Statisztikus Fizika Szemináriumok

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Tipping phenomena and resilience: two sides of the same coin?

Many systems in nature are characterized by the coexistence of different stable states for a given set of environmental parameters and external forcing. Examples for such behavior can be found in different fields of science ranging from mechanical or chemical systems to ecosystem and climate dynamics. As a consequence of the coexistence of a multitude of stable states, the final state of the system depends strongly on the initial condition. Perturbations, applied to those natural systems can lead to a critical transition from one stable state to another. Such critical transitions are called tipping phenomena in climate science, regime shifts in ecology or phase transitions in physics. Such critical transitions can happen in various ways: (1) due to bifurcations, i.e. changes in the dynamics when external forcing or parameters are varied extremely slow (2) due to fluctuations which are always inevitable in natural systems, (3) due to rate-induced transitions, i.e. when external forcing changes on characteristic time scale comparable to the time scale of the considered dynamical system and (4) due to shocks or extreme events. We discuss these critical transitions and their characteristics and illustrate them with examples from natural systems. Moreover, we discuss the concept of resilience, which has been originally introduced by C.S. Holling in ecology, and formulate it in terms of dynamical systems theory. This formulation offers mathematical and numerical tools to use it as a measure of the persistence of a function of a dynamical system.