DY 34 Nonlinear Dynamics, Synchronization and Chaos I

Time: Wednesday 14:30–16:15 Room: HÜL 186

DY 34.1 Wed 14:30 HÜL 186

Multifractal distribution of spike intervals for two neurons with unreliable synapses — •Wolfgang Kinzel and Johannes Kestler — Theoretical Physics, University Würzburg

Two neurons coupled by unreliable synapses are modeled by leaky integrate-and-fire neurons and stochastic on-off synapses. The dynamics is mapped to an iterated function system. Numerical calculations yield a multifractal distribution of interspike intervals. The Haussdorf, entropy and correlation dimensions are calculated as a function of synaptic strength and transmission probability.

Preprint: http://theorie.physik.uni-wuerzburg.de/TP3

DY 34.2 Wed 14:45 HÜL 186

Nonperturbative Calculation of a Limit Cycle in a Two-Neuron System with Delayed Feedback — •Axel Pelster[1], Sebastian Brandt[2], Michael Schanz[3], and Ralf Wessel[2] — [1]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany — [2]Physics Department, CB 1105 Washington University, 1 Brookings Drive, St. Louis, USA — [3]IPVS, Universität Stuttgart, Universitätsstraße 38, 70569 Stuttgart, Germany

Neural circuits composed of a small number of neurons form the basic feedback mechanisms involved in the regulation of neural activity. We use a bifurcation analysis and numerical simulations in order to investigate a model system which consists of two Hopfield-like neurons with a time delayed feedback. It is described by the system of delay differential equations $du_{1/2}(t)/dt = -u_{1/2}(t) + a_{1/2}\tanh[u_{2/1}(t-\tau)]$, where $u_{1/2}(t)$ denote the voltages of the Hopfield neurons at time t. If the delay τ exceeds a certain critical value τ_c, the trivial fix point at the origin looses its stability and a stable limit cycle emerges. Using the Poincaré-Lindstedt method, we calculate both period and amplitude of the limit cycle perturbatively. Then we perform a resummation of the respective perturbation series by applying variational perturbation theory and compare our nonperturbative analytic results with numerical simulations.

DY 34.3 Wed 15:00 HÜL 186

2-tori and bursting oscillations close to a generalized Hopf bifurcation in the fast subsystem — •Ronny Straube[1,2], Dietrich Flockerzi[3], Marcus J. B. Hauser[2], and Stefan C. Müller[2] — [1]Abteilung Theoretische Physik, Hahn-Meitner-Institut Berlin, Glienicker Str. 100, 14109 Berlin — [2]Abteilung Biophysik, Otto-von-Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg — [3]Max-Planck-Institut für Dynamik komplexer technischer Systeme, Sandtorstr. 1, 39106 Magdeburg

Many chemical and biological systems exhibit bursting behavior which may be conventiently classified by the type bifurcations occuring in the fast subsystem [1]. Using two examples, we demonstrate that, depending on the dynamics of the slow subsystem, the existence of a generalized Hopf bifurcation in the fast subsystem may likewise account for the emergence of bursting oscillations (which are then of subHopf/fold-cycle type) or the emergence of a 2-torus exhibiting a typical phase flow on it. This investigation reveals a common origin of both types of dynamics.

[1] E. M. Izhikevich, Int. J. Bifurcat. Chaos **10** (2000) 1171.

DY 34.4 Wed 15:15 HÜL 186

Breathing dissipative solitons in three-component reaction-diffusion system — •S. V. Gurevich, Sh. Amiranashvili, and H.-G. Purwins — Institute of Applied Physics, WWU Münster, Corrensstr. 2-4, 48149 Münster, Germany

We investigate possible destabilization mechanisms of stationary solutions in a three-component reaction-diffusion system with one activator and two inhibitors due to change of the inhibitor's time constants. The case we are interested in is that the breathing mode becomes unstable first and the dissipative soliton undergoes a bifurcation from a stationary to a "breathing" state. In this case, both self- and hard-excitations can be observed. This situation is analyzed performing a two-time-scale expansion in the vicinity of the bifurcation point resulting in the corresponding amplitude equation is obtained. Numerical simulations are also carried out showing good agreement with the analytical predictions.

DY 34.5 Wed 15:30 HÜL 186

Chaotic properties of systems of many hard particles. — •Astrid S. de Wijn — Max-Planck-Institut fuer Physik Komplexer Systeme, Noethnitzer Strasse 38, 01187 Dresden, Germany

The dynamics of a system consisting of many spherical hard particles can be described as a single point particle moving in a high-dimensional space with fixed hypercylindrical scatterers with specific orientations and positions. The similarities in the Lyapunov exponents between systems of many particles and high-dimensional billiards are investigated. Comparisons are made between billiards with randomly oriented cylinders and numerical results for systems of many hard particles as well as the analytical results for the high-dimensional Lorentz gas. The similarity shows that the hard-disk systems may be approximated by a spatially homogeneous and isotropic system of scatterers for a calculation of the smaller Lyapunov exponents, apart from the exponent associated with localization. The method of the partial stretching factor is used to calculate these exponents analytically, with results that compare well with simulation results of hard disks and hard spheres.

[1] A. S. de Wijn, Phys. Rev. E 72, 026216 (2005)
[2] A. S. de Wijn and Henk van Beijeren, Phys. Rev. E 70, 036209 (2004)
[3] A. S. de Wijn, Phys. Rev. E 71, 046211 (2005)

DY 34.6 Wed 15:45 HÜL 186

Instability of a Limit Cycle in the Van-der-Pol Oscillator with Time Delay — •Kai Schneider[1], Viktor Avrutin[1], Michael Schanz[1], and Axel Pelster[2] — [1]IPVS, Universität Stuttgart, Universitätsstraße 38, 70569 Stuttgart, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Universitätsstraße 5, 45117 Essen, Germany

The classical Van-der-Pol oscillator represents a paradigmatic model for electronic circuits with intrinsic negative resistance as, for instance, a tunnel diode. The Van-der-Pol oscillator with time delay represents an extension of this model which takes into account the finite propagation time of signals. We analyze both analytically and numerically the stability of an emerging limit cycle. To this end, we use the Poincaré-Lindstedt method and set up perturbation series for the frequency and the amplitude of the limit cycle. Then we use the Floquet theory for delay differential equations [1] to systematically perform a linear stability analysis for this time periodic reference state. Finally, we compare our analytic results for the instability point of the limit cycle with numerical simulations carried out with the software package `AnT 4.669` [2].

[1] C. Simmendinger, A. Pelster, and A. Wunderlin, Phys. Rev. E **59**, 5344 (1999)
[2] `http://www.AnT4669.de`

DY 34.7 Wed 16:00 HÜL 186

Coherence resonances in semiconductor lasers — •Oleg V. Ushakov, H-J. Wünsche, F. Henneberger, I. A. Khovanov, L. Schimansky-Geier, and M.A. Zaks — Humboldt Universität zu Berlin, Inst. für Physik, Newtonstr. 15, 12489 Berlin, Germany

Semiconductor laser with ultrashort optical feedback are excellent candidates to study novel scenarios of self-organization in optical systems. We have investigated the influence of external Gaussian noise close to the onset of sub- and super-critical Hopf bifurcations. Noise-induced oscillations appear as a Lorentzian-shaped peak in the power spectrum. The coherence factor defined by the product of height and quality factor (width divided by frequency) exhibits non-monotonous behavior with a distinct maximum at a certain noise intensity for both types of Hopf bifurcations, demonstrating coherence resonance. However, the spectral width of the peak behaves qualitatively different. Whereas it increases monotonically for the supercritical bifurcation, a pronounced minimum is observed for the subcritical case. These experimental findings are examined in terms of general potential models for the noise driven motion close to bifurcations [V.S. Anishchenko, et al., Nonlinear Dynamics of Chaotic and Stochastic Systems (Springer, Berlin, Heidelberg 2002)]. We conclude that our observations reveal a generic mode for the occurrence of coherence resonance in non-linear systems.