Generating functionals for guided self-organization

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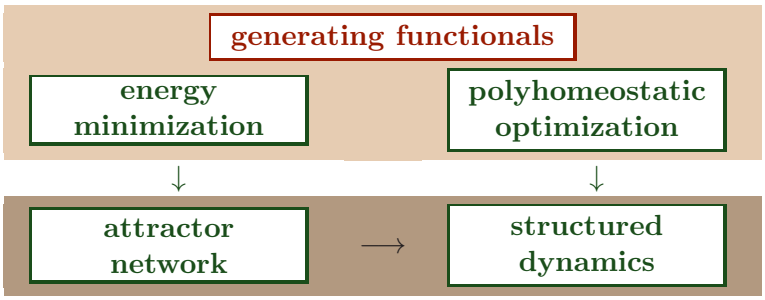
Abstract

Time evolution equations for dynamical systems can often be derived from generating functionals. Examples are Newton's equations of motion in classical dynamics which can be generated within the Lagrange or the Hamiltonian formalism. We propose that generating functionals for self-organizing complex systems offer several advantages. Generating functionals allow to formulate complex dynamical systems systematically and the results obtained are typically valid for classes of complex systems, as defined by the type of their respective generating functionals. The generated dynamical systems tend, in addition, to be minimal, containing only few free and undetermined parameters.

We make a first inroad into this field by studying the interplay between two generating functionals, based on energy maximization and polyhomeostatic optimization respectively. We find that structured dynamics arises self-organized through the competition between attractor dynamics, acting on short time scales, and slow adaption processes induced by the polyhomeostatic optimization. The structured dynamics can be tuned to take the form of either transient states, intermittent bursting, synchronized limiting cycles or chaotic behavior. We conclude that generating functionals offer a promising perspective for guiding dynamical self-organization in general.



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