DY 30: Nonlinear stochastic systems

Time: Friday 10:15–13:15 Location: ZEU 118

DY 30.1 Fri 10:15 ZEU 118

Strong interactions in diffusive random lasers — •Hakan E. Tureci[1], Douglas Stone[2], Li Ge[2], and Stefan Rotter[2,3] — [1]Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland — [2]Department of Applied Physics, Yale University, New Haven, CT 06520, USA — [3]Institute for Theoretical Physics, Vienna University of Technology, A-1040 Vienna, Austria

Novel laser designs have emerged recently due to modern nanofabrication capabilities. Striking among these are diffusive random lasers (DRLs) which have no resonator to trap light and no high-Q resonances to support lasing. Due to this lack of sharp resonances the DRL has presented a challenge to conventional laser theory, leading to controversy over their correct description. We recently presented a theory able to treat the DRL rigorously, and provided results on the lasing spectra, internal fields and output intensities of DRLs (Science 320, 643, 2008). DRLs are always multimode lasers, i.e. they emit light at a range of wavelengths. I will show that the modal interactions through the gain medium in such lasers are extremely strong and lead to a uniformly spaced frequency spectrum, in agreement with recent experimental observations. Non-hermitian character of the system is correctly captured, resulting in lasing modes which have an average spatial growth towards the loss-boundary.

DY 30.2 Fri 10:30 ZEU 118

Properties of the Langevin equation driven by noises with heavy and super-heavy tailed distributions of the increments — •Stanislav Denisov[1], Peter Hänggi[2], and Holger Kantz[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany — [2]Institut für Physik, Universität Augsburg, D-86135 Augsburg, Germany

We present our results on the statistical properties of the solutions of the overdamped Langevin equation driven by noises whose increments are distributed with heavy and super-heavy tails. Starting from an arbitrary distribution of the increments, we derive the generalized Fokker-Planck equation that in a concise and natural way captures all known particular cases including the fractional Fokker-Planck equation associated with the Langevin equation driven by a Lévy stable noise [1]. We demonstrate that the fractional Fokker-Planck equation is valid also for all noises whose increments have heavy-tailed distributions and calculate its parameters in terms of the asymptotic characteristics of these distributions [2]. In the case of super-heavy tailed distributions of the noise increments, i.e., distributions that do not possess finite moments of any fractional order, the generalized Fokker-Planck equation is solved exactly and the role of these noises is analyzed.

[1] S.I. Denisov, W. Horsthemke, and P. Hänggi, Phys. Rev. E 77, 061112 (2008).
[2] S.I. Denisov, P. Hänggi, and H. Kantz, arXiv:0811.1162.

DY 30.3 Fri 10:45 ZEU 118

Surmounting collectively oscillating bottlenecks — •Dirk Hennig[1], Lutz Schimansky-Geier[1], and Peter Hänggi[2] — [1]Institut für Physik, Humboldt Universität zu Berlin, Newtonstr. 15, 12489 Berlin — [2]Institut für Physik, Universität Augsburg, Universitätsstr. 1, 86135 Augsburg

We study the collective escape dynamics of a chain of coupled, weakly damped nonlinear oscillators from a metastable state over a barrier when driven by a thermal heat bath in combination with a weak, globally acting periodic perturbation. Optimal parameter choices are identified that lead to a drastic enhancement of escape rates as compared to a pure noise-assisted situation. We elucidate the speed-up of escape in the driven Langevin dynamics by showing that the time-periodic external field in combination with the thermal fluctuations triggers an instability mechanism of the stationary homogeneous lattice state of the system. Perturbations of the latter provided by incoherent thermal fluctuations grow because of a parametric resonance, leading to the formation of spatially localized modes (LMs). Remarkably, the LMs persist in spite of continuously impacting thermal noise. The average escape time assumes a distinct minimum by either tuning the coupling strength and/or the driving frequency. This weak ac-driven assisted escape in turn implies a giant speed of the activation rate of such thermally driven coupled nonlinear oscillator chains.

DY 30.4 Fri 11:00 ZEU 118

Estimation of an effective potential for a collective variable of globally coupled bistable systems — •Christoph Honisch — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster

We derive an effective Langevin equation for the mean field of N globally coupled bistable systems subject to a periodic driving force and Gaussian white noise. For this purpose we simulate the system and at first give evidence that the behaviour of the mean field can be described as a Markov process. Then we use a numerical algorithm to estimate the Kramers Moyal coefficients $D^{(1)}$ and $D^{(2)}$ of the corresponding Fokker-Planck equation. This estimation is used to reconstruct the behaviour of the mean field via a one dimensional effective Langevin equation. Finally the result is compared to the mean field of the original N dimensional system.

DY 30.5 Fri 11:15 ZEU 118

Transport of a dimer subject to localized forces over a periodic potential — •Steffen Martens, Dirk Hennig, and Lutz Schimansky-Geier — Institut für Physik, Humboldt-Universität zu Berlin

The overdamped Brownian motion of a dimer confined onto a periodic potential is studied. The two particles are coupled by non-linear interaction potentials, i.e., a Toda-like potential and the Morse potential. As extension of previous work [1,2] a localized dc force is applied to a one of the particles. The non-vanishing net current, instigated by thermal fluctuations and the localized point force, is quantitatively assessed by the value of the mobility of the center of mass. The latter is investigated both analytically and numerically. It turns out that the mobility of the dimer exhibits distinct properties in comparison with a monomer. In particular, the mobility as a function of the competing length scales of the system, that is the period of the substrate potential and the equilibrium distance between the two constituents, shows a resonance behavior. More precisely there exist a set of optimal parameter values maximizing the mobility. Further the net current is found to be a non-monotonous function of the localized driving force.

[1] D. Hennig, S. Martens, and S.Fugmann,Phys. Rev. E, 78, 011104, 2008.
[2] S. Martens, D. Hennig, S. Fugmann, and L. Schimansky-Geier, Phys. Rev. E, 78, 041121, 2008.

DY 30.6 Fri 11:30 ZEU 118

Entropic Stochastic Resonance — •P. Sekhar Burada, Gerhard Schmid, and Peter Hänggi — Institut für Physik, Universität Augsburg, D-86135 Augsburg

We present a novel scheme [1] for the appearance of Stochastic Resonance [2] when the motion of a Brownian particle takes place in a confined medium. The presence of curved boundaries, giving rise to a nonlinear entropic contribution to the potential, may upon application of a periodic driving force result in an increase of the spectral amplification at an optimum value of the ambient noise level [1]. The Entropic Stochastic Resonance (ESR), characteristic of small-scale systems, may constitute a useful mechanism for the manipulation and control of single molecules and nanodevices.

[1] P.S. Burada, G. Schmid, D. Reguera, M.H. Vainstein, J.M. Rubi, and P. Hänggi, Phys. Rev. Lett. **101**, 130602 (2008)
[2] L. Gammaitoni, P. Hänggi, P. Jung, and F. Marchesoni, Rev. Mod. Phys. **70**, 223 (1998)

DY 30.7 Fri 11:45 ZEU 118

Scaling of the rupture dynamics of polymer chains — •Simon Fugmann and Igor M. Sokolov — Institut für Physik, Humboldt-Universität Berlin, Newtonstrasse 15, 12489 Berlin, Germany

We consider the rupture dynamics of a homopolymer chain pulled at one end at a constant loading rate. Compared to single bond breaking, the existence of the chain introduces two new aspects into rupture dynamics: the non-Markovian aspect in the barrier crossing and the finite speed of force propagation along the chain. The relative impact of both these processes is investigated, and the second one is found to be the most important one. For not too long chains the most probable rupture force is found to decrease with the number of bonds. In the limit of large chain lengths the rupture forces saturate. Depending on the loading rate there exists a critical chain length minimizing the most probable rupture force. All our analytical findings are confirmed by extensive numerical simulations.

DY 30.8 Fri 12:00 ZEU 118

Correlation and phase-diffusion properties of coupled chemical oscillators. — •Amitabha Nandi and Benjamin Lindner — Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38 01187 Dresden, Germany.

We study two diffusively coupled Brusselator models by stochastic simulation and the corresponding chemical Langevin Equations. We investigate the diffusion of the phase difference between the two oscillators and also their correlation statistics. Diffusive coupling of the chemical oscillators introduces an elastic interaction term and a common noise term in the Langevin Equation for the coupled system. We investigate and compare the roles of these two distinct contributions to the correlation statistics of the oscillators.

Reference

[1] A. Nandi, Santhosh G., R. K. Brojen Singh and R. Ramaswamy, Phys. Rev. E.**76**, 041136, (2007).

DY 30.9 Fri 12:15 ZEU 118

The nonlinear ion transport mechanism in disordered systems — •Lars Lühning and Andreas Heuer — Institute of Physical Chemistry, University of Münster, Germany

The conduction mechanism which leads to nonlinear transport effects in disordered nonmetallic solids like ionic conductive glasses is still poorly understood but widely accepted to be due to hopping dynamics. Comparison of theoretical analysis and experimental data indicates that the random-energy model can serve as a realistic model to understand nonlinear ion transport. In this model the hopping of ions which occurs between localized sites in the glass matrix is projected on a square lattice with a characteristic hopping distance representing the typical distance between adjacent ionic sites. We analyze the evolution of the conductivity with increasing field strength. The strength of the nonlinear effects is strongly correlated with the properties of the sites with the lowest energies. First, the presence of very low-energy sites on average gives rise to stronger non-linear effects. Second, even for a fixed set of energies variation of the spatial arrangement gives rise to significant variations of the degree of non-linearity. Thus, also topological information is contained in the non-linear response. Bond-percolation current pathways are laid on the top of node-percolation energy cluster and the percolation calculations are extended to a more general cluster analysis. Surprisingly, there is no strict overlap of the current- with the energy percolation cluster. But the current cluster which carries up to 95% of the whole system current spans quasi-homogeneous the disordered energy landscape.

DY 30.10 Fri 12:30 ZEU 118

Interspike Interval Correlations of a Nonrenewal Integrate-and-Fire Neuron — •Tilo Schwalger, Rafael Dias Vilela, and Benjamin Lindner — MPI PKS, Dresden

Spike trains of neurons are often characterized by the interspike interval (ISI) density or even simpler by its first two moments (corresponding to firing rate and coefficient of variation). This first-order statistics is sufficient if the spike train constitutes a renewal point process, i.e. if all ISI's are statistically independent. It has been found, however, that ISI's of cortical neurons are correlated and hence nonrenewal, and it has been argued that such higher-order statistics of spike trains could be tightly related to biological functions, as e.g. spike frequency adaptation. In an integrate-and-fire neuron model such ISI correlations could be the result of a temporally correlated driving (synaptic input) or a threshold dynamics.

In this work we present an analytical technique to calculate the serial correlation coefficient (SCC) for an excitable integrate-and-fire neuron that is driven by a telegraph process (dichotomous noise) and white noise. The method is based on a discrete kinetic description and within this framework all results are exact. For slow driving we find a large, positive SCC, which has a maximum at a finite driving amplitude. As special cases the theoretical framework also includes simple threshold dynamics and residence time correlations of driven bistable systems.

Reference: T. Schwalger and B. Lindner, Phys. Rev. E 78, 021121, 2008

DY 30.11 Fri 12:45 ZEU 118

More and more weather records - Is global warming to blame? — •Gregor Wergen and Joachim Krug — Institut für Theoretische Physik Köln, Zülpicherstr. 77, 50937 Köln

If one believes in current media coverage it seems very simple: Due to the significant, largely anthropogenic, warming of the world's average temperature, more and more weather extremes occur. Every time we have a record breaking daily maximum temperature, or an immense amount of precipitation in a certain timespan, this is intuitively blamed on global warming. However mathematically the relation between an increasing mean value and the occurrence of records is far from trivial and not completely understood. This relation and its relevance to the analysis of weather data is the subject of this talk. Given an underlying distribution, we consider the probability that an event in a succession of events is a record, when the distribution itself is shifting, or altering its form. We found some approximations that are useful for the comparison with historical climate recordings. We obtained data for the daily maximum and daily minimum temperature and the daily precipitation amount from thousands of weather stations in Europe and the United States and analyzed them with regard to record events. The results are largely in accordance with what we predict from our calculations, but also reveal some interesting deviations.

DY 30.12 Fri 13:00 ZEU 118

Noise driven solitary waves — •Oskar Hallatschek — Max Planck Institut für Dynamik und Selbstorganisation, Bunsenstr. 10, 37073 Göttingen

While the deterministic behavior of solitary waves is well-understood, their noisy counterparts are still somewhat enigmatic. The current consensus is that number fluctuations due to discreteness substantially reduce the velocity of a traveling solitary wave. Here, we show that the very same fluctuations can sometimes increase the wave speed. In fact, we describe a new class of solitary waves whose velocity goes to zero as the noise vanishes (i.e., in the deterministic limit). The fluctuations due to discreteness drive these waves, and give them a finite velocity. We calculate the wave velocity analytically as a function of noise strength, and compare with simulations. The presented class of solitary waves naturally occurs in the context of genetics. They describe, for instance, the spread of a mutation that increases the carrying capacity. We discuss the biological implications of our results.