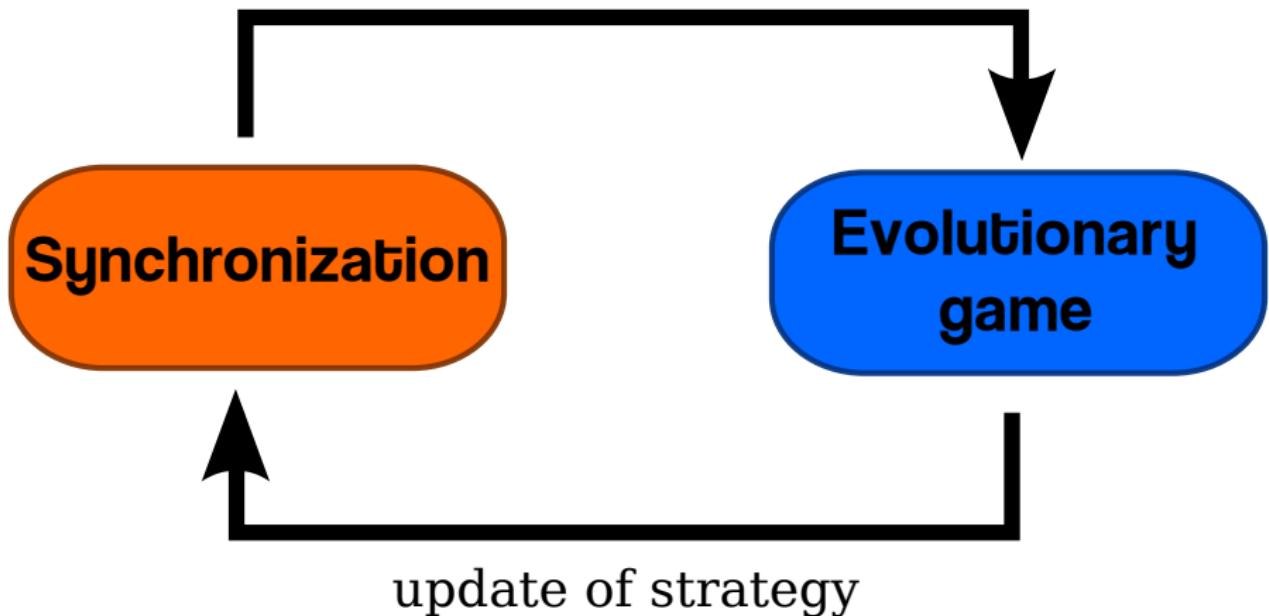
Evolutionary game

$$p_I \propto \frac{r_{L_I}}{\text{fitness}} - \alpha \frac{c_I}{\text{cost}} .$$

$$r_{L_I} = \frac{1}{k_I} \sum_{j=1}^N a_{Ij} e^{i\theta_j} \quad r_L \in [0, 1] ,$$

$$c_I \propto \Delta \dot{\theta}_I = \left| \dot{\theta}_I(t) - \dot{\theta}_I(t-1) \right| .$$

accumulation of payoff



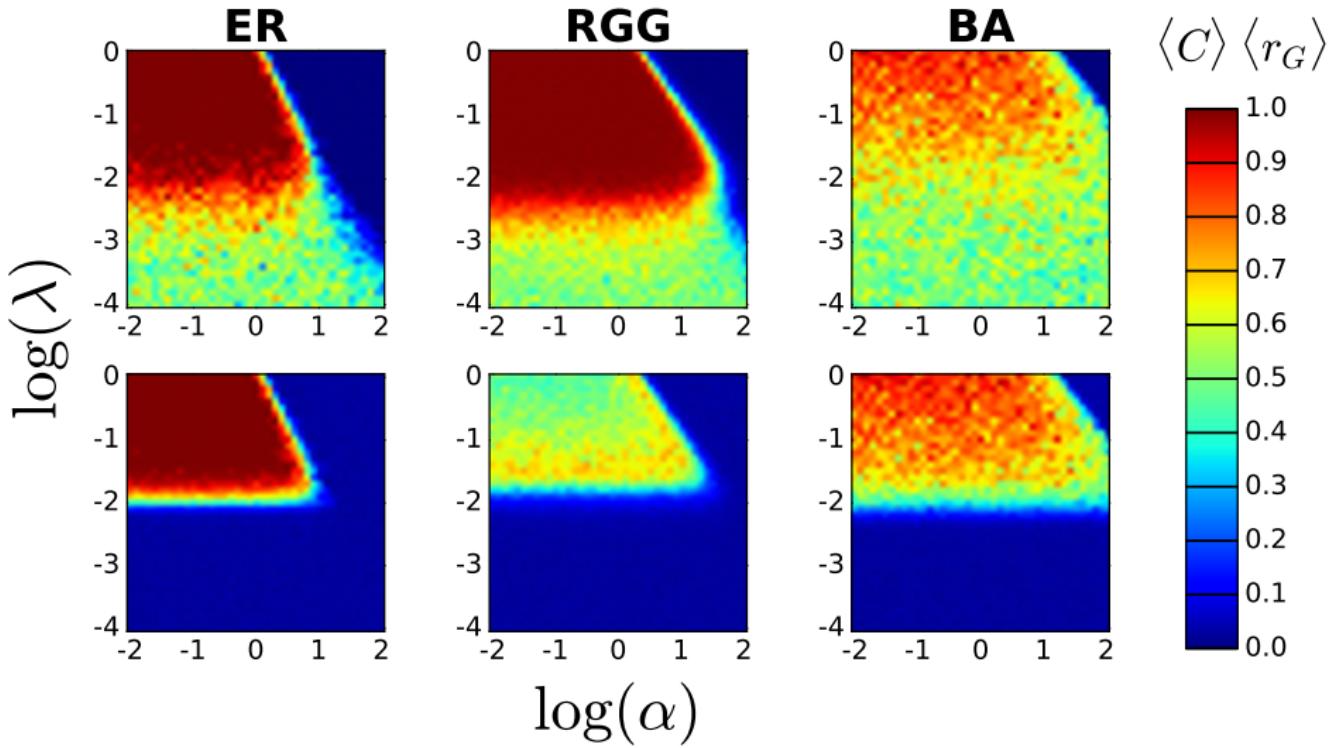


Question:

How the **underlying topology** of the interactions
affects the **emergence** of
cooperation/synchronization?

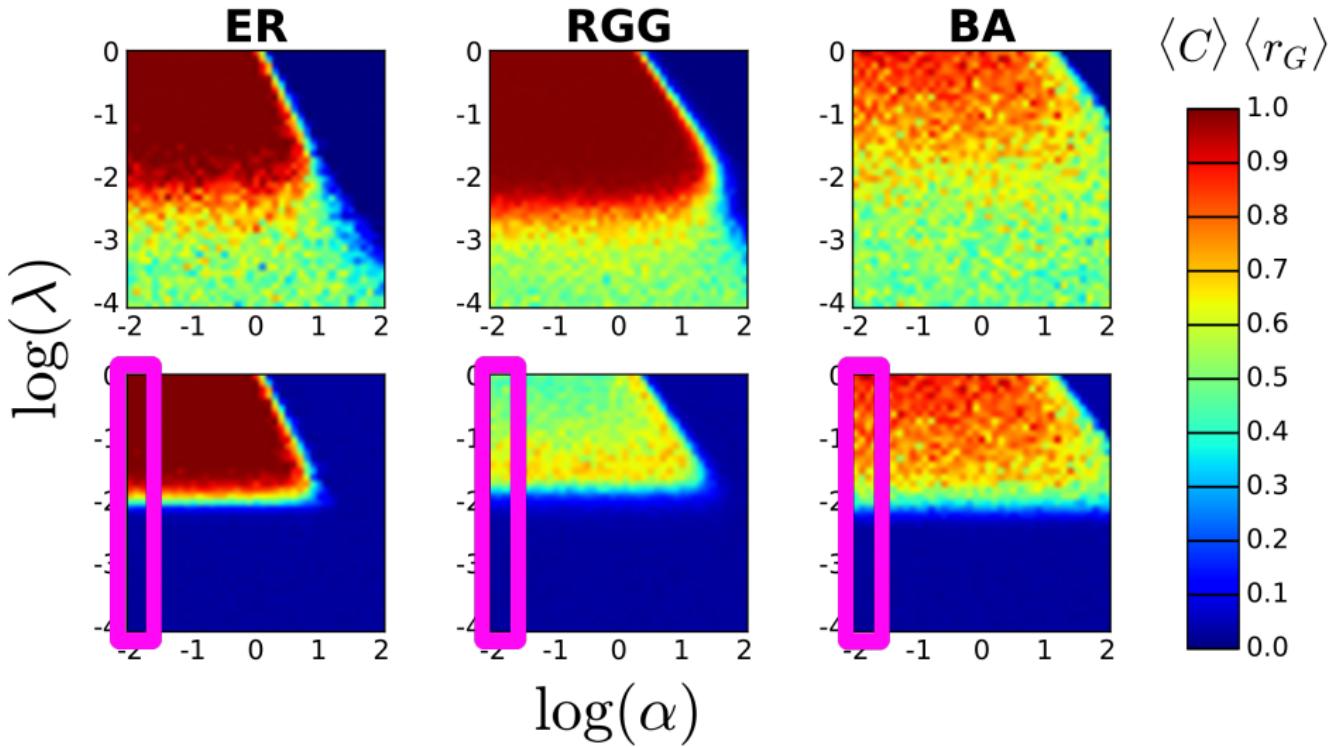


Macroscopic Behavior



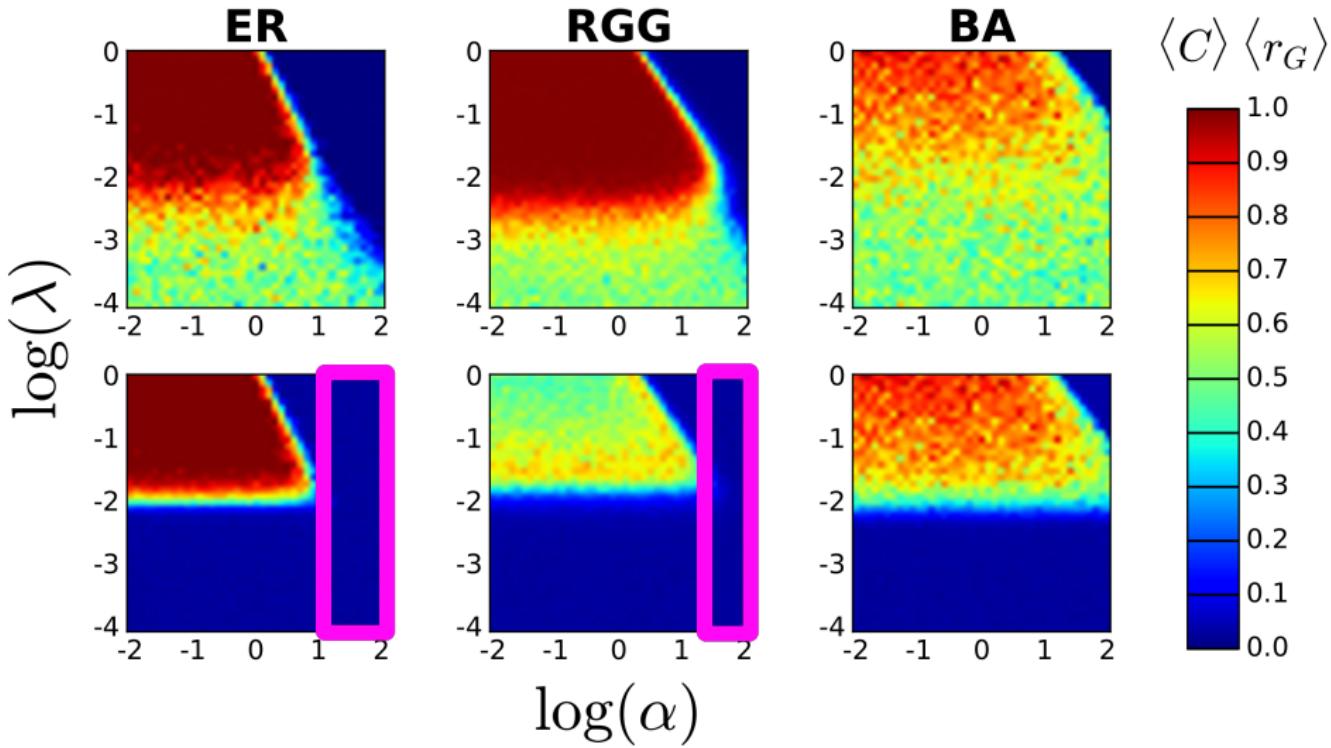


Macroscopic Behavior



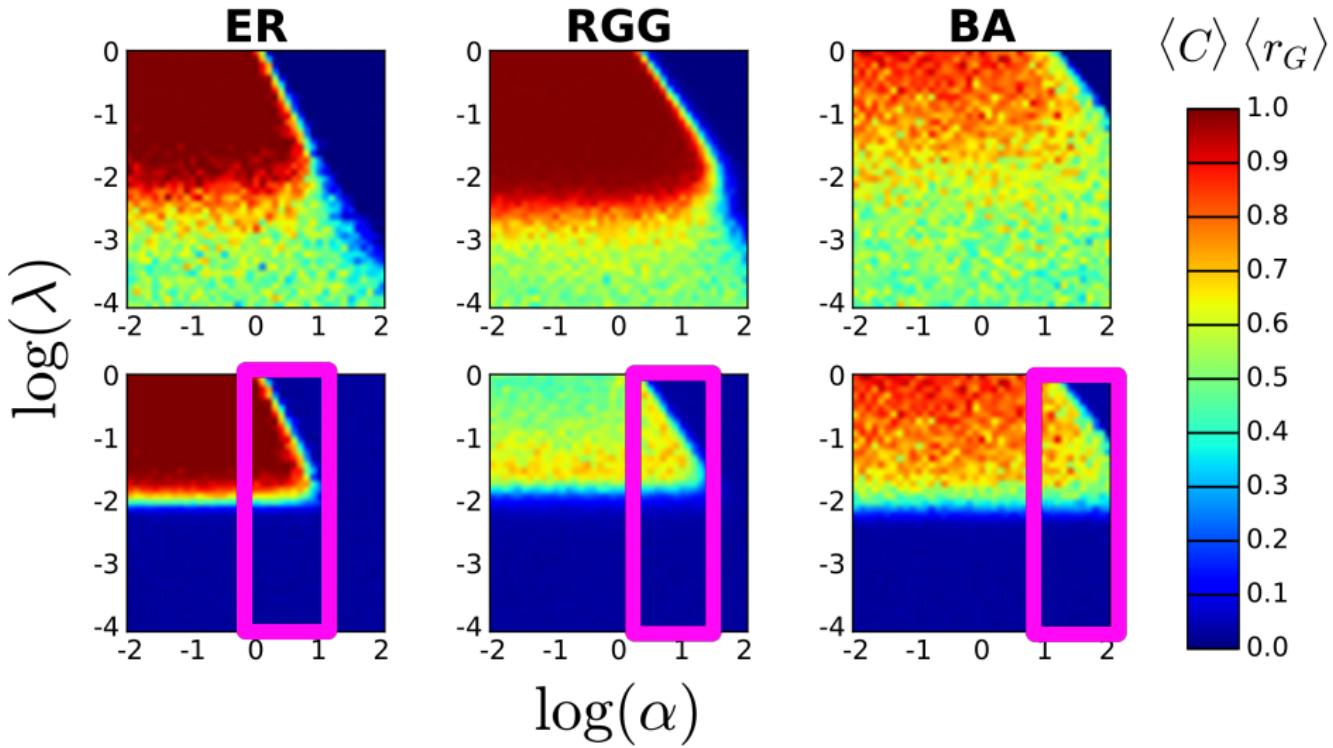


Macroscopic Behavior



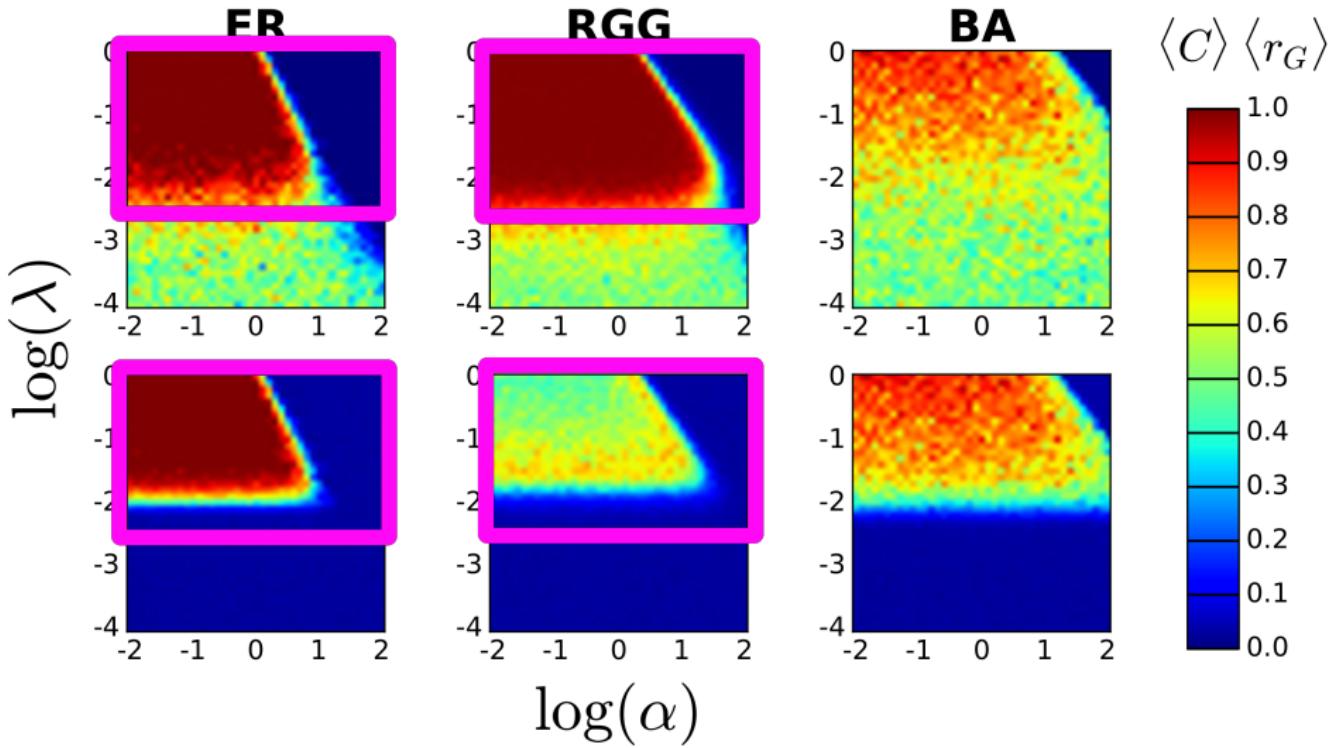


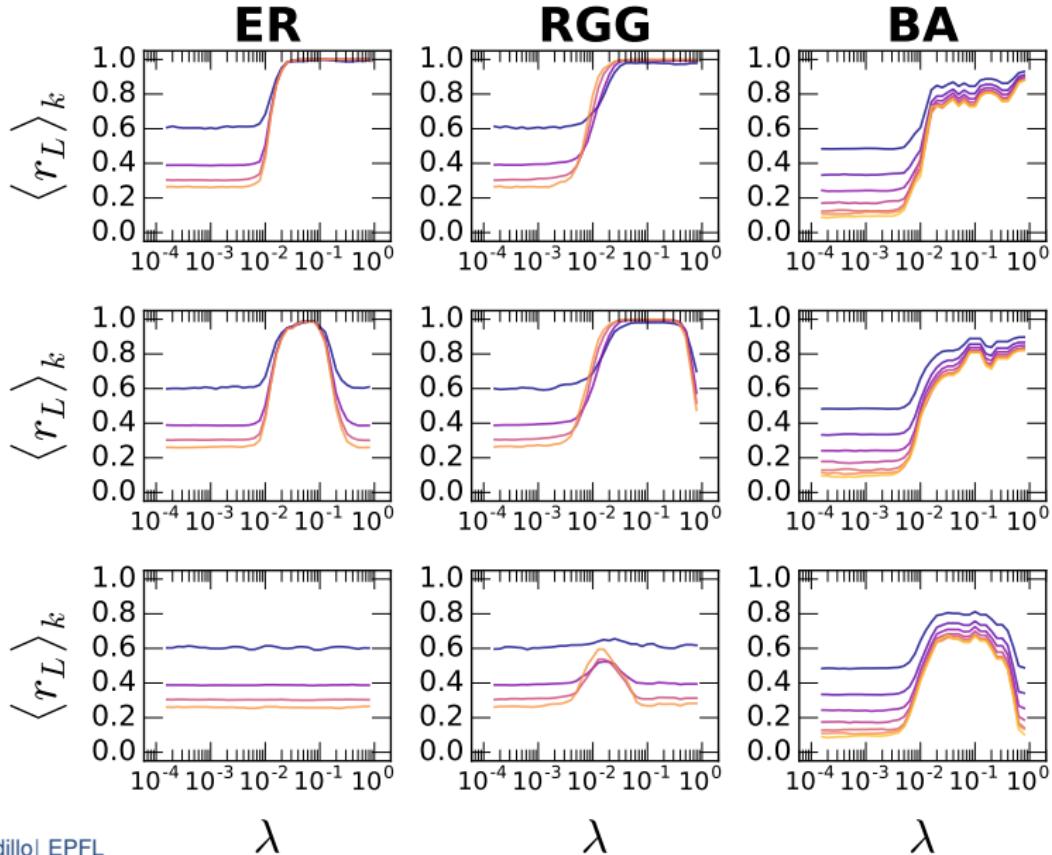
Macroscopic Behavior





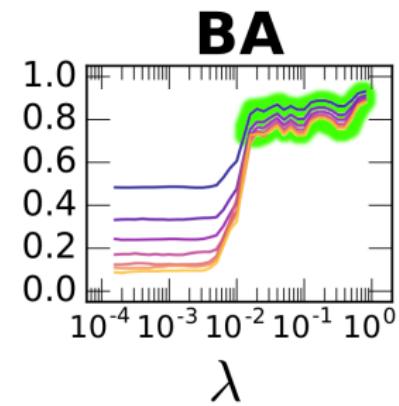
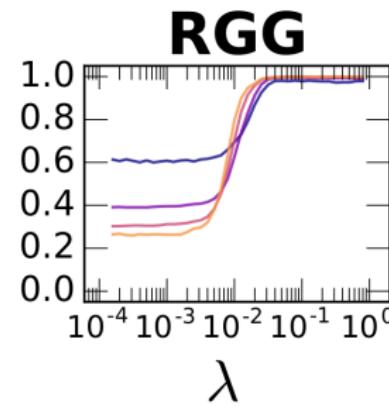
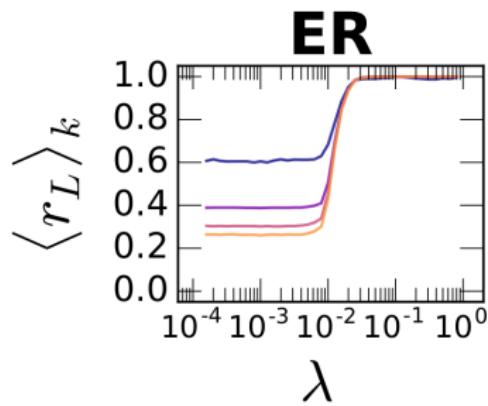
Macroscopic Behavior







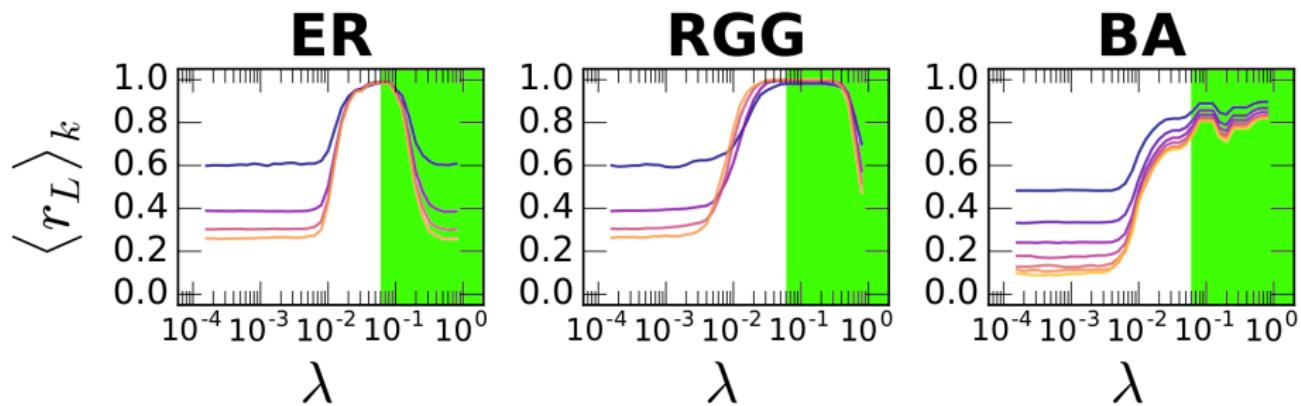
Low cost





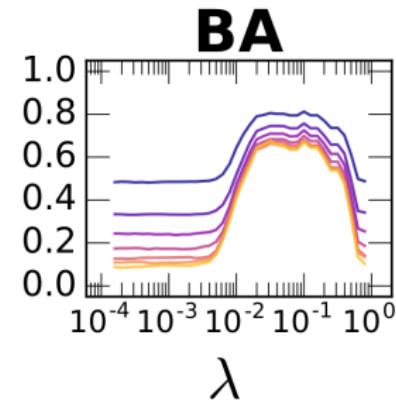
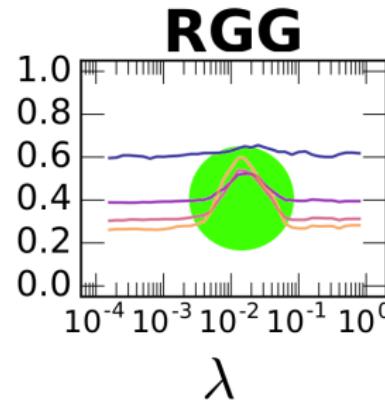
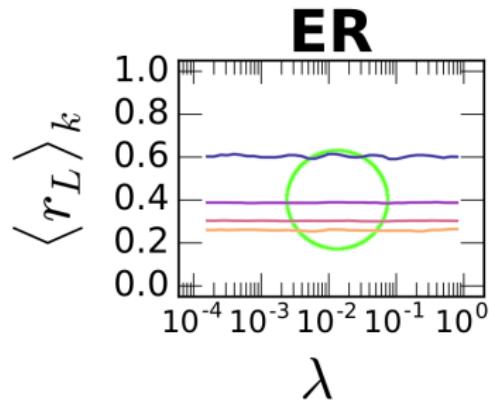
Microscopic Behavior

Medium cost



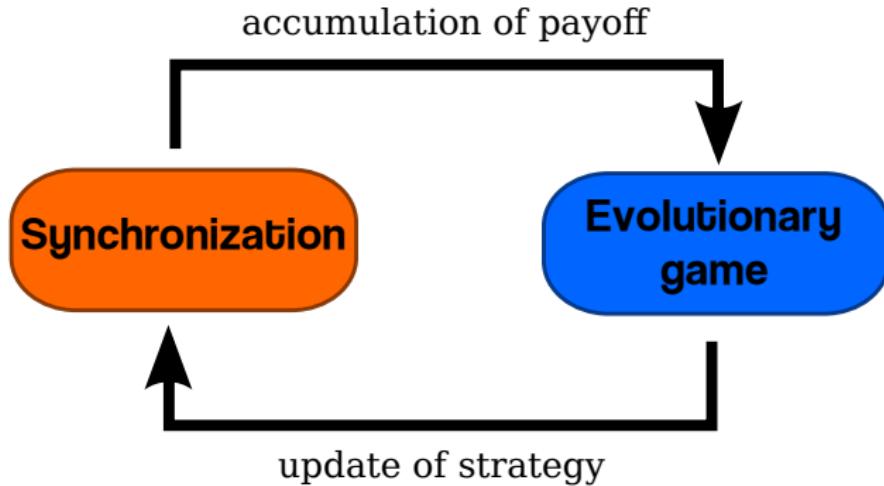


High cost

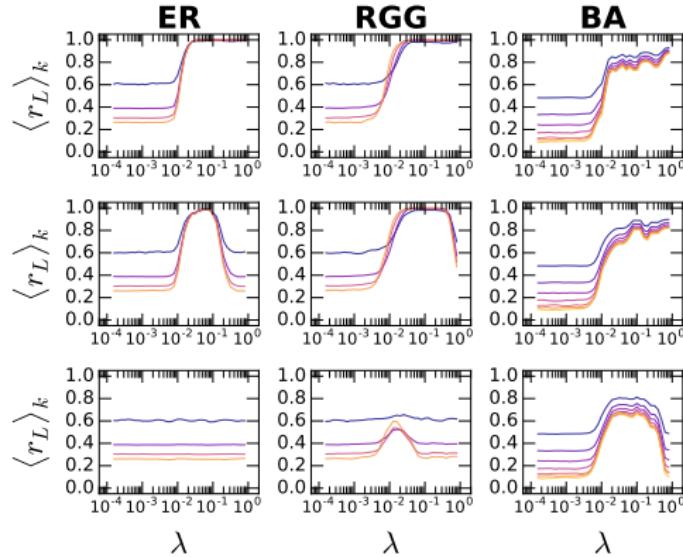


Conclusions

Coevolutionary model based on synchronization and evolutionary game theory.



Role of the underlying topology in the emergence of cooperation/synchronization.





Acknowledgements

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Alberto Antonioni
University Carlos III of Madrid





Acknowledgements

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Wanna know more?

Stay tuned on the arXiv ...



Salina, Sicily

Aug 29 - Sep 3 2016

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Mediterranean School of Complex Networks

The goal of this school is to provide a theoretical background to students (Master, PhD) and young researchers in the field, with particular attention to *current trends in Network Science*, and to *promote philosophical and scientific exchange* between all participants, lecturers and attendants.

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Granell Clara
Latora Vito
Meloni Sandro
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Peixoto Tiago
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Latora Vito (QMUL/INFN)

Local Organizing Committee

Agnello Serafina
Cardillo Alessio
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Omodei Elisa

Important dates

Apr 01 2016 Early registration deadline
Apr 15 2016 Notification of Acceptance
Apr 30 2016 Registration deadline

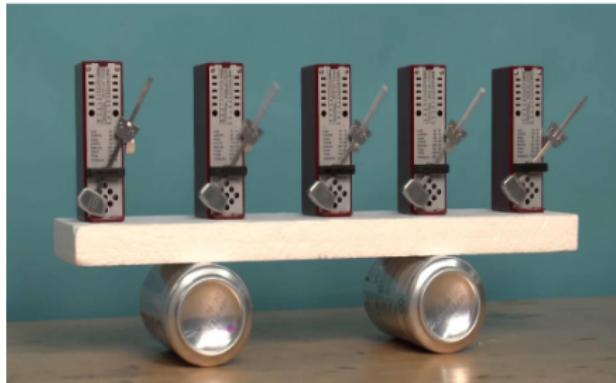
School coordinators

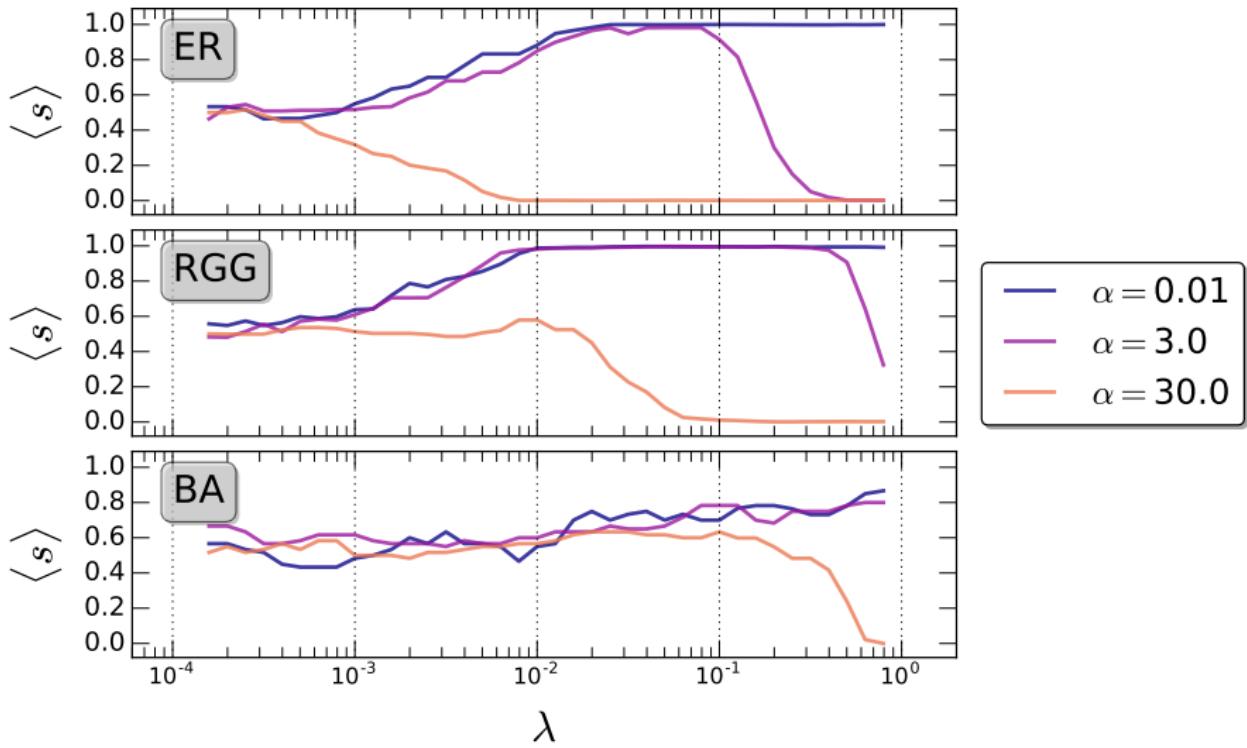
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De Domenico Manlio

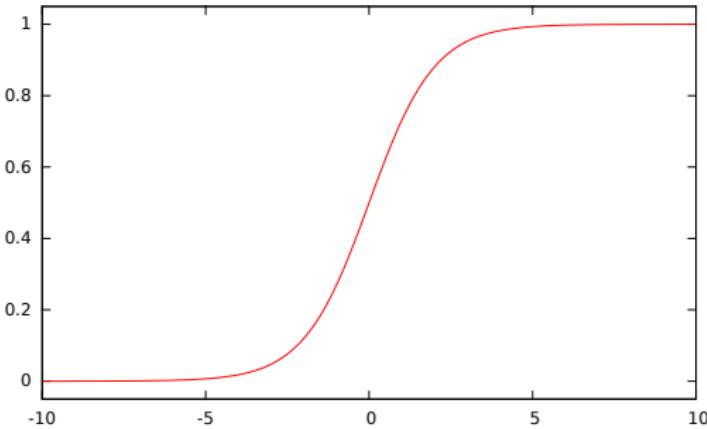
A synchronized world ...



Foto La Presse







Fermi's Rule

$$P_{I \rightarrow m} = \frac{1}{1 + e^{-\beta(\pi_m - \pi_I)}}.$$