SFB 680

Molecular Basis of Evolutionary Innovations

Molekulare Grundlagen evolutionärer Innovationen

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The generalized repressilator model and applications of feedback control for synthetic gene regulatory networks

We study the temporal dynamics of the generalized repressilator, a network of coupled repressing genes arranged in a directed ring topology, and give analytical conditions for the emergence of a finite sequence of unstable periodic orbits that lead to reachable long-lived oscillating transients. Such transients dominate the finite time horizon dynamics that is relevant in confined, noisy environments such as bacterial cells, and are therefore of interest for bioengineering and synthetic biology. We show that the family of unstable orbits possesses spatial symmetries and can also be understood in terms of traveling wave solutions of kink-like topological defects. The long-lived oscillatory transients correspond to the propagation of quasistable two-kink configurations that unravel over a long time.

Based on the quasi-stable periodic orbits in this genetic network we propose a design for a switchable and controllable genetic oscillator. The oscillator operates around a quasi-stable periodic orbit using the classical engineering idea of read-out based control.

The insights from the read-out based control scheme for the genetic oscillator lead us to the idea to implement an algorithmic controller, which would direct any genetic circuit to a desired state. The algorithm operates model-free, i.e. in principle it is applicable to any genetic network and the input information is a data matrix of measured time series from the network dynamics. The application areas for readout-based control in genetic networks open a new perspective for tissue engineering, whenever quantitatively and temporarily targeted intervention is required.

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Institute for Genetics, Zülpicher Str. 47a, Lecture Hall, 4th floor

Host: Michael Lässig

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