DY 28: Nonlinear stochastic systems

Time: Thursday 14:00–16:30 Location: H2

DY 28.1 Thu 14:00 H2

Polymer translocation through a nanopore - A twodimensional Langevin dynamics study — •Dirk Hennig, Simon Fugmann, and Lutz Schimansky-Geier — Institut für Physik, Humboldt Universität zu Berlin, Newtonstr. 15, 12489 Berlin

We study the process of translocation of a polymer through a nanopore using a two-dimensional Langevin dynamics simulation. Initially the whole chain is placed on one side of the nanopore in a certain distance to the entrance of the latter. Special attention is paid to the influence of the chain length on the time it takes till the first segment of the chain enters the nanopore as well as the translocation time. It is demonstrated that depending on the flexibility of the chain and the width and longitudinal extension of the nanopore several translocation scenarios arise. For narrow nanopores the chain can pass the nanopore only in a completely stretched configuration whereas if the width of the nanopore is beyond a critical value the chain is translocated even in folded shape. Thus in the last case any segment of the chain can be the one that enters first the nanopore in contrast to the former case for which necessarily an end segment of the chain enters first the nanopore and is consecutively followed by the remaining segments.

DY 28.2 Thu 14:15 H2

Self-organized critical control in human balance behaviour — •Markus Riegel, Christian Eurich, and Klaus Pawelzik — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn Allee 1, D-28334 Bremen

Humans are known to exhibit power law distributed fluctuations in their behaviour e.g. when trying to stand still. Here we show, that power law distributed fluctuations generically arise in control of unstable dynamical systems driven with gaussian noise when an optimal controller can use observations only from the immediate past to estimate the parameters of the controlled subsystem. With increasing memory the exponent of the distributions grows and the auto-correlations of fluctuation amplitude decays faster. We tested the predictions of this self-organized critical control (SOCC) in a simple task where humans where required to stabilize an unstable target on a computer screen with the computer mouse. We found that also here the resulting dynamics are close to Levy-flights and exhibit power law distributed fluctuations. In stationary tasks the exponent of the distributions and the decay rates of auto-correlations increased with duration indicating that in this case the memory span utilized by humans expands. No such changes were seen in experiments where the systems parameters where constantly changed. Taken together our results indicate that the nervous system indeed employs self-organzed critical control and furthermore adapts its memory span depending on the stationarity of the task.

DY 28.3 Thu 14:30 H2

Generalized Markov approximations — •Detlef Holstein and Holger Kantz — Max-Planck-Institut fuer Physik komplexer Systeme, Dresden

In general arbitrary dynamics can be highly nonmarkovian, i.e. the future evolution of the dynamics can in principle depend on quite a lot of time points in the far past. For practical purposes it is often necessary to truncate a rather irrelevant part of the memory. Hence a criterion based on information theory and statistics is developed, which identifies the relevant memory terms. Consequences for prediction, especially wind speed prediction, are investigated.

DY 28.4 Thu 14:45 H2

Cooperative escape dynamics of an oscillator chain under microcanonical conditions — •Simon Fugmann, Dirk Hennig, and Lutz Schimansky-Geier — Institut fuer Physik, Humboldt Universitaet zu Berlin, Newtonstrasse 15, 12489 Berlin, Deutschland

We consider the self-organized escape of a chain of coupled oscillators from a metastable state over an energetic barrier. The underlying dynamics is conservative and deterministic. Supply of sufficient total energy or application of external forces brings the chain into the nonlinear regime from which an initially almost uniform lattice state becomes unstable and nonlinear redistribution leads to strong localization of energy. A spontaneously emerging critical localized mode grows to the unstable transition state and the chain, passing through the latter, performs a collective escape process over the barrier. It turns out that this nonlinear barrier crossing in a microcanonical situation is more efficient compared with a thermally activated chain for small ratios between the total energy of the chain and the barrier energy.

DY 28.5 Thu 15:00 H2

Stochastic Modeling of fast Hamiltonian Chaos — •Anja Riegert[1], Niluefer Baba[2], Wolfram Just[3], and Holger Kantz[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]TU München, Germany — [3]Queen Mary/University of London, United Kingdom

The study of the long time behavior of systems with time scale separation is considerably facilitated if the fast degrees of freedom can be eliminated without affecting the slow dynamics. By applying projection operator techniques we show that in chaotic Hamiltonian systems the fast subsystem can be replaced by a suitable stochastic process so that the slow motion is effectively described by a Fokker-Planck equation where the interplay of viscous damping and diffusion conserves the total energy and ensures the correct long time behavior. The accuracy and efficiency of this approach is verified by a numerical investigation of suitable model systems.

DY 28.6 Thu 15:15 H2

How to characterize chaotic time series distorted by interacting dynamical noise — •Achim Kittel[1], Tobias Letz[1], and Joachim Peinke[2] — [1]Energy and Semiconductor Research Laboratory, Institute of Physics, University of Oldenburg — [2]Hydrodynamics and wind energy, Institute of Physics, University of Oldenburg

Results of commonly used time series analysis methods on experimental and, therefore, noisy data become often questionable if the underlying deterministic part of the dynamics is a priori unknown and additionally chaos is involved. We apply a recently proposed method, based on the theory of Markovian processes, for extracting the deterministic dynamics from data distorted by dynamical noise. We treat the typical experimental situation where only one variable is measurable of a higher dimensional dynamics. Here we show that an improved estimation of power spectrum, attractor dimension, and Lyapunov exponents can be achieved for the hidden pure deterministic dynamics. In particular we study exemplarily two different systems, namely, the Roessler system distorted by noise and an experimental laser system supposed to behave in low dimensional nonlinear manner.

DY 28.7 Thu 15:30 H2

Supressing noise-induced intensity pulsations in semiconductor lasers by means of time-delayed feedback — •Valentin Flunkert and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

We investigate the possibility to suppress noise-induced intensity pulsations (relaxation oscillations) in semiconductor lasers by means of the Pyragas control scheme. This idea is first studied in a generic normal form model, where we find an analytic expression for the mean square radius of the oscilltions. We also investigate the control scheme numerically in a model of Lang-Kobayashi type.

DY 28.8 Thu 15:45 H2

Analysis of Nonstationary Stochastic Processes with Application to the Fluctuations in the Oil Price — •Fatemeh Ghasemi[1], Mohammad Reza Rahimi Tabar[2,3], Muhammad Sahimi[4], Joachim Peinke[5], and Rudolf Friedrich[6] — [1]The Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany — [2]Dep. of Physics, Sharif University of Technology, P.O. Box 11365-9161, Tehran 11365, Iran — [3]CNRS UMR 6529, Observatoire de la Côte d'Azur, BP 4229, 06304 Nice Cedex 4, France — [4]Mork Family Department of Chemical Engineering & Materials Science, University of Southern California, Los Angeles,CA 90089-1211 — [5]Carl von Ossietzky University, Institute of Physics, D-26111 Oldenburg, Germany — [6]Institute for Theoretical Physics, University of Münster, D-48149 Münster, Germany

We describe a method for analyzing a nonstationary stochastic process, and utilize it to study the fluctuations in the oil price. Evidence is presented that the fluctuations in the returns constitute a Markov process, characterized by a Markov time scale t_M. We compute the

coefficients of the Kramers-Moyal expansion for the probability distribution function, and show that $P(y,t|,y_0,t_0)$ satisfies a Fokker-Planck equation, which is equivalent to a Langevin equation for $y(t)$. The Langevin equation provides quantitative predictions for the oil price over Markov time scale t_M. The method described is applicable to a wide variety of nonstationary stochastic processes.

DY 28.9 Thu 16:00 H2

Theoretical description of the statistics of ventricular beat intervals during atrial fibrillation — •Thomas Hennig and Philipp Maass — Institut für Physik, Technische Universität Ilmenau, 98684 Ilmenau, Germany

Atrial fibrillation (AF) is the most common arrhythmia of the heart. It is characterised by rapid electrical excitations in the atria with a mean fibrillation rate (AF rate) of 3-12 Hz and an irregular relation with respect to the excitations in the ventricles. Recent studies showed that the AF rate is an important parameter for estimating the risk of a transition from paroxysmal to chronical AF and for predicting the probability of a conversion to sinus rhythm by pharmaceutical treatment. In this work it is our goal to determine the AF rate from the statistics of ventricular beat intervals taken from the surface electrocardiogram (ECG) based on a model [1] for the transduction of impulses through the atrio-ventricular node. The model can be rewritten in terms of a first passage time problem for a random walk with moving boundary, which is solved analytically by applying the Wiener-Hopf technique. It successfully reproduces specific characteristics found in the statistics of ventricular beat intervals during AF [2]. Tests with clinical data yield good agreement with the theoretical predictions.

[1] P. Jørgensen, C. Schäfer, P. G. Guerra, M. Talajic, S. Nattel, L. Glass, Bull. Math. Bio. **64** 1083 (2002).

[2] Th. Hennig, P. Maass, J. Biol. Phys., in press; cond-mat/0605295.

DY 28.10 Thu 16:15 H2

Detrended Fluctuation Analysis in Stochastic Global Optimization — •Kay Hamacher — Max-Planck-Institut fuer Physik komplexer Systeme, Dresden

Global optimization (GO) is one of the key numerical tools in computational physics. Among the GO algorithms the ones originating in statistical physics (e.g. Monte Carlo) are particular powerful. We show how an approach to time series analysis (detrended fluctuation analysis) can be leveraged to analyze the dynamics of GO algorithms. The emergence of random walks indicates suboptimal, diffusive behavior. This can be dealt with by adaptive schemes for general GO procedures, such as stochastic tunneling [1,2] and energy landscape paving [3].

[1] K. Hamacher. Adaptation in Stochastic Tunneling Global Optimization of Complex Potential Energy Landscapes, Europhys.Lett. **74** 944, 2006

[2] W. Wenzel and K. Hamacher. A Stochastic tunneling approach for global minimization. Phys. Rev. Lett. **82** 3003, 1999

[3] K. Hamacher. Energy Landscape Paving As A Perfect Optimization Approach Under Detrended Fluctuation Analysis, Physica A 2007, *in press*