DY 30: Nonlinear stochastic systems

Time: Friday 10:15–13:00 Location: MA 001

DY 30.1 Fri 10:15 MA 001

Increase of Coherence in Excitable Systems by Delayed Feedback — Tobias Prager[1], Hans-P. Lerch[1], •Lutz Schimansky-Geier[1], and Eckehard Schöll[2] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, D-12489 Berlin — [2]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, D-10623 Berlin

The control of coherence and spectral properties of noise-induced oscillations by time-delayed feedback is studied in a FitzHugh-Nagumo system which serves as a paradigmatic model of excitable systems. A semianalytical approach based on a discrete model with waiting time densities is developed which allows one to predict quantitatively the increase of coherence measured by the correlation time, and the modulation of the main frequencies of the stochastic dynamics in dependence on the delay time. The analytical mean-field approximation is in good agreement with numerical results for the full nonlinear model.

Literature: Prager, T., Lerch, H. -P., Schimansky-Geier, L., and Schöll, E. "Increase of coherence in excitable systems by delayed feedback", J. Phys. A: Math. Theor. 40, 11045 (2007).

DY 30.2 Fri 10:30 MA 001

Controlling the coherence resonance in an excitable model exhibiting a global bifurcation — •Roland Aust, Johanne Hizanidis, and Eckehard Schöll — Institut f. Theor. Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We examine a generic model [1] exhibiting a global bifurcation, namely a saddle-node bifurcation on a limit cycle (SNIPER) under the influence of Gaussian white noise and time-delayed feedback control. It was shown earlier [2] that the delayed feedback itself is able to induce multistability in the system. Here we study the interaction between noise and time-delayed feedback. In the whole control-parameter plane the existence of coherence resonance can be confirmed. By varying the system's parameters we are able to choose the governing dynamics. In the regime where noise excites the system, the resulting oscillations can be controlled by the delayed feedback. We demonstrate the enhancement of coherence resonance by examining characteristic measures like the power spectral density and the correlation time. We also show how control enhances the regularity of the system's oscillations, and in which way noise affects the delay-induced oscillations in the multistability regime.

[1] G. Hu, T. Ditzinger, C. Z. Ning and H. Haken, *Stochastic resonance without external periodic force*, Phys. Rev. Lett. **71**, 807 (1993)
[2] J. Hizanidis, R. Aust and E. Schöll, *Delay-induced multistability near a global bifurcation*, Int. J. Bif. Chaos (2008), in print.

DY 30.3 Fri 10:45 MA 001

Stochastic modelling of experimental chaotic time series — Thomas Stemler[1,2], •Johannes P. Werner[1], Hartmut Benner[1], and Wolfram Just[3] — [1]Institut für Festkörperphysik, TU Darmstadt, 64289 Darmstadt — [2]School of Mathematics and Statistics, University of Western Australia, Crawley WA 6009, Australia — [3]Queen Mary / University of London, School of Mathematical Sciences, London E1 4NS, UK

Modelling dynamical degrees of freedom by suitable stochastic forces is a classical subject in theoretical physics and applied mathematics. While the replacement of many degrees of freedom in a thermodynamic system by Gaussian white noise is a textbook example and the foundation of e.g. irreversible thermodynamics, it is quite a recent finding that even few chaotic degrees of freedom can be modelled by stochastic differential equations.

Applying the Kramers–Moyal expansion to data from an electronic circuit experiment, we obtain a stochastic model of the low dimensional chaotic system [1]. We demonstrate that reliable drift and diffusion coefficients can be obtained even when there is no pronounced time scale separation. By comparing the *analytical* solution of the corresponding Fokker–Planck equation with *experimental* data we show that crisis induced intermittency can be described in terms of a stochastic model which is dominated by state space dependent diffusion.

[1] Phys.Rev.Lett. **98** No. 4, 044102 (2007)

DY 30.4 Fri 11:00 MA 001

Asymptotic continuous-time random walks models for deterministic diffusion — •Markus Niemann and Holger Kantz — Max-Planck-Institut fuer Physik komplexer Systeme, Dresden

Continuous-time random walks (CTRW) are often used to model anomalous diffusion. We set up a general description of a (possibly) space-time coupled version of a CTRW with continuous "virtual time". We identify the self-affine ones which emerge as long time limits. For a certain class of deterministic maps we identify the components of such CTRWs from the probabilistic behavior of these maps. In particular, we include classes with non-normalizable ergodic measure. Hence, we obtain a stochastic model for the long time behavior. This setup is exemplified analytically and numerically in a Manneville-Pomeau like setting. Depending on the ranges of the parameter we obtain sub- and superdiffusion.

DY 30.5 Fri 11:15 MA 001

Noisefree Stochastic Resonance at an Interior Crisis — •Thomas Jüngling[1], Thomas Stemler[1,2], Hartmut Benner[1], and Wolfram Just[3] — [1]Institut für Festkörperphysik, TU-Darmstadt, 64289 Darmstadt, Germany — [2]School of Mathematics and Statistics, University of Western Australia, Crawley, Australia — [3]Queen Mary/University of London, United Kingdom

We report on the observation of noisefree stochastic resonance in an externally driven diode resonator close to an interior crisis. At sufficiently strong excitation the diode resonator shows a strange attractor which, after the collision with a unstable period-3 orbit, exhibits crisis-induced intermittency. In the intermittency regime the system jumps between the previously stable chaotic attractor and the new phase space regions accessible due to the crisis. The random jumping between these two dynamic states can be used to amplify a weak periodic signal through the mechanism of stochastic resonance. In contrast to conventional stochastic resonance no external noise is needed, but its role is taken on by the fast intrinsic chaotic dynamics. Our data obtained at the diode resonator are compared with numerical results from the logistic map, where a similar crisis-induced intermittency is observed.

DY 30.6 Fri 11:30 MA 001

Noise-induced Nucleation in Spatially Extended Excitable Media — •Felix Müller — Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

We investigate the spontaneous noise-induced nucleation of dissipative structures. For this purpose we use the stochastic FitzHugh-Nagumo model in the excitable regime with diffusive coupling in one and two dimensions. The appearance of these structures like moving waves, stable wave segments or rotating spirals is well known from a wide range of complex systems. Famous examples are the Belousov-Zhabotinsky reaction or the intracellular calcium dynamics.

We explore the dependency of the mean nucleation time on the main features of the system as excitability, noise strength, and time scale separation and compare it with the scaling known from the analytical results in the limit of the local dynamics.

DY 30.7 Fri 11:45 MA 001

Noise-induced synchronisation in heterogeneous nets of neural elements — •Erik Glatt, Martin Gassel, and Friedemann Kaiser — Institute of Applied Physics, Darmstadt University of Technology, 64289 Darmstadt, Germany

Noise may have a strong influence on the dynamics of many spatially extended nonlinear systems. Variability (diversity, heterogeneity), where variability denotes static stochastic differences between otherwise equal elements of a system, may have similar effects. In this contribution the interplay of additive noise and additive variability in an oscillatory net of FitzHugh-Nagumo elements is studied. Both have a crucial influence on the phase synchronisation of the elements in the net. It is shown that additive variability induces pattern formation (phase waves) and hence even small values of the variability strength destroy the synchronised oscillation the net exhibits without variability. In such a heterogeneous net the synchronisation can be restored via additive noise. This noise-induced phase synchronisation exhibits a resonance-like dependency on the noise strength.

The variability-induced pattern formation is again a resonance-like effect provided additive noise is present in the net. In this case one finds maximally coherent patterns for intermediate values of the variability strength.

DY 30.8 Fri 12:00 MA 001

Noise-Dependent Stability of the Synchronized State in a Coupled System of Active Rotators — •Sebastian F. Brandt[1], Axel Pelster[2], and Ralf Wessel[1] — [1]Department of Physics, Washington University in St. Louis, MO 63130-4899, USA — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

We consider a Kuramoto model for the dynamics of an excitable system consisting of two coupled active rotators. Depending on both the coupling strength and the noise, the two rotators can be in a synchronized or a desynchronized state. The synchronized state of the system is most stable for intermediate noise intensity in the sense that the coupling strength required to desynchronize the system is maximal at this noise level. We evaluate the phase boundary between synchronized and desynchronized states through numerical and analytical calculations.

DY 30.9 Fri 12:15 MA 001

Chaos induced oscillations by multiplicative noise in the Kapitza Pendulum — •Angelo Facchini[1,2], Chiara Mocenni[1,2], and Antonio Vicino[1,2] — [1]Center for the Study of Complex Systems, University of Siena, Italy — [2]Department of Information Engineering, University of Siena, Italy

Also known as the *Kapitza Pendulum*, the parametrically forced pendulum has been widely investigated by many scientists as the paradigmatic toy model of a wide range of phenomena. Physically it consists of a physical pendulum whose pivot oscillates sinusoidally with amplitude A and frequency ω. Despite the simplicity, the KP depends strongly on its parameters. In particular the variation of the amplitude of the sinusoidal forcing, produces complex behaviors such the stabilization of the inverted position, parametrically forced oscillations, bifurcations and chaotic oscillations (for more details see [*Am. J. of Physics*, **60**, 903-908, 1992;]). The influence of noise on the dynamical behavior of the KP has been also studied. In particular, the role of additive noise has been studied by Blackburn [*Proc. of the Royal Soc. A*, **462**, 1043-1052, 2006], while the case of the randomly oscillating pivot has been investigated by Landa [*Phys. Rev. E*, **54**, 3535, 1996]. Both found the arise of noise-mediated chaotic oscillations and noise-mediated transitions. We study the influence of the stochastic perturbation of the parameter A. This results in the study of the effect of multiplicative noise on the pendulum. We show that the adding of a very small amount of noise induces the anticipation of bifurcation points and sustains permanently chaotic oscillations, extending the results of Blackburn.

DY 30.10 Fri 12:30 MA 001

Reconstruction of nonlinear dynamics from discrete observations — •Andreas Ruttor and Manfred Opper — Institut für Softwaretechnik und Theoretische Informatik, Technische Universität Berlin, Franklinstr. 28/29, 10587 Berlin, Germany

Nonlinear dynamical systems are often described by diffusion models based on stochastic differential equations (SDEs). As long as the distance between observations is small, drift and diffusion can be calculated directly and used to determine unknown parameters. Otherwise, both the state of the system between observations and the parameters of the SDEs have to be estimated. However, Markov chain Monte Carlo based methods used for that purpose can be very time consuming. As an alternative a fast approximate approach is proposed. By solving the backward Fokker-Planck equation of the diffusion model in the weak noise limit, it is possible to obtain the drift of the posterior SDE directly. Afterwards the posterior statistics can be computed either by applying the weak noise limit again (leading to an approximate Gaussian posterior process), or more simply by simulating many samples of the posterior SDE. Parameter estimation is based on the negative log-likelihood of the data. Minimizing an upper bound of this quantity, which can also be calculated in the state inference algorithm, leads to type II maximum likelihood estimates of unknown system parameters. Results obtained in the case of reaction systems indicate that this approach works well.

DY 30.11 Fri 12:45 MA 001

Collective transport of an array of nonlinear coupled oscillators in a periodic potential — •Steffen Martens, Dirk Hennig, and Lutz Schimansky-Geier — Institut fuer Physik, Humboldt-Universitaet zu Berlin, Newtonstrasse 15 12489 Berlin, Germany

The transport of an array of nonlinear coupled particles subjected to a two-dimensional eaves gutter potential is investigated in the high-friction limit. Due to the application of an external point force the symmetry is broken and therefore a directed motion occurs. The mobility of the center of mass of the system of coupled particles possesses distinct properties depending on the system size. Thus, the behaviour is different compared to a monomer under the same transport conditions. In particular it is found that the mobility is a complicated non-monotonous function of the equilibrium distance. Depending on the coupling strength between the particles two different transport scenarious occur. For weak coupling, the transport is for a given set of parameters dominated by the temperature. In contrast, for strong coupling the mobility is determined by the applied point force only.