The evolutionary Kuramoto's dilemma

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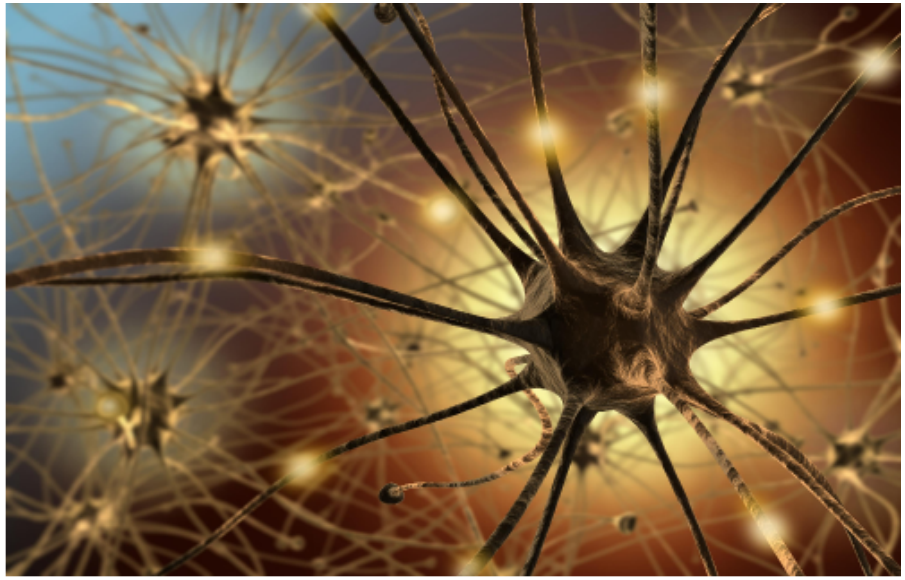
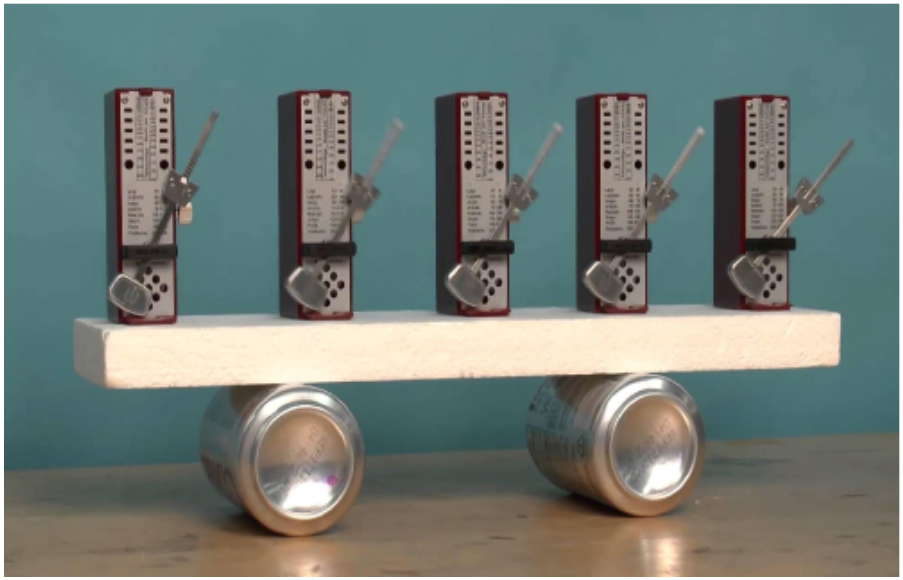
A synchronized world . . .






CHARIOTS OF FIRE

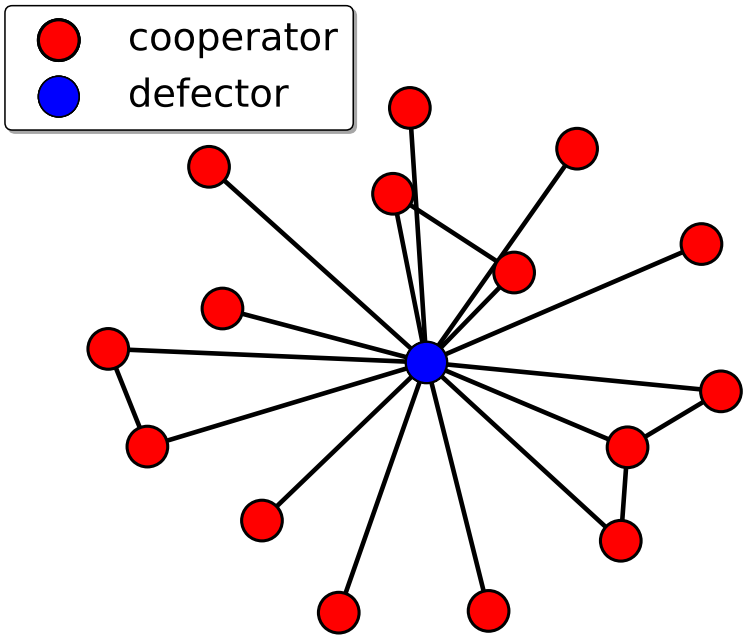
Kuramoto's Dilemma

Motivation

Question:

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

The model



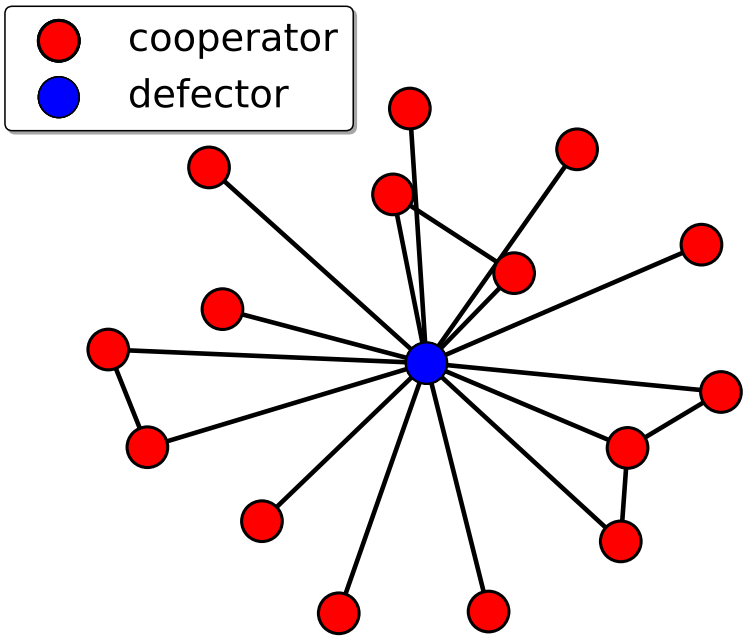
Strategy

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

Phase

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

The model

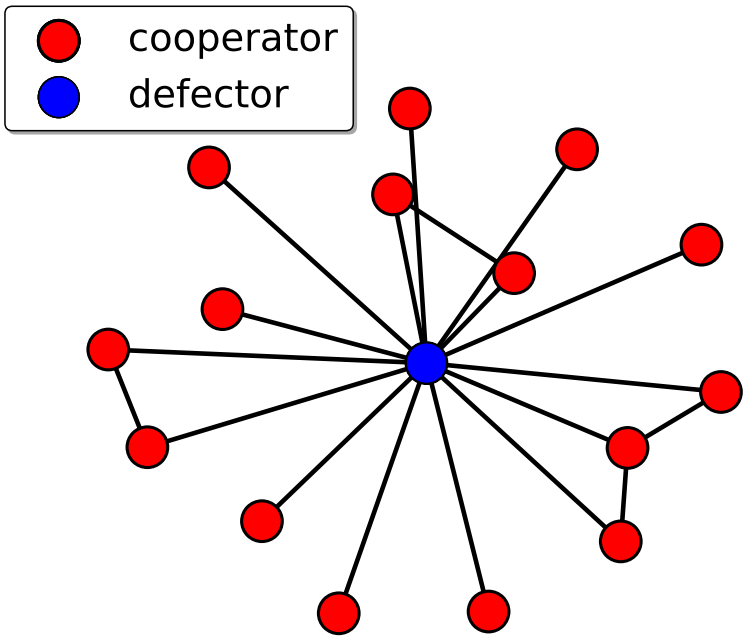


Kuramoto

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

J. Acebrón, *et al.* "*The Kuramoto model: A simple paradigm for synchronization phenomena*." Rev. Mod. Phys., **77**, 137 (2005).

The model



Evolutionary game

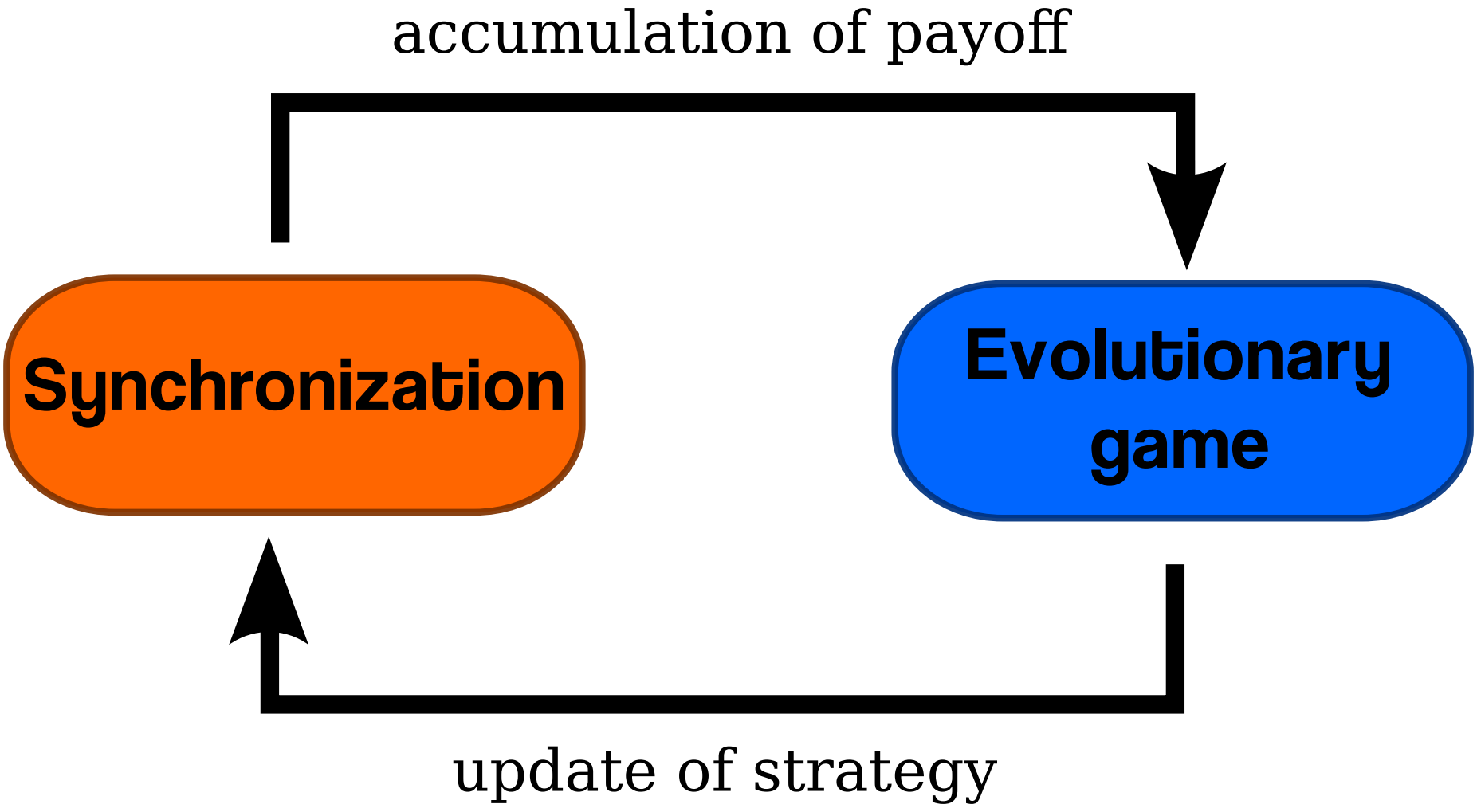
$$p_l \propto \underbrace{r_{L_l}}_{\text{benefit}} - \underbrace{\alpha\, c_l}_{\text{cost}} .$$

$$r_{L_l} = \frac{1}{k_l} \sum_{j=1}^{N} a_{lj} \frac{|e^{i\theta_l} + e^{i\theta_m}|}{2} \qquad r_L \in [0, 1] ,$$

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

C. P. Roca, *et al.* "*Evolutionary game theory: Temporal and spatial effects beyond replicator dynamics*." Phys, Life Rev., **6**, 208 (2009).

The model

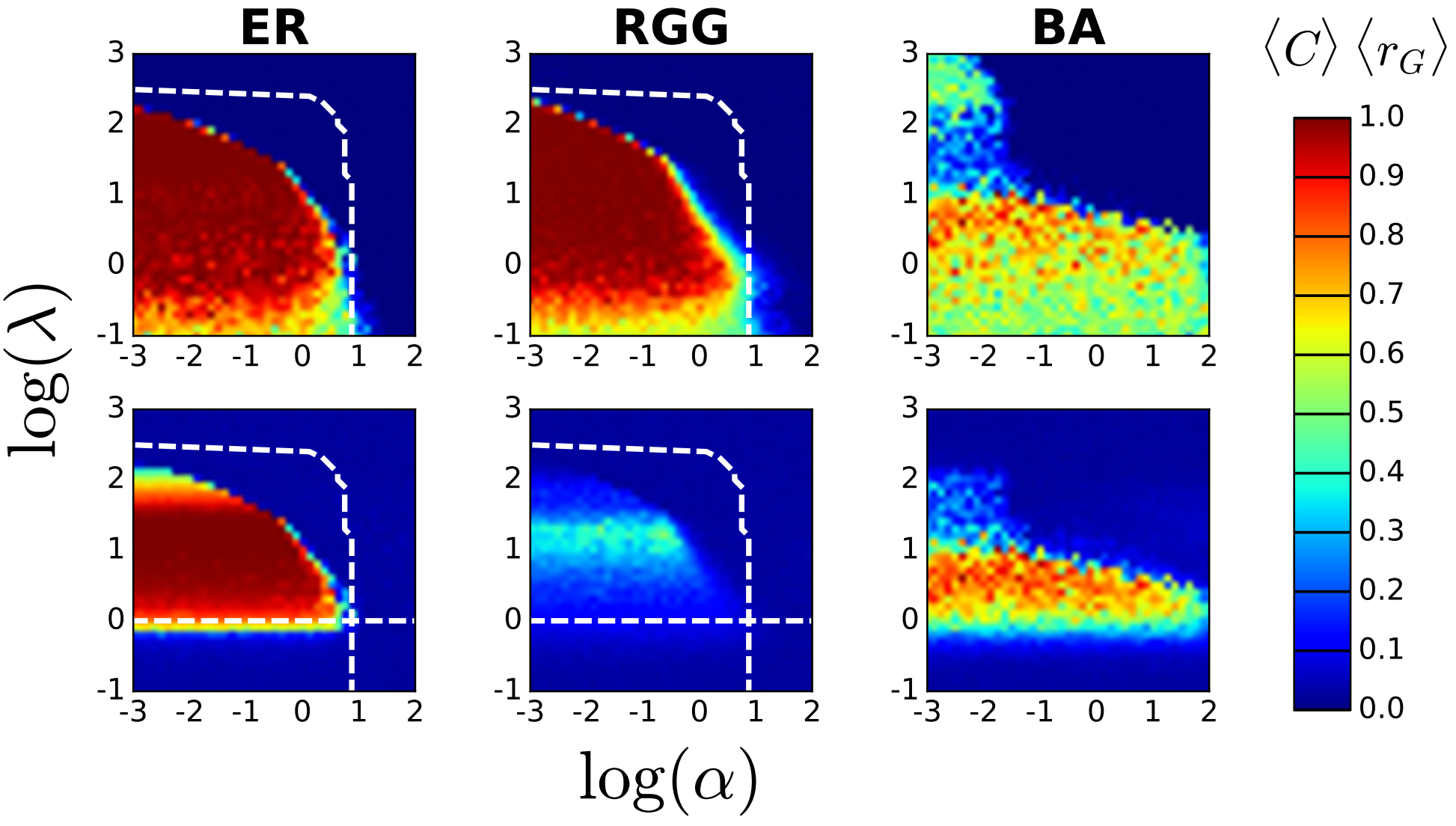

accumulation of payoff
Synchronization
Evolutionary game
update of strategy

The model

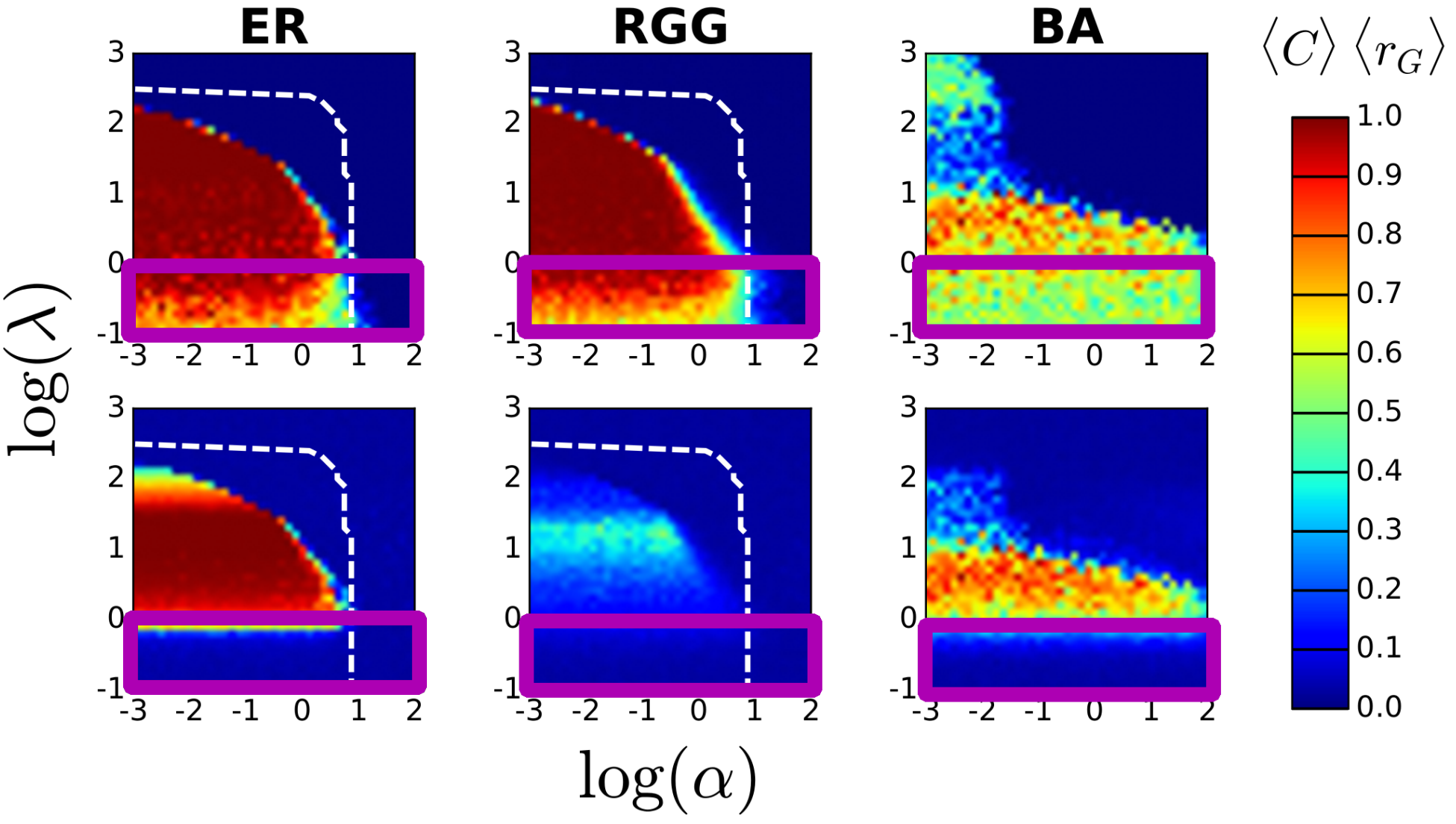
Question:

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

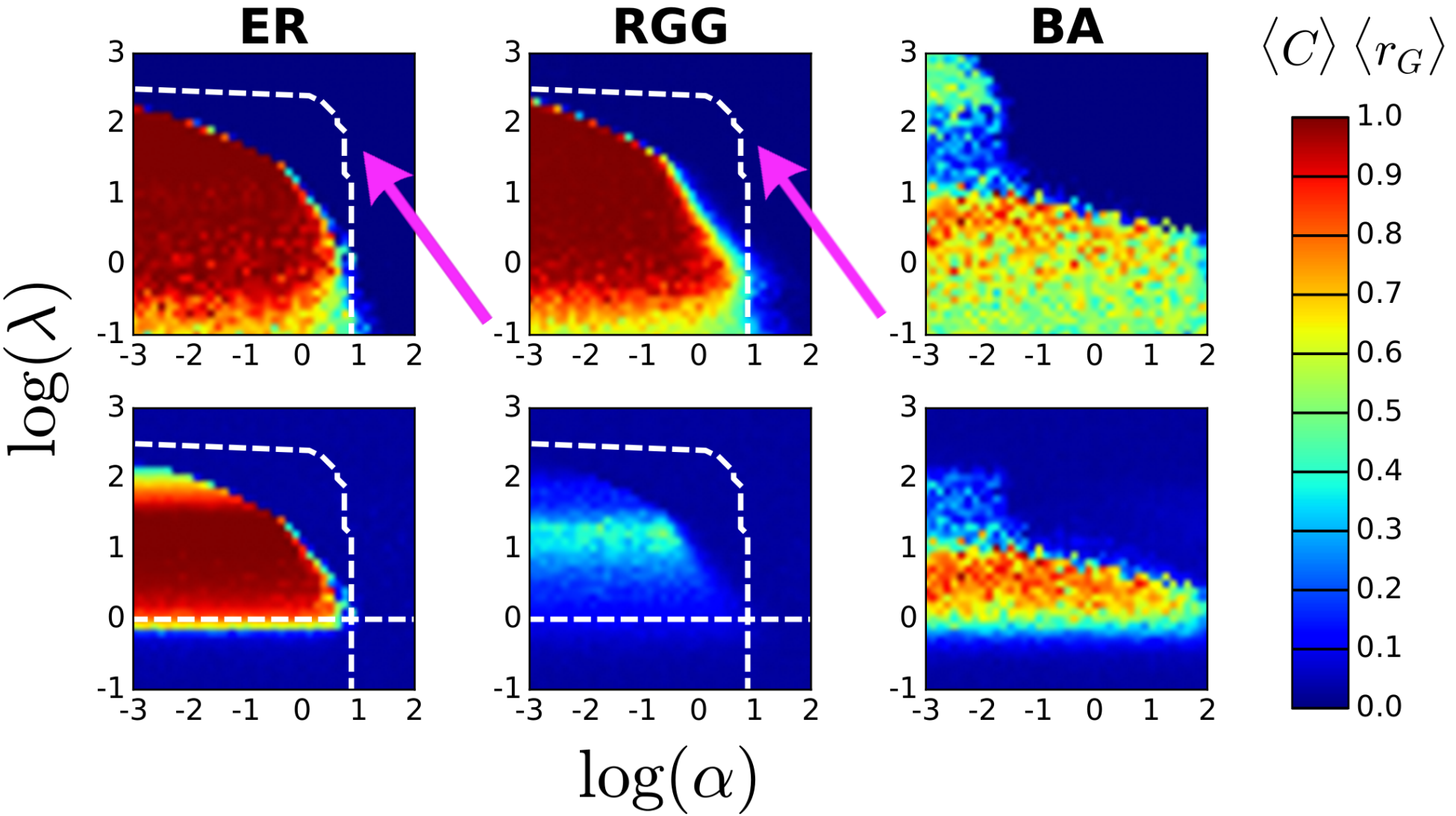
Macroscopic Behavior



Macroscopic Behavior

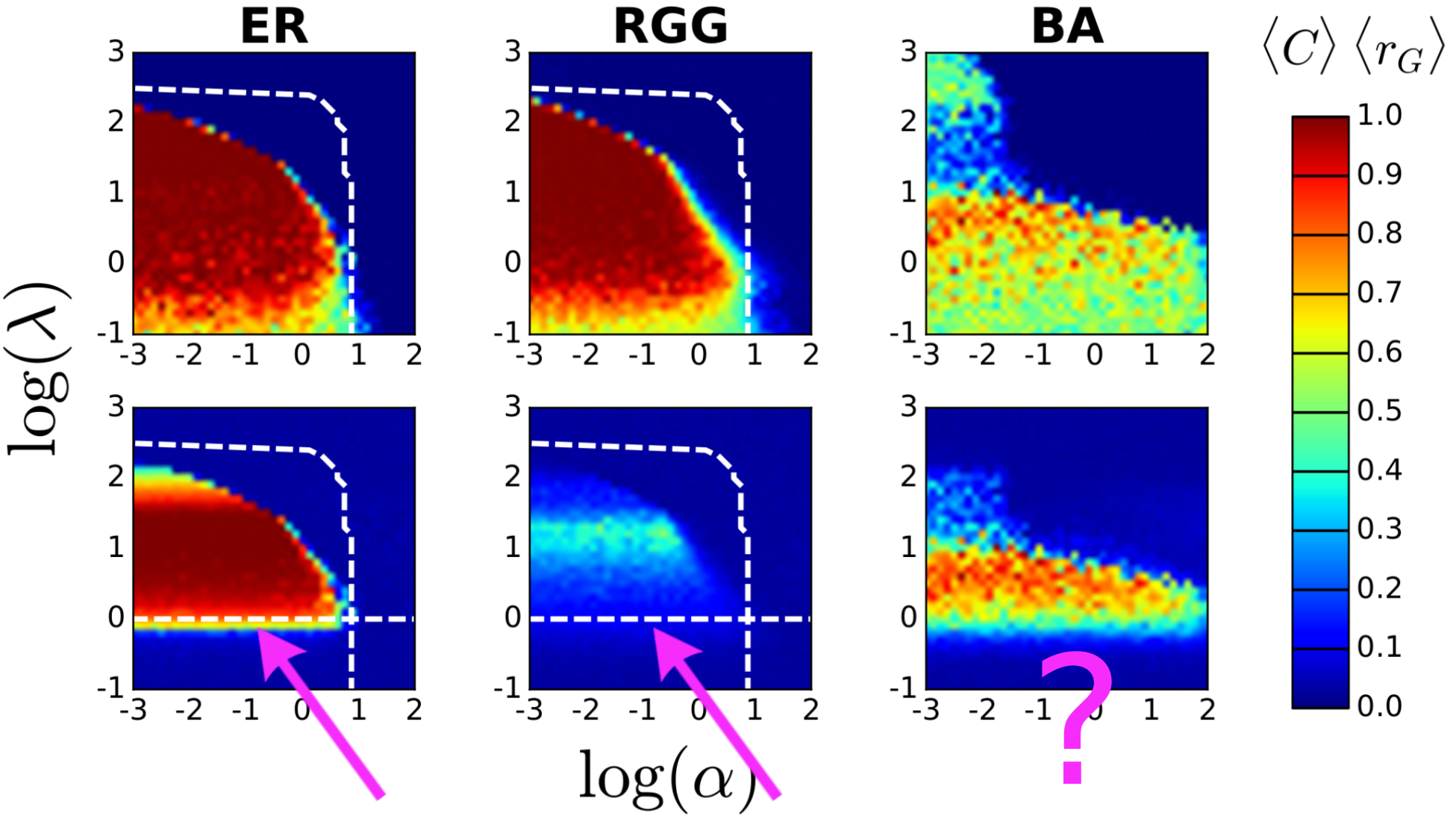


Macroscopic Behavior



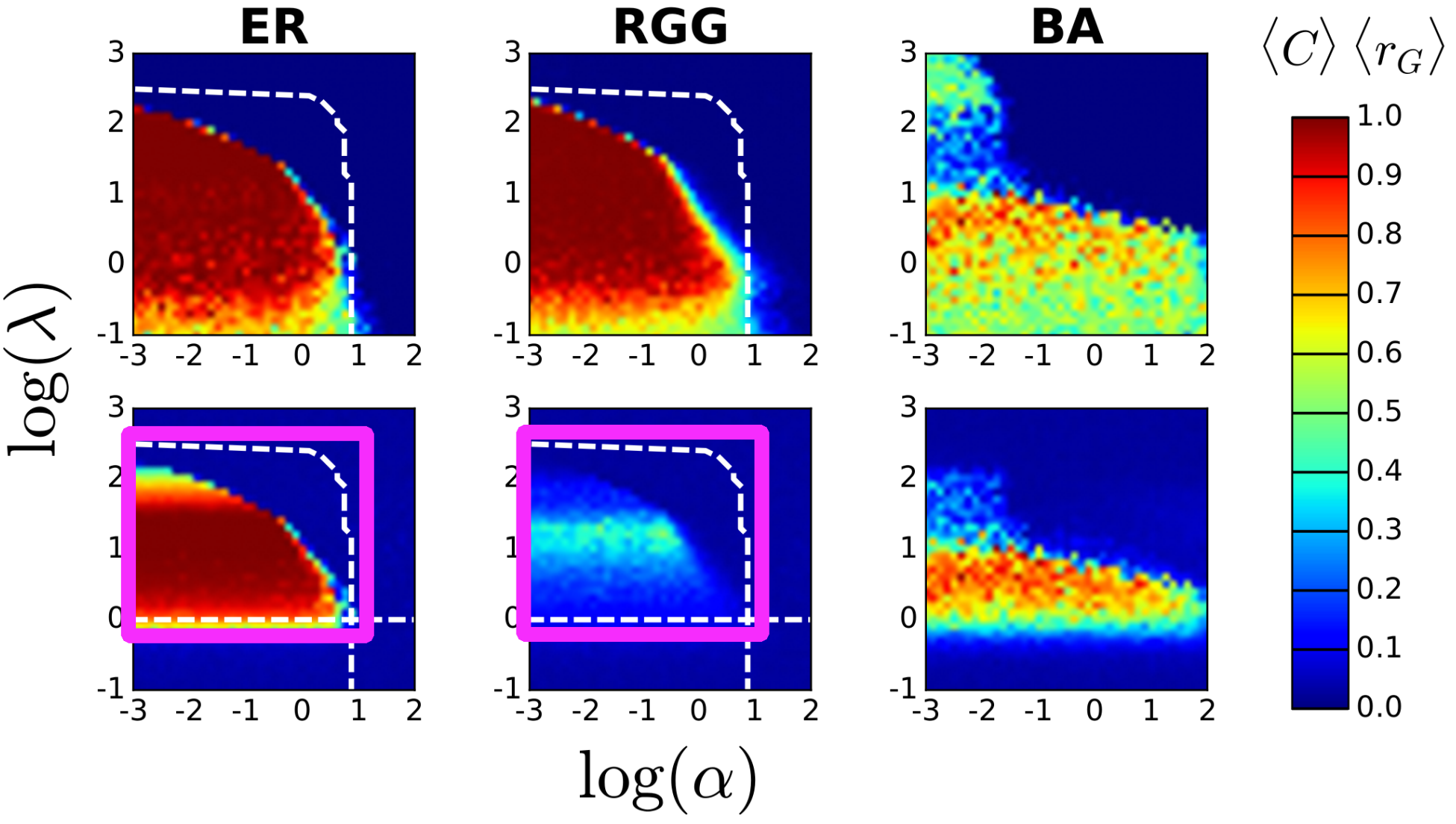
H. Ohtsuki *et al.* "*A simple rule for the evolution of cooperation on graphs* [. . .]". Nature, **441**, 502–505 (2006).

Macroscopic Behavior

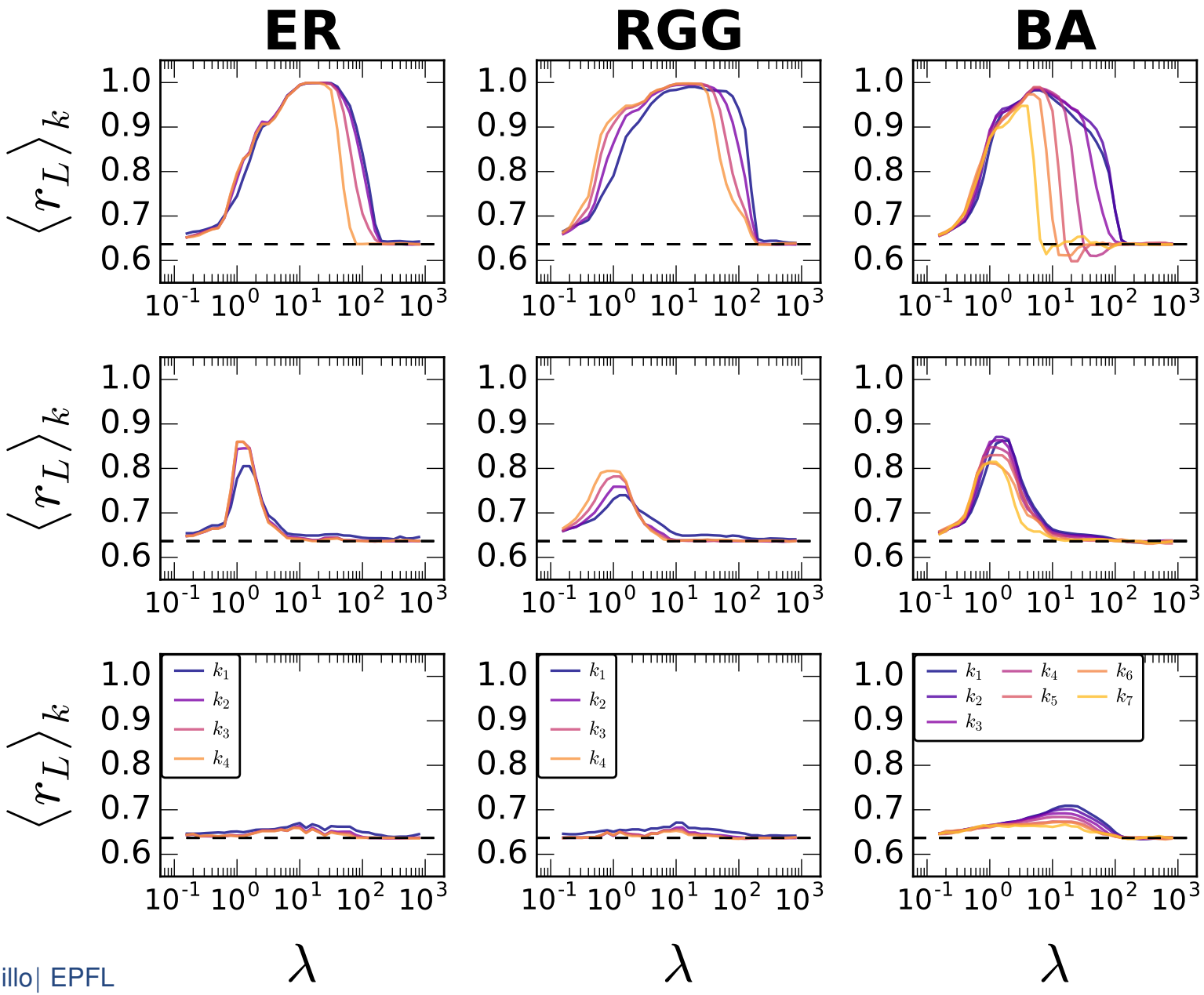


A. Arenas *et al.* "*Synchronization in complex networks.*" Physics Reports, **469**, 93–153 (2008).

Macroscopic Behavior

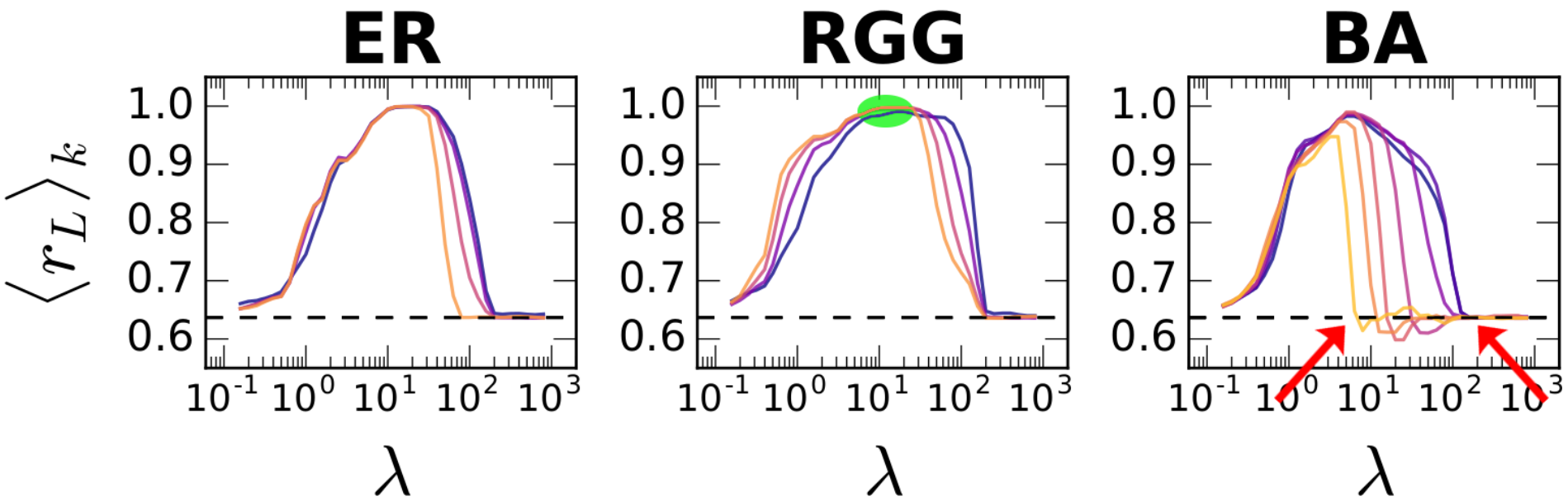


Microscopic Behavior



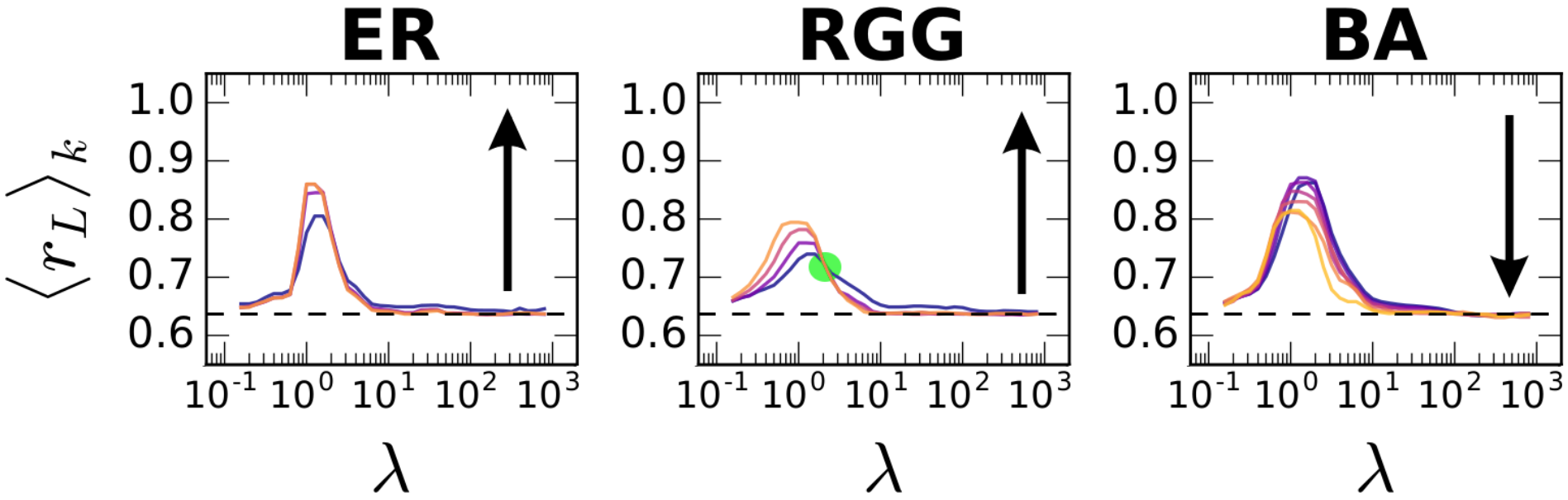
Microscopic Behavior

Low cost



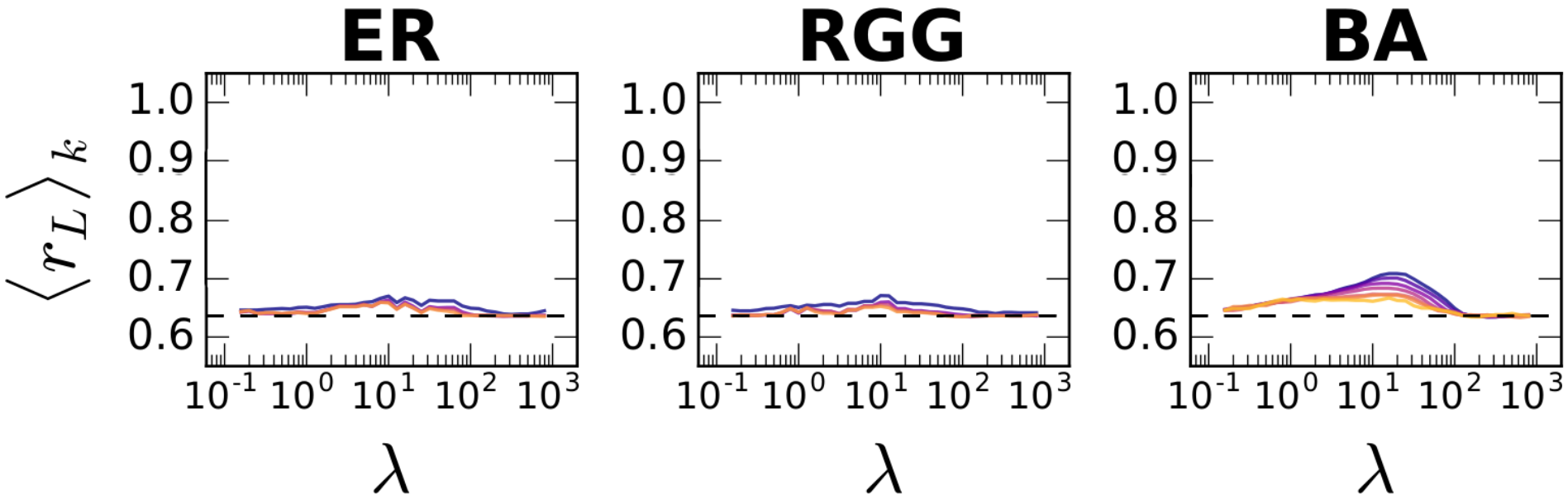
Microscopic Behavior

Medium cost



Microscopic Behavior

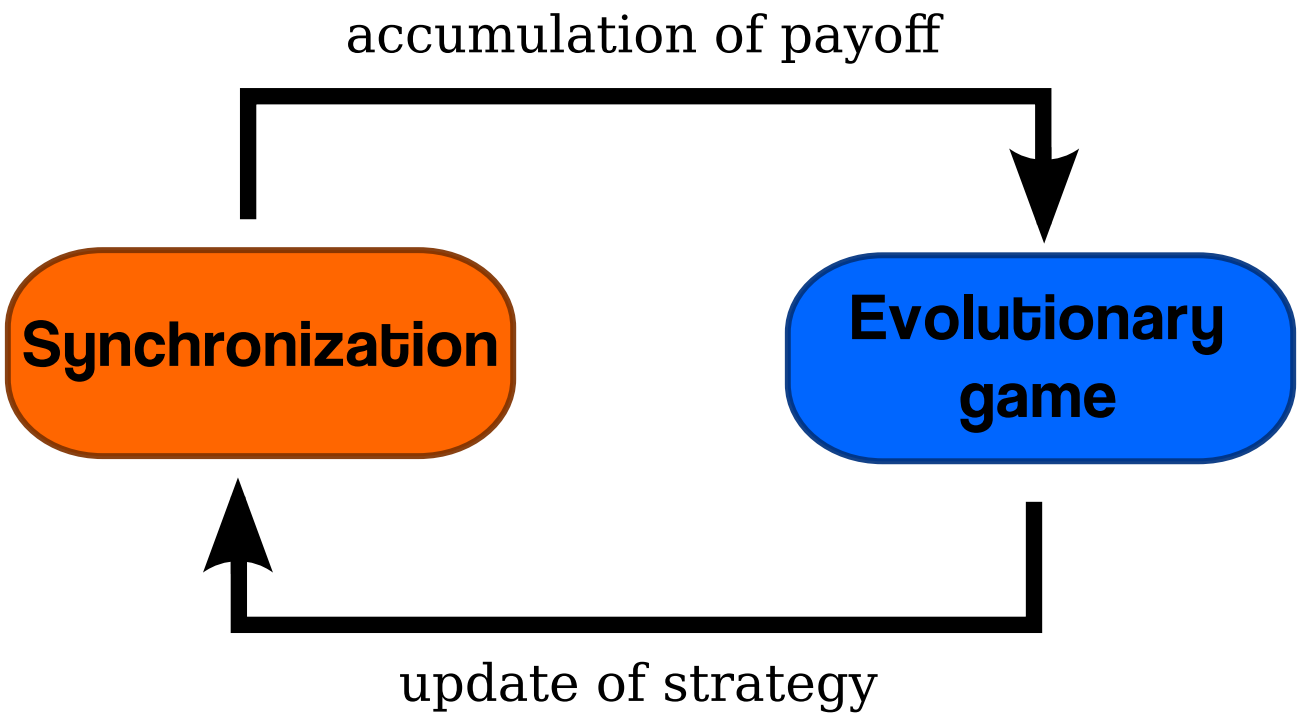
High cost



Conclusions

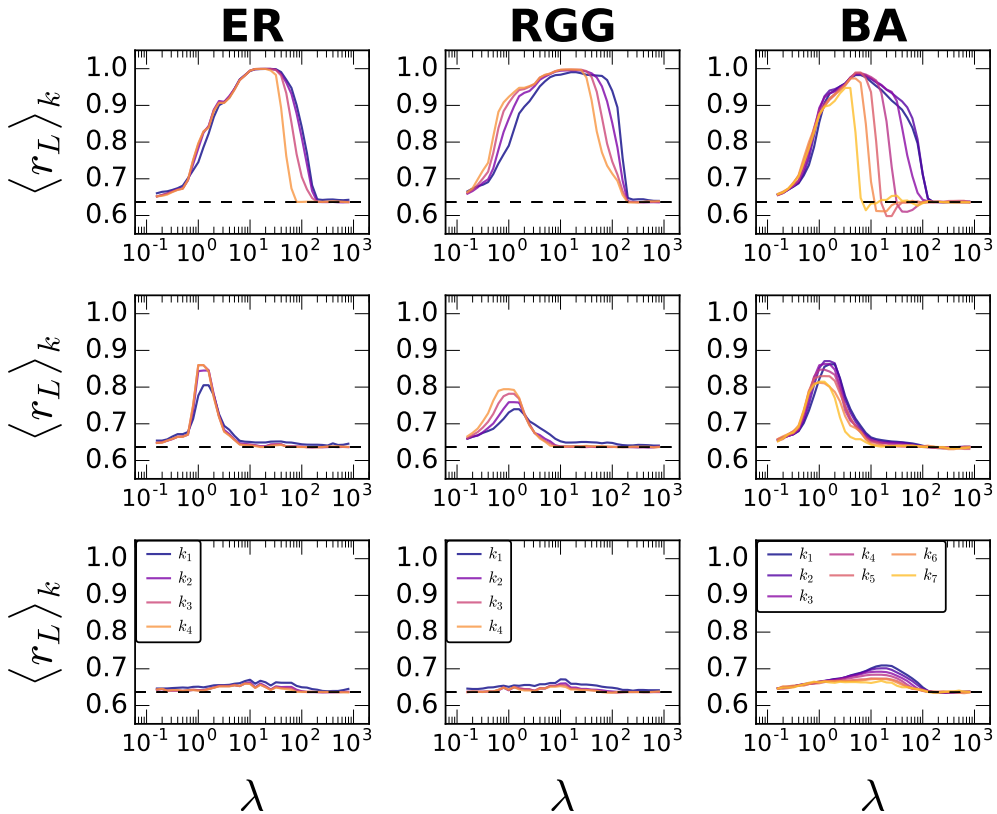
Take home messages

Coevolutionary model based on synchronization and evolutionary game theory.



Take home messages

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



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Acknowledgements

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Acknowledgements

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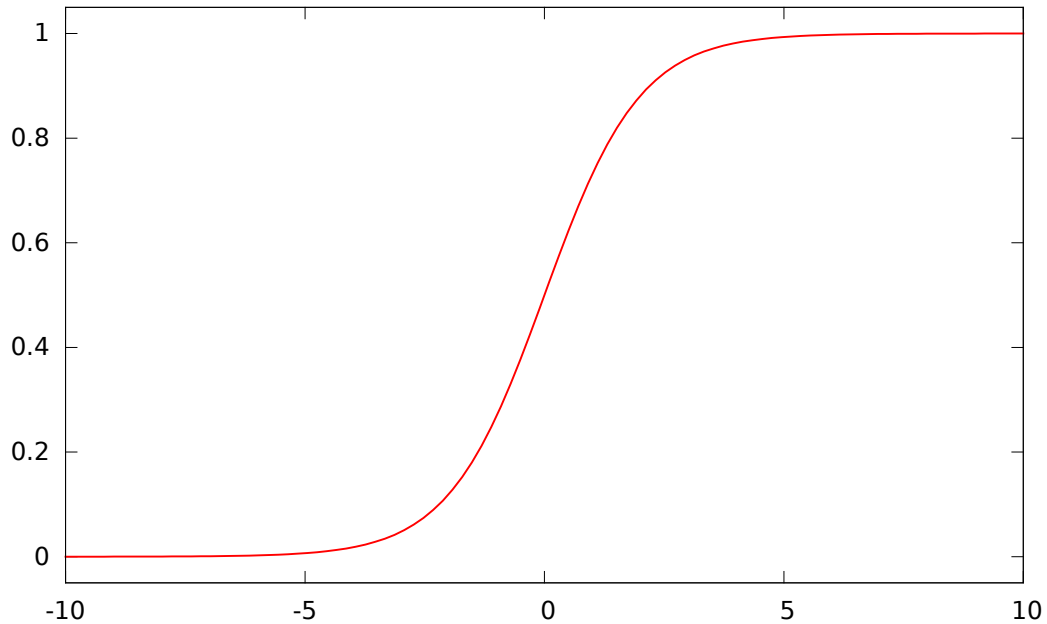
Wanna know more?

Stay tuned on the arXiv . . .



Fermi's Rule

$$P_{l\to m} = \frac{1}{1 + e^{-\beta(p_m - p_l)}} .$$