DY 30 Spiral Formation and Feedback

Zeit: Montag 10:00–12:45 Raum: TU H3010

Hauptvortrag

DY 30.1 Mo 10:00 TU H3010

Evolution in complex systems: record dynamics in models of spin glasses, superconductors and evolutionary ecology. — •Henrik Jeldtoft Jensen — Department of Mathematics, Imperial College London, South Kensington campus, London SW7 2AZ, U.K.

What features characterise complex system dynamics? Drawing on analogies with equilibrium critical phenomena power laws and scale invariance of fluctuations are often taken as the hallmarks of complexity. Here we argue that slow, directed dynamics, during which the system's properties change significantly, is fundamental. The underlying dynamics is related to slow, decelerating but spasmodic release of a generalized intrinsic strain. Time series of a number of appropriate observables can be analysed to confirm this effect. The strain arises from local frustration. As the strain is released through 'quakes', some system variable undergoes record statistics with accompanying log-Poisson statistics for the quake event times. The talk will illustrate this scenario and its consequences through discussions of memory effects in spin glasses, the observed temperature independence of thermally activated magnetic creep in superconductors and a number of properties of biological macro evolution including the gradual decrease in the extinction rate during the last 470 million years

DY 30.2 Mo 10:30 TU H3010

Analytical tools for solving dynamics with time delay — •Andreas Amann[1], Wolfram Just[2] und Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin,Hardenbergstr. 36, D–10623 Berlin — [2]School of Mathematical Sciences, Queen Mary / University of London, Mile End Road, London E1 4NS, United Kingdom

Time-delay dynamics plays a prominent role in such diverse fields of science as e.g. biological systems, internet traffic, or the control of complex motion. Even for simple model systems analytical approaches face considerable challenges because of infinite dimensional phase spaces. We review in elementary terms how eigenmode expansions can be used to solve linear differential-difference equations and how the spectrum of the corresponding eigenvalue problem can be computed in terms of transcendental functions. We use such schemes for two particular applications: (i) the determination of power spectra of stochastic delay-dynamics, and (ii) the weakly nonlinear perturbation theory for time-delayed feedback control of chaos.

DY 30.3 Mo 10:45 TU H3010

Experimental relevance of global properties of time–delayed feedback control — •Clemens v. Loewenich[1], Hartmut Benner[1] und Wolfram Just[2] — [1]Institut für Festkörperphysik, Technische Universität Darmstadt, D-64289 Darmstadt — [2]School of Mathamatical Sciences, Queen Mary/ University of London, UK

We show by means of theoretical considerations and electronic circuit experiments that time–delayed feedback control suffers from severe global constraints if transitions at the control boundaries are discontinuous. Subcritical behaviour gives rise to small basins of attraction and thus limits the control performance. The reported properties [1] are on the one hand universal since the mechanism is based on general arguments borrowed from bifurcation theory, and on the other hand directly visible in experimental time series.

[1] C.v. Loewenich et al., Phys. Rev. Lett. 93, 174101 (2004).

DY 30.4 Mo 11:00 TU H3010

Delayed Feedback Control of Dynamical Systems at a Subcritical Hopf Bifurcation — •Klaus Höhne[1], C. von Loewenich[1], C.-U. Choe[1], H. Benner[1], W. Just[2], K. Pyragas[3], and V. Pyragas[3] — [1]Institut für Festkörperphysik TU-Darmstadt — [2]Queen Mary, University of London, UK — [3]Semiconductor Physics Institute, Vilnius, Lithuania

Delayed feedback control is a convenient tool to stabilize unstable periodic orbits embedded in strange attractors of chaotic systems. Here we consider the control of a torsion-free unstable periodic orbit originated in a subcritical Hopf bifurcation. Close to the bifurcation point the problem is treated analytically using a time averaging method. We discuss the necessity of employing an unstable degree of freedom in the feedback loop [1] as well as the effect of a nonlinear coupling between the controller and the controlled system. Our analytical approach is demonstrated for the specific example of a nonlinear electronic circuit [2]. Our analytical results are supported by both numerical simulations and real experiments.

[1]K. Pyragas, Phys. Rev. Lett. **86**, 2265 (2001). [2]K. Pyragas et al. Phys. Rev. E **70**,026412 (2004).

DY 30.5 Mo 11:15 TU H3010

Latency effects in the feedback-mediated control of spiral waves — •Jan Schlesner, Vladimir Zykov, Harald Engel, and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We propose several feedback schemes that allow to stabilize the regime of rigid rotation of spiral waves beyond the meander instability of the uncontrolled system. To study experimentally unavoidable latency effects in the control loop we determine the control domain in the parameter plane spanned by the feedback strength and the latency time. As expected with increasing latency time the control domain shrinks. The account of latency effects reveals an explanation of our recent experimental results obtained for rotating concentration waves in light-sensitive Belousov-Zhabotinsky media.

DY 30.6 Mo 11:30 TU H3010

Feedback-mediated resonant drift of a spiral wave core near a one-dimensional detector — •Vladimir Zykov and Harald Engel — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, D-10623, Berlin, Germany

It is shown that a spiral wave core can be tracked along a prescribed trajectory through a two-dimensional excitable medium. Each time when the wave front is tangent to a virtual detector line or touches its open end, a short excitability perturbation is globally applied to the medium. Such a relatively simple, robust feedback loop has been successfully realized in a light-sensitive Belousov-Zhabotinsky medium. A theory of the feedback-mediated controlled motion of the spiral core is developed based on very general assumptions about the unforced spiral dynamics. This theory allows to reduce the partial differential equations describing the excitable medium in the presence of the feedback to ordinary differential equations for the coordinates of the spiral core. For the light-sebsitive BZ medium, the predictions of this theory are in perfect agreement both with the obtained experimental data as well as with the results of direct numerical integration of the underlying Oregonator model.

DY 30.7 Mo 11:45 TU H3010

Multi-armed spiral formation driven by defects in an excitable medium — •Maria Inmaculada Rodriguez Ponce and Franz Schwabl — Lehrstuhl 5 für theoretische Physik, Physik Department, Technische Universität München, James-Franck-Strasse, D-85747 Munich, Germany

We simulated a cellular automaton based on a model for Dictyostelium discoideum cells (Dd's) in order to study the appearance of multi-armed spirals and their stability in an excitable medium. In a certain parameter region, the model displays stable spiral structures, as well as concentric rings and other spatio-temporal structures. We focus on the appearance of multi-armed spirals when they are formed by the presence of defects inthe lattice. We describe the multi-armed spiral formation in terms of tip-tip interaction and defect size. We find that the number of arms in the spiral almost solely depends on the defect size.

DY 30.8 Mo 12:00 TU H3010

Selection of the number of spiral-arms in a single-mirror feedback scheme — •Florian Huneus, Thorsten Ackemann, and Wulfhard Lange — Institut für Angewandte Physik, Westfälische Wilhelms-Universität, Corrensstrasse 2/4, 48149 Münster

In the experiment we report on, sodium vapor in an oblique magnetic field is irradiated by a laser beam. A plane mirror feeds the transmitted light back into the vapor.

Beyond a certain input intensity, self-organized inwardly moving targets and spirals emerge in the transverse intensity profile. For the same set of parameters, targets and spirals with different numbers of arms are observed; the system is multistable. In experiments, in which the intensity is switched abruptly from zero to a value beyond threshold, histograms of the number of spiral-arms are obtained. The dependence of the most

frequent number of arms on parameters is investigated experimentally and theoretically. A linear stability analysis that regards perturbations of different azimuthal order reproduces the experimental results qualitatively. A correlation is found between the most frequent number of arms and the focal-length of a self-induced lens.

DY 30.9 Mo 12:15 TU H3010

Verdrehte Spiralen und gefangene Phasenfronten in getriebenen ozillatorischen Systemen — •Oliver Rudzick und Alexander S. Mikhailov — Abt. Physikalische Chemie, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, http://www.rz-berlin.mpg.de/~complsys/

Die periodisch getriebene komplexe Ginzburg-Landau-Gleichung (CGLE) ist ein allgemeines Modell für räumlich ausgedehnte Systeme mit oszillatorischer Dynamik und periodischer äußerer Kraft. Sie beschreibt eine Vielzahl von Strukturbildungsphänomenen, wobei Phasenfronten eine Schlüsselrolle spielen. Wir haben die Dynamik periodischer Züge aus solchen Phasenfronten untersucht. Als wichtiges neues Ergebnis haben wir gefunden, daß sich die Ausbreitungsrichtung dieser Frontenzüge umkehren kann, wenn man die räumliche Periode verringert. Das bedeutet, daß die Phasenfronten „rückwärts“ laufen können, falls sie sich zu nahe kommen. Mit Hilfe der Phasenapproximation konnten wir zeigen, daß diese Umkehr der Wellenausbreitungsrichtung immer möglich ist, wenn man Benjamin-Feir-stabile Systeme periodisch treibt. Dies gilt für beliebige Resonanzen.

Als Konsequenz ist eine neue Form von Spiralwellendynamik möglich. Wir beobachten verdrehte Spiralen, in denen der innere und äußere Teil in entgegengesetzte Richtungen rotieren. In inhomogenen Systemen, wo die Rückwärtsbewegung von Phasenfronten nur in einem isolierten Teilbereich unterstützt wird, können Phasenfronten eingefangen werden. Diese Effekte lassen sich auch in einem realistischen Modell für die CO-Oxidation auf Pt(110)-Oberflächen beobachten.

DY 30.10 Mo 12:30 TU H3010

Stabilization of unstable steads states by time-delayed feedback methods — •Philipp Hövel and Eckehard Schöll — Technische Universität Berlin, 10623 Berlin, Germany

Time-delayed feedback methods have successfully been used to control unstable periodic ortbits. We show that the same technique provides a tool to stabilize unstable steady states. We present an analytical investigation of the feedback scheme using the Lambert function and discuss effects of both a low-pass filter included in the control loop and non-zero latency times, i.e., the time associated with the generation and injection of the feedack singal.