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Editorial

The study of complex nonlinear processes is devoted to investigations of spatio-temporal structures in dynamical system far from equilibrium. The many and multi-faceted dynamical processes under study have their origin in the complex interaction of many degrees of freedom. The complex spatio-temporal dynamics at a macroscopic scale results from enhancement of common nonlinear modes which ignites processes of selforganization in these dynamical systems.

Basic concepts and principles, fundamentals as well as pioneering experimental work, go back to the sixties and seventies of the last century and are connected with the names of many renowned scientists from physics, applied mathematics and chemistry. Priogogine, Haken, Kuramoto, Belousov, Zhabotinsky, and later on Ertl pioneered the principles of the new scientific field of complex nonlinear processes. Up to now an immense number of fruitful studies have followed these seminal works, new fields of interest as well as new mathematical approaches and techniques have widened this rapidly evolving area of research.

Nowadays the field of complex nonlinear processes is flourishing. Today complex nonlinear processes are, comparable to statistical physics, ubiquitous in different areas of scientific research. Especially the evolving field of system biology benefits from the diverse achievements of the theory in the past. This is also the reason why the current issue collects various manuscripts devoted to biophysical problems. In addition large-scale geophysical and climatic behavior is accessible and can be understood with the help of methods from nonlinear modeling in nonequilibrium, only. Surprisingly, the unconventional approach to study all these diverse examples from a common point of view is still a powerful motor which strongly drives this research. The interdisciplinary approach which connects the different objects is a permanent source of new ideas and new solutions.

On the other hand it still continues the search for new mathematical methods and techniques which improve the ability to describe complex processes. In the last decade stochastic processes including anomalous transport theory became intrinsic parts of the theoretical framework. Also the inclusion of memory effects as well as retarded and delayed interactions gave a new impact during the last five years. Also effective methods to regularize chaotic, turbulent and stochastic behavior opened new grounds.

The present collection of original and review-type papers has been compiled by previous members of the Collaborative Research Center 555 "Complex Nonlinear Processes" of the German Research Foundation (DFG) which was located in the Berlin/Potsdam area. The center terminated its work in June 2010 and the current issue reflects the actual state of art in this field. In the final stage we encouraged the authors to combine their different expertise which is manifested in various contributions by groups of coauthors from different institutions and backgrounds. It also reflects the well established collaborations between the different groups of the center.

The current collection of papers included in this issue demonstrates the applicability of nonlinear deterministic and stochastic methods to various diverse fields. The striking plurality of phenomena is also reflected in the diversity of examples which are solved by a common mathematical approach. The main focus of the first three contributions is devoted to synchronization phenomena in oscillating, chaotic and stochastic dynamical systems. Synchronization is studied in models of neuronal activity (Omelchenko et al.), in coupled chaotic dynamics (Ngamga et al.) as well as in discrete two-state systems (Kouvaris et al.) where the controlling element between the two states is a delayed coupling.

The following three articles elaborate specific features of time-delayed feedback as a control method of the dynamical behavior of nonlinear systems. The first paper by Fiedler et al demonstrates the stabilization of odd number orbits by time delayed feedback and thereby refutes the previous common belief that this is never possible. Dahms and coauthors apply delayed feedback to semiconductor laser structures which gives rise to a novel noninvasive optical control technique. The case of large delay in nonlinear dynamics, including optical applications, is the topic of the article by Wolfrum et al.

The next two articles are devoted to geophysical and climatic dynamical systems which cannot be readily controlled. These examples possess higher significance as objects of their correct modeling and parameter forecasting. New predictions are made for the rupture propagation in an earthquake simulator (Zöller et al.) and for the rhythmicity of the Dansgaard-Oeschger events (Braun et al.). The latter are shown to be driven by solar activity and optimal noise.

Especially successful is the inclusion of biophysical examples as possible applications of nonlinear dynamics. The objects are by definition far from equilibrium, and fascinating applications are given at different spatial scales. The sequence of articles starts with complex molecules at active interfaces in the paper by Alonso et al. Faber at al consider the actin polymerization as driving force of cell motility and formulate a stochastic theory for the number of filaments. Radszuweit and coauthors study the calcium controlled thickness of protoplasmatic droplets of the slime mode of Physarum polycephalum. Eventually, the size distributions of aggregating self-propelled particles are discussed within the known Smoluchowski theory for cluster formation (Peruani et al.).

Basic concepts of stochastic dynamics in systems with many attractors require the calculation of escape rates which allow for a characterization of how fast the attractor is left. Two papers consider fundamental open problems, that is the escape process of high dimensional systems. In particular Fugmann et al look at the rupture of chains as response of an applied force and at a chain bound in a metastable minimum. In both systems nonlinear modes are excited to manage the problem. The second paper by Imkeller et al consider the well known Kramers problem but now driven by white noise whose support is given by a Levy distribution. Similar noise is used to discuss the occurrence of directed flows in potentials with broken reflection symmetry (Pavlyukevich et al.).

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