# Dynamics Days Europe 2002

Heidelberg, July 15–19, 2002

## Book of Abstracts

Jens Starke — Jürgen Vollmer

July 2002

## Welcome to the XXII. Dynamics Days Europe in Heidelberg

We are looking forward to a week of interesting talks, poster presentations, and discussions in the entire field of dynamics and nonlinearity. For more than twenty years the Dynamics Days are a forum for the exchange of ideas on the modelling of nonlinear behavior. They have been truly multidisciplinary already at times, when the benefit of the scientific exchange across the borders of traditional disciplines was felt much less in other fields, and still enjoy substantial popularity. This year we are proud to host more than 250 participants from all continents and a vast range of different disciplines, and sincerely hope that the conference enhances existing collaborations and helps to stimulate new ones.

We are most grateful to everybody who helped organizing the conference. In particular, we would like to thank the secretaries Herta Fitzer and Doris Kirsch in Heidelberg and Mainz, as well as our colleagues Simina Bodea, Somporn Chuai-Aree, Alexander Dressel, Elfriede Friedmann, Dirk Hartmann, Séverine Lacharme, Michael Lenzinger, Thomas Lorenz, Anna Marciniak, Eberhard Michel, Maria Neuss-Radu, Peakdey Nguonphan, Mariya Ptashnyk, Christian Reichert, Alice Renner, Jan Rübel, Frank Strauß, Cristina Surulescu, Adela Tambulea, and Doris Vollmer. Furthermore, we are grateful to Cathrin Raab for designing the Dynamics Days Poster, to our scientific host at the DKFZ, Roland Eils, to Willi Jäger and Rolf Rannacher for the support by the IWR and the SFB 359 of the University of Heidelberg, and last but not least to many others not explicitly mentioned here.

Finally, the conference would not have been possible without the financial support of our sponsors, the *Deutsche Forschungsgemeinschaft*, the *SFB 359: Reactive Flows, Diffusion and Transport*, the *European Physical Society*, the *Heraeus-Stiftung*, the *German Cancer Research Center (DKFZ)*, the *Max-Planck-Institute for Polymer Research*, and *Megware Computer*.

Wishing you all a good week here in Heidelberg,

Jens Starke and Jürgen Vollmer

# Contents



## Guidelines for using the book of abstracts

In the main text the starting time of the talks and the number of the posters are marked in the margins.

For **plenary talks** only starting times are given. They will take place in the *lecture hall* on the ground floor of the convention center of the DKFZ.

**Contributed talks** either take place in the *lecture hall* or in the *seminar room* upstairs. The former lectures are marked by an additional **L** (for Lecture hall) in the margin, and the latter by **S** (for Seminar room).

The **poster** number given in the margins reflect the number of the poster boards placed in the ground floor of the convention center and on the upper floor in front of the seminar room. All posters are on display for the full period of the conference from Monday morning till after the last break on Friday 4:30pm. Posters are ordered alphabetically by the name of the first author.

hier kommt die Tabelle mit dem Programm hin

# Opening Session

### The problem of linear response and fluctuation-dissipation far from equilibrium — 9:45

*David Ruelle*
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It is difficult to give a mathematical formulation and treatment of the problems of nonequilibrium statistical mechanics. Part of the difficulty is certainly due to the fact that different physical situations call for different idealizations. In any case the use of Gaussian thermostats has led to a mathematically consistent theory of situations far from equilibrium. This will be reviewed briefly, and we shall then discuss in this framework the problem of the linear response, in particular, what remains of the fluctuation-dissipation formulas valid close to equilibrium.

# Structured Devices

### Nanostructures in polymers — 11:00

*Martin Möller*
Institut für Technische und Makromolekulare Chemie der RWTH Aachen

We are interested in macroconformation and peculiar functions of single macromolecules as well as interfacial ordering and dynamics of such molecules in thin films to prepare ordered films and patterned surface with a long range coherence on the nanometer scale. E.g., one of the peculiar function of cylindrical brushes is due to changing of their contour length in dependence of the external conditions (temperature, solvent quality, ionic strength, pH). This function can find interesting application as molecular springs, muscles, and wires. Based on experimental findings we develop a concept to exploit the interplay of the different interactions and elastic forces for creating a molecular walker. The surface interaction of brush like macromolecules causes a perturbation that can be manipulated in very specific ways. Thus, the localized interaction of the probing tip of a scanning probe microscope can be exploited to stimulate macromolecules to move according their particular relaxation modes. Other means to apply an external field can be considered such as photo-chemical transformations or varying electrical or magnetic fields

### Addressable catalysts, and some twists and turns in the path of improving surface activity — 11:30

*Yannis G. Kevrekidis*(1), *H.-H. Rotermund*(2), *Papathanassiou*(2), *Wolff*(2), *G. Ertl*(2), *X.-J. Li*(1)
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(2) Fritz-Haber-Institut der MPG, 14195 Berlin, Germany

Focussing an addressable laser beam to differentially heat a Pt single crystal surface, we have been able to modify the surface catalytic activity in real time and space. Ellipsomicroscopy imaging of local conditions (such as reactant and product local coverages) enables us to close the loop between sensing and actuation (both spatio-temporally resolved). We show that pulses and fronts, the basic building blocks of patterns, can be formed, accelerated, modified, guided and destroyed at will. Image processing and feedback allow the design and implementation of new classes of non-local evolution rules.

Usually chemical processes are designed to operate under optimal steady state conditions, possibly stabilized through feedback. Strategies to operate the entire process under non-steady-state (e.g. periodic) conditions are also being developed, leading to the emergence of commercially successful processes such as pressure swing operation or reverse flow reactors. In loose analogy with resonance in linear systems, the benefits emerge when the characteristic times (periods) of the non-steady operation are close to important intrinsic time constants of the system itself. We will also show initial attempts to explore the optimisation of reaction rates by interacting simultaneously with intrinsic system time and space scales. These policies are implemented on a Pt catalytic surface addressable through our moving focused laser beam.

**12:00**

## Modelling of microreactors

*Milos Marek, Igor Schreiber, Pavel Hasal, Juraj Kosek, Dalimil Snita*
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"Microreactor" traditionally has meant a small reactor used, for testing of catalysts or evaluation of kinetic data. Microfabrication techniques of electronics industry have been recently applied to construction of microreactors used as microanalysis chips in chemistry and biology and in a number of other applications. In this presentation a brief review of several examples of observed nonlinear dynamics in typical heterogeneous catalytic chemical and liquid - phase electric field driven biochemical microreactor systems will be given first and then dynamical regimes in coupled biochemical reactors exposed to an electric field will be discussed in detail. Experimental demonstration of the evolution of outlet concentrations and temperatures in a single catalytic pellet for CO oxidation, starting from simple oscilations and leading via period - doubling bifurcations to chaos was given long-time ago(1). Mutiple steady states on the growing polymer particle in the gas-phase catalytic polymerization due to overheating were predicted recently (2). Complex spatiotemporal temperature patterns in the form of waves were also observed in individual channels of monolithic catalytic reactor under periodic variation of inlet conditions. Models used for the description of such catalytic systems are usualy formed by systems of partial differential equations of the reaction diffusion type, cf (4), with the increasing dimension following from the complexity of the considered reaction kinetics. Enzymatic separating microreactor contains immobilized enzyme with mass transport enhancement by electric field (constant or pulsed). Multiple steady state can be observed in such systems (5,6). Investigations of the operation of such enzyme microreactors in the laboratory served as an inspiration for detailed studies of relevant mathematical models. We consider a compartmental model system consisting of a reactor coupled to a reservoir by a semipermeable electrically inert membrane. An enzyme reaction involving ionic species is assumed to take place in the reactor. By using numerical continuation and bifurcation methods we examine the effects of an external electric field on the following systems: 1) Single reactor-reservoir unit: voltage is applied via pair of electrodes connected to the reservoir and the reactor. An intra-membrane electric field caused by the applied voltage generates electrophoretic fluxes of each charged reaction component. We study the effects of a static and a periodically varying electric field on the dynamical regimes in the reactor. In the static case we find that a negative field supports the oscillatory dynamics while a positive field promotes multiplicity. Sinusoidal variations of the field cause a rich variety of dynamical responses, ranging from various periodic firing patterns to quasiperiodicity and chaos. These dynamical modes are associated with characteristic bifurcation structures in a forcing period - forcing amplitude bifurcation diagram which can be used for their classification. 2) Two reactor-reservoir units mutually coupled via membrane connecting the reactors: voltage is applied via electrodes connected to each of the reservoirs. The diffusion-migration coupling in the static case generates nonuniform steady state and periodic oscillatory patterns. Periodic alteration of the electric field implies complex dynamical patterns which arise after an anti-phase periodic regime undergoes a symmetry breaking. The forcing period - forcing amplitude bifurcation diagram provides an explanation for the complexity of the dynamical patterns.

(1) J. Kapicka, M. Marek; Surface Science 222, 885, (1989)
(2) J. Kosek, Z. Grof, A. Novák, F. Łtìpánek, M. Marek; Chem. Eng. Sci. 56, 3951, (2001)
(3) R. Jahn, D. Łnita, M. Kubíèek, M. Marek; Catalysis Today 70, 393 - 409, (2001)
(4) J. Jirát, M. Kubíèek, M. Marek; Computers and Chem. Engng. 25, 643, (2001)
(5) M. Pøibyl, P. Hasal, M. Marek; Chem. Biochem. Eng. Q. 12, 141, (1998)
(6) M. Pøibyl, R. Chmelíková, P. Hasal, M. Marek; Chem. Eng. Sci. 56, 433, (2001)

# Patterns and Waves

## Fast crack propagation by surface diffusion **14:00**

*Efim Brener, Robert Spatschek*
FZ-Jülich, 42425 Jülich, Germany

We present a continuum theory which describes the fast growth of a crack by surface diffusion. This mechanism overcomes the usual cusp singularity by a self-consistent selection of the crack tip radius. It predicts the saturation of the steady state crack velocity appreciably below the Rayleigh speed and tip blunting. Furthermore, it includes the possibility of a tip splitting instability for high applied tensions.

## CO oxidation on platinum: Pattern formation and stochastic model **14:30**

*Markus Eiswirth*(1), *Christian Reichert*(2), *Jens Starke*(2,3)
(1) Fritz-Haber-Institut der MPG, 14195 Berlin, Germany
(2) IWR Universität Heidelberg
(3) Angewandte Mathematik, Universität Heidelberg

The CO oxidation on low-index plane platimun surfaces is well known to exhibit a large variety of complex spatiotemporal pattern formation. In the bistable regime nucleation and growth of domains has been observed, in the excitable parameter region there are, among other patterns, pulses and spirals, the oscillatory region exhibits e.g. standing waves and chemical turbulence. While the patterns observed under low-pressure conditions have been modelled successfully with a deterministic ansatz using reaction-diffusion equations, for intermediate pressures patterns that are obviously of random origin are observed in experiment. We present a rescalable stochastic model which is able to reproduce such patterns. The mean-field limit can be derived rigorously; it reproduces the well-understood low-pressure behavior. Stochastic phenomena not captured by earlier models, such as nucleation, can be successfully described with the new approach.

## Emerging patterns in a hyperbolic model for locally interacting cell systems **15:00**

*Angela Stevens, Frithjof Lutscher*
Max-Planck-Institute for Mathematics in the Sciences, Inselstr. 22–26, 04103 Leipzig, Germany

Morphogenetic processes like, for example, neurulation and gastrulation involve coordinated movements of cells. It is assumed that these processes happen due to long range signaling, although the detailed mechanisms are not completely understood. Therefore, one is interested in biological "model-systems" where self-organization of cells and in particular the mechanisms of signaling can be analyzed in greater detail. A major question is whether or not also short range signaling or local interaction of cells can be the cause of coordinated movement and morphogenetic processes. As a model problem we analyze ripple formation of myxobacteria due to purely local interaction, a hypothesis which is discussed in the biological literature. These ripples can be observed before the final aggregation of the bacteria and fruiting body formation takes place.

Our basic mathematical model is a one-dimensional hyperbolic system with density dependent coefficients. Conditions for the existence of traveling waves are discussed.

**15:30**

### Nonideal behaviour of hydrogels in electrolyte diodes and transistors

*Zoltan Noszticzius, Kristóf Iván, Mária Wittmann*
Dept. Chem. Physics, Budapest Univ. of Techn. and Eco., Buafoki 6-8, 1521 Budapest, Hungary

Research in the field of the so-called electrolyte or acid-base diodes and transistors started a few years ago in our laboratory. The "building block" of these devices is an acid-base reaction-diffusion system embedded in a hydrogel medium. It was assumed that reaction, diffusion and ionic migration in such a medium proceeds in a similar way like in a free aqueous solution but the gel prevents any convection. Thus the gel originally was applied as an idealized or "inert medium" whose only role was to block mechanical flows. It turned out, however, that the gel contributes to various interesting nonlinear phenomena like bistability and oscillations.

After discussing the behaviour of electrolyte diodes and transistors this work describes our experimental and modelling efforts aimed to disclose the physical mechanism behind the observed nonlinear phenomena.

## Statistical Physics

**16:30**

### Many-body Lyapunov spectra for soft and hard disks: collective modes and fluctuations

*Harald Posch, Christina Forster*
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The dynamical instability of many-body systems is best characterized by the set of time-dependent (local) Lyapunov exponents and their respective time averages, the so-called Lyapunov spectrum. We demonstrate that the infinitesimal perturbation associated with the maximum exponent is localized in space and that this localization persists in the thermodynamic limit, regardless of the force law between the particles. The perturbations belonging to the smallest positive exponents, however, are very sensitive to the interaction potential. For hard particles they develop wave-like patterns, collectively spread out over space and reminiscent of the sound and optical modes of fluctuating hydrodynamics. For soft disks, however, these so-called Lyapunov modes are wiped out by the much larger fluctuations of the associated local exponents along the trajectory in phase space. All the number dependences can be described by power laws. For hard particles, the smallest non-vanishing exponents converge to zero in the thermodynamic limit and give rise to an infinite slope of the reduced spectrum at this point. For soft particles, the slope remains finite.

### Power fluctuations in a liquid crystal **17:00**

*Walter Goldburg*[1], *Y. Y. Goldschmidt*[1], *H. Kellay*[2]
[1] Univ. of Pittsburgh, Department of Physics and Astronomy, 15260 Pittsburgh, USA
[2] Univ. of Bordeaux

The well-known fluctuation-dissipation theorem relates the dissipative parameters of a system to the fluctuations that will inevitably appear. It is applicable only to systems that are fluctuating about their thermal equilibrium state. The experiments described here center on the fluctuations in the power dissipated in a thin, thermostatted, liquid crystal layer driven far from equilibrium and into an electroconvecting state where defect turbulence appears. Measurements of the power autocorrelation function suggest that the dissipation is correlated over large spatial scales.

### Statistical mechanics of low-dimensional dynamical systems: Replacing fast chaotic degrees of freedom by a stochastic process **17:30**

*Wolfram Just*[1], *Nilüfer Baba*[2], *Katrin Gelfert*[2], *Holger Kantz*[2], *Anja Riegert*[2]
[1] Institut für Physik, Reichenhainer Str. 70, 09107 Chemnitz, Germany
[2] Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

We discuss for a general dynamical system how fast chaotic degrees of freedom can be modelled in terms of suitable stochastic forces. Projection operator techniques, that are well known from nonequilibrium statistical mechanics, are employed to derive the properties of the stochastic forces from the basic equations of motion. We end up with a Fokker-Planck equation for the density of the slow variables where the diffusion matrix is given in terms of correlation properties of the fast chaotic motion. Complementary to statistical physics we need neither the Hamiltonian structure of the basic equations of motion nor the thermodynamic limit to obtain a stochastic description for the slow variables.

## Microstructures

### Nonlinear multiscale problems, microstructure and effective behaviour **18:00**

*Stefan Müller*
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Most challenging problems in science involve a wide range spatial and temporal scales and thus cannot be resolved by brute force resolution of the finest scale. One crucial question is how to extract the relevant information on the finer scale to build a good effective model on the coarser scales. In this talk I will review some mathematical ideas to tackle this problem (such has relaxation, Gamma-convergence, Young measures and quasiconvexity) and illustrate them with a number of case studies such as microstructures due to martensitic transformation, nematic elastomers, magnetization patterns in thin films.

## Buffet and Posters **19:00**

# Dynamical Systems

**9:00**

## Rigorous computation of low dimensional dynamics in high dimensional systems

*Konstantin Mischaikow*
Georgia Institute of Technology, School of Mathematics, 30030 Atlanta, GA, USA

Many of the dynamical structures of interest are low dimensional, e.g. fixed points, periodic orbits, heteroclinic orbits, horseshoes. Unfortunately, many of the models, for example PDEs, in which we would like to understand these objects are infinite dimensional. This talk will provide an overview of current efforts to develop efficient, but mathematically rigorous, computational techniques for problems of this nature. In particular, I will discuss the issues of:
1) appropriate finite dimensional reductions;
2) extracting rigorous topological information from the reduced finite dimensional system;
3) lifting this information back to the infinite dimensional system.

**9:45**

## Stochastic bifurcation theory

*Ludwig Arnold*
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Stochastic bifurcation theory should deal with "qualitative changes" in parametrized families of random dynamical systems (systems perturbed by noise), and should reduce to the deterministic theory if noise is absent. While the concept of a random dynamical system can be unanimously formalized, this is not the case with "qualitative change". I offer a "phenomenological approach" introduced by physicists already in the eighties, and a "dynamical approach" based on Lyapunov exponents, invariant measures and random attractors.

We then try to find the stochastic versions of the elementary bifurcation scenarios, in particular of the Hopf bifurcation, mainly by way of prototypical examples like the Duffing-van der Pol oscillator with multiplicative noise and the Duffing (Kramers) oscillator with additive noise.

**11:00**

# Poster Session

# Applications in Natural Sciences

## Nonlinear wave equations in the inflationary cosmology models with scalar Higgs fields and their multiple self-similar solutions **L 14:00**

*Nadezhda Konyukhova, Alla Dyshko*
Dorodnicyn Computing Centre of RAS, Vavilov str.40, 119991 Moscow, Russia

A brief review of some recent papers of authors is given. In the four-dimensional space-time with the de Sitter metric we consider a system of $N$ nonlinear scalar neutral fields with the Higgs self-action potential. These fields are described by the system of $N$ nonlinear wave equations defined in all the space. For $N = 1, 2, 3$, these equations were found to have some self-similar soliton-type solutions with the different space symmetries: there are domain walls and billows, cylindrical tubes and the sting-type solutions, spherical bubbles and the monopole-type solutions. The singular boundary value problems (BVPs) for the second-order nonlinear ordinary differential equations obtained in the terms of automodelling variables are posed and the results of their analitical-numerical investigations are given. In particular, we obtained that these singular BVPs are solvable, their nontrivial solutions are continuable with no limit as independent variable tends to infinity and there occurs the multiplicity of the soliton-type solutions. A number of solutions increases with the growth of the dimensionless parameter connecting a depth of the Higgs fields and the de Sitter horizon. Thus the nontrivial effects of the expansion of the early Universe on some classical physical objects are obtained.

## Crash test for the classical Kopenhagen problem **L 14:20**

*Jan Nagler*
Institute for Theoretical Physics, U Bremen, 28334 Bremen, Germany

We discuss the classical restricted three-body problem for the Kopenhagen case of equal main masses. Two suns move with unit angular frequency on a circle. The dynamics of a test planet is investigated. Instead of two singularities we consider finite sun radii. Thus, the test planet can potentially crash with one of the suns. We present final state diagrams which display complex boundaries between crash basins and regions where bound and unbound motion occur. Live visualizations are scheduled.

## Collective plasma dynamics: From localization to patterns **L 14:40**

*Michael Zeitlin, Antonina Fedorova*
IPME, Russian Academy of Sciences, V.O. Bolshoj pr., 61, 199178 St. Petersburg, Russia

We consider applications of numerical–analytical technique based on the methods of local nonlinear harmonic analysis to nonlinear collective models of beam/plasma physics, e.g. some forms of Vlasov-Maxwell/Poisson equations. In our approach we use fast convergent variational-wavelet representations for solutions, which allows to consider polynomial and rational type of nonlinearities. The solutions are represented via the multiscale decomposition in nonlinear high-localized eigenmodes, which corresponds to the full multiresolution expansion in all underlying hidden time/space or phase space scales. In contrast with different approaches we do not use perturbation technique or linearization procedures. Fast scalar/parallel modeling demonstrates appearance of high-localized coherent structures/patterns in spatially–extended stochastic systems with complex collective behaviour.

**L 15:00**

## Diffusion of topological solitons and dielectric high-temperature relaxation in a polymer crystal

*Elena Zubova*[(1)], *N.K. Balabaev*[(2)], *L.I. Manevitch*[(1)]
[(1)] N.N. Semenov Institute for Chemical Physics RAS, 4 Kosygin, 119991 Moscow, Russia
[(2)] Institute of Mathematical Problems of Biology RAS, Puchshino, Russia

Dielectric high-temperature relaxation has been first observed in 1957 in polyethylene and definitely assigned to crystalline fraction. After later experiments, in 1980 'soliton' theory of the process have been suggested. It connected the process with diffusion of localized twist defects in polymer chains. These defects were identified with solitons in models of Sine-Gordon or phi-4 type. But the value of defects' diffusion coefficient needed for fitting the experimental data appeared to be many orders higher than estimates known in the models mentioned. So theoretical interpretation of the process reached a deadlock. In the work presented we suggest a solution of the problem. We show (using theoretical arguments and molecular-dynamical simulation) that the soliton theory may be valid if one of its assumptions is abandoned.

This work was supported by the RFBR (proj. 01-03-33122 and 00-15-97431).

**L 15:20**

## Oscillations, synchronization, and open-loop control in electrochemical semiconductor pore etching

*Jens Christian Claussen*[(1)], *Jürgen Carstensen*[(2)], *Marc Christophersen*[(2)], *Sergiu Langa*[(2)], *Helmut Föll*[(2)]
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[(2)] General Materials Sciences, University Kiel

Electrochemical Etching of Semiconductors can result in a rich variety of porous structures from 2 nm to 50 $\mu$m and various structures with morphologies from regular pores to branched pores similar to dendritic structures. While direct local observations during etching processes are not available in general, the underlying etching process seems to be understood by the Current Burst Model [Föll, Carstensen]. This model already has supported a large variety of experimental observations by detailed numerical simulations. In this paradigmatic approach, carriers locally are transported only through charge quantizing current bursts, corresponding to a breakthrough of the oxide layer, resulting in a lateral and temporal effect on subsequent bursts: On neighboring sites current bursts are inhibited; on the same site the burst probability is zero for a fixed oxidation time, then reaches a maximum followed by a decay due to chemical surface passivation. This behavior appears to be different for the main crystallographic directions which has direct implications on the pore morphologies.

Applying a small additional sinus wave to the etching current (i. e. an open-loop control method), the dendritic-like pores can be stabilized to non-branching pores, however with oscillating diameter. In InP even self-sustained and synchronized oscillations of the pore diameters accompanied by voltage oscillations have been obtained.

**L 15:40**

## On the dynamics of mobile wireless ad-hoc networks

*Rudolf Sollacher, Martin Greiner, Ingmar Glauche*
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It is wide spread belief that wireless mobile ad-hoc networks will be a further evolutionary step towards ubiquitous communication and computing. Due to the mobility of the network nodes, the strongly varying radio propagation conditions and the varying data traffic load these networks constitute a very dynamic environment. One essential step in evaluating the true benefit of this new technology consists of estimates and constraints concerning the scalability and performance of such networks. Using a simple model we discuss in detail the effect of interference on the link quality and connectivity of large networks. It turns out that the link failure probability rapidly increases with increasing traffic load saturating at a value smaller than one. Furthermore, we investigate the connectivity of the network under varying traffic load and find a percolation phase transition at a particular value of the traffic load. We discuss the dependence of these effect on parameters of the receiver and of the radio propagation conditions. For networks under realistic conditions especially including media access control one may conclude that the systems self-organize at a state where the traffic load balances the effective, interference-reduced capacity. We derive estimates for the critical traffic load as well due to interference as due to the percolation threshold. We find that for a wide range of parameters the percolation phase transition determines the critical traffic load.

# Hydrodynamics

### Asymptotic properties on the steady fall of a body in a viscous fluid **S 14:00**

*Sarka Necasova*
Mathematical Institute of Academy of Sciences, Zitna 25, 11567 Prague 1, Czech Republic

We consider the fall under its own weight of a bounded connected rigid body in an infinite Navier-Stokes fluid which is at rest at infinity. We say that the falling motion is steady if the velocity and pressure of the fluid in a coordinate system which is attached to the body are independent of time. We prescribe the shape and downward orientation of the body we think of the body as a holow one inside which we are free to move masses about, and we seek a position result in a steady falling motion with the given downward orientation. In general, the body must undergo a rotation about the vertical axis as well as a translation in this motion. The velocity at infinity in this moving coordinate frame is $-[U + \omega \times r]$, where $U$ and $\omega$ are linear and angular velocities of the body relative to a Galilean frame. Since the flow is to be independent of time, $U$ and $\omega$ must be constant. These two vectors are to be determined by equations the viscous force and torque on the body to the force and torque due to gravity. The viscous force must be constant. The direction of the gravitational field $g$ in the moving coordinates will rotate about the $\omega$ -axis, so that the force is not constant, unless $\omega$ is in the direction of $g$. We have $\omega = \lambda g$, where $\lambda$ is a scalar constant and $g$ is a vector which is fixed in the body. Since $U$ and $\omega$ are constant, the difference between the velocity and its limiting value $-[U+\omega\times r]$ will also be independent of time in the moving coordinates. We call this difference $u(x)$. Its componets $u_j$ are the components of velocity in Galilean coordinate system resolved along the coordinate directions of the moving coordinate frame. The steady Navier-Stokes equations has the following form

$$\begin{aligned} &\rho[(u - U - \lambda g \times r) \cdot \nabla]u + \lambda \rho g \times u + \nabla p - \mu \Delta u = \rho g \\ &\nabla \cdot u = 0. \end{aligned} \tag{1.1}$$

The equations (1.1) are to hold in a fixed domain $D$ which is the exterior of a closed bounded connected set $B$. The constant vectores $U$ and $\lambda g$ are to be determined from the equilibrium conditions

$$\begin{aligned} &\textstyle\int_{\partial B} f dS = m' g \\ &\textstyle\int_{\partial B} f \times r dS = m' g \times r' \end{aligned} \tag{1.2}$$

and with a condition on the boundary

$$u(x) = U(x), \ x \in \partial D$$

and with the behaviour in infinity

$$\lim_{|x| \to \infty} u(x) = 0.$$

Here $m', r'$ are the mass and the position of the center of mass of the mass distribution on $B$ and $f_i = \sigma_{ij} n_n$ is the surface force per unit area on $B$. We are interested in the case given $g, m'$, find $r', \omega, P, U$. First, we prove the asymptotic properties of the steady fall in Stokes and Oseen fluids in the case of presence of the Coriolis forces. Then we prove an existence of solution of the steady fall of a body in the Navier-Stokes equations. Finally, we are interested in more complicated scheme when both terms which rotation brings are considered.

[N1] Nečasová, Š., 2001, Some remarks on the steady fall of a body in Stokes and Oseen flow, submited to Journal of Mathematical Fluid Mechanics

[N2] Nečasová, Š.,2002, Asymptotic properties of the steady fall of a body in viscous fluids, Preprint

**S 14:20**

## Chaotic advection of finite size tracers

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The finite size of tracers (aerosols, bubbles, balloons, bouyes) has an important effect on the advection problem. The tracer velocity then typically differs from that of the flow and the Stokes drag acts as an accelerating force. The density ratio of tracer and fluid becomes a relevant parameter. The advection dynamics is then dissipative, and we point out that this might lead to an accumulation of the tracers in certain regions of the flow. In particular, in the wake of an obstacle, a permanent trapping takes place, due to the appearance of a periodic or chaotic attractor in this region.

**S 14:40**

## Bailout embeddings for the control of Hamiltonian chaos, and the distribution of small particles in fluid flows

*Julyan Cartwright*[(1)], *Marcelo Magnasco*[(2)], *Oreste Piro*[(3)]

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[(3)] Institut Mediterrani d'Estudis Avançats, CSIC–UIB, E-07071 Palma de Mallorca, Spain

We introduce a technique, which we term bailout embedding, that can be used to target orbits having particular properties out of all orbits in a flow or map. We explicitly construct a bailout embedding for Hamiltonian systems so as to target invariant tori. We show how the bailout dynamics are able to lock onto extremely small regular islands in a chaotic sea. We demonstrate furthermore how bailout embeddings occur in fluid dynamics. The dynamics of small spherical neutrally buoyant particulate impurities immersed in a two-dimensional fluid flow are known to lead to particle accumulation in the regions of the flow in which vorticity dominates over strain, provided that the Stokes number of the particles is sufficiently small. If the flow is viewed as a Hamiltonian dynamical system, it can be seen that the accumulations occur in the nonchaotic parts of the phase space: the KAM tori.

## Bound states and chaos of topological defects in extended spatially periodic hydrodynamical systems **S 15:00**

*Alexander Ezersky*
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General regularities of bound states and spatio-temporal chaos arising in extended hydrodynamical systems such as Marangoni-Benard convection, Faraday ripples, and a Karman street behind a heated cylinder are investigated. Experiments have verified that in all these systems topological defects forming bound states can be generated, in a definite range of supercriticality, against the background of spatially periodic lattices. Comparison of the fields of bound states of topological defects has shown that the phase fields of interaction of two topological defects in bound state have quadrupolar components. It has been revealed that when control parameters (temperature difference between the upper and lower boundaries of a liquid layer at Marangoni-Benard convection, amplitude of spatially homogeneous oscillations of a liquid layer in Faraday ripples, and temperature of a streamlined cylinder in a Karman street) are increased, there occurs a transition from a regular regime to spatio-temporal chaos the image of which is an ensemble of topological defects. The average number of defects in all the systems under consideration has been shown to depend on the control parameter in a similar manner. These dependences can be approximated by the Arrhenius formula. Physical causes of such a universality are analyzed.

## Statistics of phase turbulence **S 15:20**

*Hiroshi Shibata*
Sojo University, Ikeda 4-22-1, 860-0082 Kumamoto, Japan

The phase turbulence has been attracting a lot of investigators. We take up the system described by Kuramoto-Sivashinsky equation (SKSE). We calculate the local expansion rate, the two time correlation function, and the probability distribution function for the solution of the SKSE. The local expansion rate fluctuates around at zero. It shows that the chaoticity of the SKSE is weak. The two time correlation function decays algebraically. This means that the SKSE loses its memory algebraically. Note that this algebraic decay saturates until time t=20. If we average the solution for the SKSE over the time longer than this saturate time, we obtain the large deviation statistics for the probability distribution function concerning the SKSE.

## Resonances in modulated turbulence **S 15:40**

*Anna von der Heydt, Siegfried Grossmann, Detlef Lohse*
Faculty of Applied Physics, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands

We study isotropic and homogeneous turbulence driven by a periodically varying energy input rate. Within a variable-range mean-field theory the linear response of the system, observed in the second order moment of the large-scale velocity difference, is calcuated for varying modulation frequencies $\omega$ and weak modulation amplitudes $e$. For low frequencies the system follows the modulation of the driving with almost constant amplitude, whereas for higher frequencies the amplitude of the response decreases on average $\propto 1/\omega$. In addition, at certain frequencies *resonances* occur: the amplitude of the response either almost vanishes or is strongly enhanced. These frequencies are connected with the large eddy turnover frequency scale and multiples thereof. Within a numerical analysis of the nonlinear Gledzer-Ohkitani-Yamada shell model we find the same trend for the response, including the main resonance.

## Stochastics and Applications

**16:30**

### Derivation of $N$ Brownian motions from deterministic dynamics of 2 systems of particles

*Peter Kotelenez*
CWRU, Cleveland, USA

Consider two types of particles in d-dimensional Euclidean space, where the first type is much bigger than the second one. The positions of the "big" particles will be denoted by R, their velocities by $V$ and their masses by $M$, whereas the positions, the velocities of the "small" particles will be denoted by $Q$, $W$, and $m$, respectively. Particles will be indexed by their initial starting position. The distribution of the initial positions and velocities of the small particles will be independent, but their motion entirely deterministic. The motion of the finite number of big particles is completely determined by the kicks they receive from the (infinite) number of small particles, where most of them move deterministically with very large initial velocities. After scaling limits the small particles become a Brownian medium and act as fluctuation forces on the big particles, which can be obtained by a law of large number argument as a transformation of the initial velocity distribution of the small particles. The potential contains a critical parameter, which is the difference between a spatial mesoscale parameter for the small particles and the (original) spatial extension of a big particle. Now coarse graining lets the small particles move as ensembles. the very large velocities let an ensemble of small particles interact with a big particle only for a short time, before the ensemble escapes to infinity. Thus in disjoint short time intervals changes in the velocity of the big particles due to the interaction with the small particles will essentially be independent. The mesoscale allows to use standard techniques to derive a discretized version of the stochastic ordinary differential equations (SODE's) with spatially correlated Brownian noise, where the correlation length is the aforementioned critical parameter. The macroscale is used to derive a continuum model from the space-time discrete model. The dimension of the state space will be $d > 1$.

**17:00**

### Averaging of nonstationary nonlinear reaction-diffusion equations

*Andrey Piatnitski*[(1)], *Etienne Pardoux*[(2)]
[(1)] Narvik Univ. College and Lebedev Physical Inst., 117333 Moscow, Russia
[(2)] LATP/CMI, Aix-Marseille University

We consider an averaging problem for a nonstationary parabolic equation with a large nonlinear potential. Assuming that the coefficients of the operator oscillate rapidly both in spatial and time variables, and that the spatial microstructure is periodic while the dependence on time is random stationary, we show that under certain growth and mixing conditions the following homogenization result holds. The law of solution of Cauchy or initial-boundary problem for the original operator converges to the law of solution of the limit stochastic partial differential equation.

**17:30**

### Domain growth dynamics and steady states in driven diffusive systems

*Beate Schmittmann*
Physics Department, Virginia Tech, 24061 Blacksburg, USA

Though nonequilibrium phenomena abound in nature, they are still only very poorly understood. Even the study of nonequilibrium steady states is still in its early stages. However, investigations of simple model systems have revealed a wealth of unexpected behavior which can appear highly counterintuitive when compared to our equilibrium-trained expectations. Time permitting, I will briefly review some distinguishing features of equilibrium and far-from-equilibrium statistical mechanics and then discuss a simple nonequilibrium model, whose physical applications include traffic, microemulsions and electrophoresis. In equilibrium, its properties are completely trivial in any dimension. Once driven into a nonequilibrium steady state, however, in two (and higher) dimensions the model develops a line of phase transitions, reminiscent of traffic jams. Different ordered phases, including a topologically interesting one, coexist. In one spatial dimension (i.e., on a ring), one can prove exactly that long-range order cannot persist; surprisingly, however, a stable ordered state re-emerges if two rings are coupled to one another. Recent results, demonstrating anomalously fast domain growth in this model, will be discussed.

## Diffusion-Limited Growth

### Fractal growth patterns and conformal maps **18:00**

*Itamar Procaccia*
Weizmann Institute of Science, 76100 Rechovot, Israel

I will present the theory of fractal growth patterns that is based on calculating the conformal map from the exterior of the unit circle to the exterior of the growing fractal object. The conformal map is obtained as an iteration of fundamental conformal maps each of which adds one "particle" to the growth pattern. Having the conformal map at hand offers a considerable analytic power, allowing us to present a converged computation of the fractal dimension of Diffusion Limited Aggregation (DLA). In addition, we can discuss Laplacian Growth patterns and show that they belong to a different universality class than DLA, contrary to widespread expectations. Finally, I will mention that the same approach offers a novel and useful outlook on fracture patterns of brittle materials.

# Fluids

**9:00**

## Liquid pearls

*David Quéré*
Physique de la Matière Condensée, Collège de France, 75005 Paris, France

We describe different situations where drops remain quasi-spherical when deposited on solids. This generates remarkable dynamic situations, which are dramatically different from what happens with usual drops. In particular, drops are found to be very quickly evacuated from tilted solids, which can generate spectacular changes in the drop shape. Liquid pearls are also observed to bounce quasi-elastically when thrown to the solids. These strange behaviours are related to the absence of contact lines (which usually bound drops), which lowers viscous dissipation.

**9:45**

## Inertial particles in turbulence

*Gregory Falkovich*(1)*, Alexander Fouxon*(1)*, Michael Stepanov*(2)
(1) Weizmann Institute of Science, 76100 Rehovot, Israel
(2) Institute of Automation and Electrometry, Novosibirsk 630090 Russia

I shall describe clustering of inertial particles in a random flow and present quantitative description of concentration statistics. I shall also describe different processes that lead to collisions of inertial particles in turbulent flows. The collision rate of inertial particles in turbulence will be derived for the interval of parameters relevant, in particular, for droplet collisions in clouds. The role of turbulence in accelerating rain start will be discussed.

# Nonlinear Quantum Dynamics

**11:00**

## Ultrashort pulses in optical fibers - the nonlinear dynamics of macroscopic quantum states

*Gerd Leuchs*
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The nonlinear evolution of light pulses in fibers is described by the nonlinear Schrödinger equation. Soliton pulses are stationary solutions of this classical differential equation. In a quantised field theory, however, solitons are no longer stable. The shape of the Wigner function describing the soliton pulse changes in a characteristic manner. Recent theoretical and experimental results will be presented.

**11:30**

## Quantum transport in the mixed phase space: How deterministic?

*Henning Schomerus, H-S Sim*
Max Planck Institute PKS Dresden, Noethnitzer Str. 38, 01187 Dresden, Germany

Shot noise is a convenient probe for dynamical aspects of transport through quantum dots whose classical phase space consists of both regular and chaotic regions. For these systems the noise is systematically suppressed below the universal value of fully indeterministic (chaotic) dynamics. We analyze the dynamical origin of the suppression by adding disorder to the system and show that it arises due to the deterministic nature of transport through regular regions and along short chaotic trajectories.

## Simultaneous escape of electrons in multiple ionization of atoms in strong fields **12:00**

*Krzysztof Sacha*(1), *Bruno Eckhardt*(2)
(1) Institute of Physics, Jagellonian University, ul. Reymonta 4, 30-059 Krakow, Poland
(2) Fachbereich Physik, Philipps Universitat, Marburg, D-35032 Marburg, Germany

Recent high resolution measurements of the momenta of two electrons emitted from atoms in a strong laser field show a strong preference for the outgoing electrons to have similar momenta and to be ejected in the same direction along the field. We discuss the final stages of the ionization process of two (or more) electrons in a classical model. Starting from an intermediate state of high but negative energy the field opens up a channel through which electrons can escape. Near the threshold for this process Coulomb repulsion favors an escape with the electron momenta and positions symmetric with respect to the electric field axis. Classical trajectory simulations within this symmetry subspace account for most features of the observed momentum distribution.

## Control and Time Series

L 14:00

### Chaos control of spatio-temporal dynamics in semiconductor systems

*Eckehard Schöll*[(1)], *A. Amann*[(1)], *J. Schlesner*[(1)], *J. Unkelbach*[(1)], *W. Just*[(2)]
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[(2)] Institut für Theoretische Physik, Technische Universität Chemnitz, D-09107 Chemnitz, Germany

We study time delayed feedback control, i.e. time delay autosynchronization, of chaotic spatio-temporal patterns in semiconductor models. Different control schemes, e.g., a diagonal control matrix, or global control, or combinations of both, are compared. In particular, we use two models of semiconductor nanostructures which are of particular current interest [1]:

(i) Electron transport in semiconductor superlattices shows strongly nonlinear spatio-temporal dynamics. Complex scenarios including chaotic motion of charge accumulation and depletion fronts have been found under time-independet bias conditions [2]. Unstable periodic orbits corresponding to travelling field domain modes can be stabilized by time delayed feedback control. A novel control scheme using gliding temporal means and allowing for control loop latency is presented. (ii) Charge accumulation in the quantum-well of a double-barrier resonant-tunneling diode (DBRT) may result in lateral spatio-temporal patterns of the current density. Various oscillatory instabilities in form of periodic or chaotic breathing and spiking modes may occur [3]. We demonstrate that unstable current density patterns, e.g., periodic breathing oscillations, can be stabilized in a wide parameter range by means of a simple delayed feedback loop.

[1] E. Schöll, *Nonlinear spatio-temporal dynamics and chaos in semiconductors* (Cambridge University Press, Cambridge, 2001).

[2] A. Amann, J. H. Schlesner, A. Wacker, and E. Schöll, cond-mat/0112215.

[3] E. Schöll, A. Amann, M. Rudolf, and J. Unkelbach, Physica B (2002).

L 14:20

### A study on domain of attraction in time-delayed feedback controlled Duffing system

*Takashi Hikihara, Kohei Yamasue*
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Control of unstable periodic orbits embedded in chaotic attractor has become an important research field in nonlinear dynamics in this decade, since the OGY method was proposed [1]. The time-delayed feedback control method is recognized as one of the practical methods for controlling chaos in the continuous dynamical systems [2]. Without any exact model and the phase plane structure of dynamical system, it makes it possible to stabilize unstable periodic orbits embedded in the chaotic attractor by using the deference between output signals and time-delayed data. When we stabilize an unstable periodic orbit, the time delay is fixed at the period. Many demonstrative experiments have been reported in mechanical oscillator [3], laser [4] and so on. Recently, the method is applied to many practical systems [5]. The stability of the unstable orbit under time-delayed feedback control has also been discussed in discrete systems [6] and the continuous systems [7]. Their results let us know the limitation of the control method. Recently, a new expansion of the control method is proposed by Pyragas in order to overcome the limitation [8] .

The control method has other important problems in its performance [9]. One of them is the domain of attraction of the stabilized orbit by time-delayed feedback control scheme. The domain of attraction plays an important role for the estimation of the stability of orbit. It also implies the robustness and structural stability of the system under control. However, in the case of the time-delayed feedback controlled nonlinear system, the estimation of the domain of the stabilized orbit is difficult. The stabilized orbit by the time-delayed feedback control scheme has the same dimension as the original dynamical system. However, the trajectories under transient state with control input are in a class of infinite dimension to the space including the initial function. The stabilized unstable periodic orbit has no domain of attraction in the original system except its stable manifolds. Therefore, the importance is how we can estimate the domain at the start of control. Since Pyragas proposed the method, no one pays any attention to the problems.

In this paper, the stabilized unstable periodic orbits embedded in the chaotic attractor of Duffing system will be discussed. The system is an ideal mathematical model of the mechanical system discussed in ref.[3]. The detail dynamics has already been studied in ref. [10]. The time-delayed feedback control input consists of the output velocity signal and the memorized one. The system can be described by

$$\ddot{x}(t) + 2\gamma\dot{x}(t) + x(t)^3 - x(t) = A\cos\omega t - K\{\dot{x}(t) - \dot{x}(t-\tau)\}. \tag{1}$$

The performance and the limit of the stabilization have also been confirmed in experiments [9].

The domain of attraction on the unstable periodic orbit under control should be considered in the functional space including the orbit. The trajectory of the system is originated from the initial value and parameters. The controllability depends on the trajectory as an initial function of the control scheme. Therefore, it is appropriate to consider the domain of attraction in the initial function space. However, the function space has infinite possibilities of variation. Then the targeted unstable periodic orbit is set as a stable periodic orbit in the system under control. Then the domain of attraction is considered in the function space, which is induced from the targeted orbit with an impulsive function, which is denoted by Gaussian like function. The disturbance has the flexibility on the phase and the amplitude. As results of numerical discussion, the domain of attraction for the targeted unstable periodic orbit is obtained. On the initial function parameter space, which consists of the phase and the amplitude of impulsive disturbance, there appears the typical self-similarity in the structure. Moreover, it is shown that the coexisting orbits in the system with control have an essential effect to the transient behavior in the stabilization process.

In the final paper, we are going to discuss the details on the numerical results. Hopefully, the results will be a clue to the further theoretical discussions of time-delayed feedback control method for controlling chaos.

[1] Ott, E., Grebogi, C. and Yorke, J. A., Controlling chaos, Phys. Rev. Lett., 64, 1196-1199 (1990).

[2] Pyragas, K., Continuous control of chaos by self-controlling feedback, Physics Letters A, 170, 421-428 (1992).

[3] Hikihara, T. and Kawagoshi, T., An experimental study on stabilization of unstable periodic motion in magneto-elastic chaos, Physics Letters A, 211, 29-36 (1996).

[4] Sukow, D. W., and et. al., Controlling chaos in a fast diode resonator using extended time-delay autosynchronization: experimental observations and theoretical analysis, Chaos, 7(4), 560-576 (1997).

[5] Hikihara, T., Konaka, M. and Ueda Y., Controlling Chaotic Chattering in Discontinuous Switching Mode of DC-DC Buck Converter, 2000 IEEE International Conference on Industrial Electronics, Control and Instrumentation (IECON-2000), October 22-28, Nagoya, 2400-2406 (2000).

[6] Ushio, T., Limitation of delayed feedback control in nonlinear discrete-time system,"IEEE Trans. on Circuit and Systems -I, 43(9), 815-816 (1996).

[7] Nakajima, H. and Ueda, Y., Limitation of generalized delayed feedback, Physica D, 111, 143-150 (1998).

[8] Pyragas, K., Control of chaos via an unstable delayed feedback controller, Phys. Rev. Lett., 86(11), 2265-2268 (2002).

[9] Just, W., and et. al., Influence of stable Floquet exponents on time-delayed feedback control, Phys. Rev. E, 61(5), 5045-5056 (2000).

[10] Ueda, Y., Nakajima, H., Hikihara T. and Stewart, H. B., Forced Two-Well Potential Duffing's Oscillator, Dynamical Systems Approaches to Nonlinear Problems in Systems and Circuits, Edited by Fathi M. A. Salam and Mark L. Levi, SIAM, pp.128-137 (1988).

**L 14:40**

## What information of a dynamical system can be extracted from a differential embedding?

*Claudia Lainscsek, Irina Gorodnitsky*
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In 1980 Packard proved, that a single variable time series can be used to construct a geometrical object, an embedding in a space spanned by the time series and its successive derivatives that is topologically and diffeomorphically equivalent to the underlying dynamical system. Since then this theory has been the basis for several applications such a global modeling and classification of dynamical systems among others.

Here we present analytical forms of maps between classes of dynamical systems and their embeddings, which are referred as differential models or Jerk models in the literature. Such maps provide a basic understanding on how much information about the system is contained in a global model constructed from a single variable time series. We further can invert this map in order to get a representation of the original dynamical system in a space spanned by the time series itself and generic functions of the other state variables. In cases of 'simple' dynamical systems, such as the Lorenz and Rössler systems we are able to reconstruct the systems of ODEs up to scalings and location in the phase space from the time series of the x-coordinate of the Lorenz and the y- and z-coordinates of the Rössler system.

**L 15:00**

## Direction of coupling from time series

*Milan Palus*
Institute of Computer Science, Pod vodarenskou vezi 2, 182 07 Prague 8, Czech Republic

Various asymmetric measures have been proposed in order to establish a direction of coupling in asymmetrically coupled chaotic (or other complex) systems. Results are easily interpretable if in one direction a measure of coupling is significantly positive, while in the other direction it vanishes. If the measures in both directions are positive, the interpretation is not trivial and simple comparison of values can lead to contradictory results. We argue that in order to reliably establish the direction of coupling, the used measure should have suitable metric properties concerning the processes under study. One possibility is to measure information flow between the (sub)systems using measures based in information theory. Definitions, properties and sensitivity of such measures are discussed and their applications in analysing synchronization in EEG and localization of epileptic foci are demonstrated.

**L 15:20**

## Pin pointing determinism

*Joachim Holzfuss, Olaf Göhrs*
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During the measurement of time series data from complex nonlinear systems one may be confronted with the question, wether all system information has been extracted or if one can gain new information by measuring different observables. We present a new method based on information theoretic concepts that allow qualified statements about the relevance of different observables. The effects of determinism in the signals are identified and extracted regardless if the systems are regular or chaotic. This information can be used to identify the relevant observables for subsequent modelling and prediction. An extension shows that embedding procedures are justified within this approach. Examples of information transfer between coupled systems quantifies the state of synchronization. The method is also applied to several experimental systems.

### Phase synchronization from one-dimensional time series — L 15:40

*Natalia Janson*[(1)], *Alexander Balanov*[(1)], *Vadim Anishchenko*[(2)], *Peter V.E. McClintock*[(1)]
[(1)] Physics Department, Lancaster University, LA1 4YB Lancaster, United Kingdom
[(2)] Physics Department, Saratov State University, Astrakhanskaya 83, Saratov 410026, Russia

A general approach is proposed to detect phase relationships, e.g., synchronousness or otherwise, between two or more different processes interacting within a single system, using one-dimensional time series only. The approach is based on studying the angles of return times map. A model is derived analytically decribing the angles behavior for a dynamical system under weak quasiperiodic forcing with an arbitrary number of independent frequencies. The technique is applied to heart rate variability (HRV) data of 20 healthy humans at rest and under forcing. It is first demonstrated for filtered human HRV data that in many cases the behavior of angles can be well described by the derived model; interaction between different processes within cardiovascular system can be considered as weak for many subjects studied; a view of map for angles gives an immediate idea of currently dominating processes; in some subjects the strength of interaction between processes is sufficiently large, what is clearly detectable from the map of angles.

## Bifurcations and Quantum Dynamics

### On codimension of the bifurcation problem for systems with simple dynamics — S 14:00

*Mikhail Shashkov*
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The main problem of the bifurcation theory is to describe changes of phase portraits of dynamical systems under continuous change of parameters. This description implies construction of the bifurcation diagram, i.e. splitting the space of parameters onto classes of the equivalent systems. It is well known, that many bifurcations of codimension $k$ dynamical systems admit the complete bifurcation description by so-called versal $k$ parametric families which contain the complete information on the structure of the bifurcation set for any family of general position. It is known also that majority of dynamical systems with chaotic behaviour of trajectories do not admit the complete bifurcation analysis. It is explained, first of all, by the existence of small perturbations which lead to appearance of infinitely-degenerate orbits. Such possibility is impossible for systems with simple dynamics. So, in contrast to the chaotic systems, it seems natural, that codimension $k$ systems with simple dynamics must admit the complete bifurcation analysis by versal $k$-parametric families, i.e. the codimension of the degeneration must coincide with the codimension of the correspondent bifurcation problem. But it is not so.

The present work demonstrates that the codimension of the bifurcation problem can be arbitrary big in spite of small codimension of the system and simplicity of dynamics. It is shown that high codimension of the bifurcation problem implies existence of topological invariants. These topological moduli are one of the main bifurcation parameters.

### Fluctuational transitions through a fractal basin boundary — S 14:20

*Alexander Silchenko, Dmity G. Luchinsky, Peter V. E. McClintock*
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We study noise-induced transitions between attractors separated by a fractal basin boundary in the two-dimensional map introduced by Holmes in [1]. Our main goal is to find the optimal

escape path – if such a path exists. It is shown that escape from an attractor always seems to occur through a homoclinic saddle cycle belonging to the fractal boundary, and thence via a saddle cycle belonging to the multifractal homoclinic structure. The deterministic optimal control function needed to effect escape in the absence of noise may be identified with the corresponding optimal fluctuational force, which can be found by numerical simulation using method [2].

[1] P. Holmes, Phil. Trans. R. Soc., v. 292, 419 (1979).

[2] I.A. Khovanov, D.G. Luchinsky, P.V.E. McClintock, and R. Mannella, Phys. Rev. Lett., v. 85, 2100 (2000).

S 14:40

## Eigenstates ignoring quantum-classical correspondence

*Holger Schanz, Lars Hufnagel, Roland Ketzmerick, Marc-Felix Otto*
Universität Göttingen, Bunsenstr. 10, 37073 Göttingen, Germany

The semiclassical eigenfunction hypothesis is a cornerstone for the quantum theory of systems with chaotic classical analogue. It states that in the semiclassical limit all eigenfunctions are either regular or chaotic in the sense that their phase-space representations condense on the corresponding classically invariant sets. We show that this type of quantum-classiscal correspondence can break down as soon as regular classical transport coexists with chaotic dynamics. An example are the accelerator modes of the standard map, arguably the most important paradigm of Hamiltonian chaos. In the semiclassical limit, all eigenfunctions of such systems are "amphibious": They spread uniformly over the chaotic sea and the embedded regular islands.

S 15:00

## Bell's inequality, hidden variables in quantum mechanics, and chaos

*Wm. C. McHarris*
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In the most straightforward interpretation, Bell's inequality should be obeyed by classical dynamics but violated by quantum mechanics. A number of experiments measuring the polarizations of entangled photon pairs have demonstrated its violation, and this has been interpreted as ruling out the existence of local interactions in the so-called hidden variables extensions of quantum mechanics. However, Bell's inequality was derived basically using linearly-based statistics, and one can obtain nonlinear formulations of it more or less consistent with the experimental outcomes. This raises the question as to whether the violation of Bell's inequality is moot for ruling out local hidden variables. Indeed, this problem is but one of the "imponderables" generated by quantum mechanics that are at least consistent with some possible chaotic underpinnings for quantum mechanics [Wm. C. McHarris, Z. f. Naturforsch. 56a, 208 (2001)].

S 15:20

## Polarization and phase symmetry-breaking and restoration in vector-field lasers

*Larissa Svirina*
Institute of Physics of NASB, F. Skaryna prospekt, 68, 220072 Minsk, Belarus

The nonlinear dynamical phenomena reflecting invariance of equations of motion under transformations of the variables and parameters have been studied in gas class-A lasers. Firstly in a laser system, the phenomena of polarization symmetry breaking and restoration were described by symmetric (singular) bifurcations of stationary and periodic solutions of equations of motion. Conditions for spontaneous polarization symmetry breaking have been revealed. The solutions have been found with symmetry of chiral and achiral biological macromolecules. This analogy provides the possibility to use laser dynamics to study the process of evolution in biology and could suggest a new approach to the problem of chirality. Spontaneous phase symmetry breaking (restoration) accompanied by chaos originated from period doubling bifurcation cascade of an asymmetric limit cycle have been found in an autonomous four-frequency ring gas class-A laser with elliptically polarized eigenstates.

L.P. Svirina. Journal of Optics B: Quantum & Semiclassical Optics,3 (2001) S133.

### Transparent boundary conditions for quantum-waveguides and in underwater acoustics

**S 15:40**

*Anton Arnold*[(1)], *Matthias Ehrhardt*[(1)], *Ivan Sofronov*[(2)]
[(1)] Faculty of Mathematics, Saarland University, Postfach 15 11 50, D-66041 Saarbrücken, Germany
[(2)] Keldysh Institute of Appl. Math., Moscow

The electron transport through a quantum-waveguide can be modeled in good approximation by a Schrödinger equation on an unbounded domain. For numerical simulations, however, it is necessary to restrict this problem to a finite domain. This is possible without changing the solution by introducing "transparent boundary conditions" (TBC). In this talk we shall discuss numerical discretizations of these artificial boundary conditions, the approximation of the involved discrete convolutions by exponential sums, and the stability of the resulting numerical scheme. A very similar question appears in wave propagation problems like underwater acoustics. If horizontal reflections within the water can be neglected, the acoustic field emanated from a time-harmonic source can be modeled by a pseudo-differential 1-way-wave equation of Schrödinger type.

## Excursion

**16:30**

# Dynamical Systems

**9:00**

## A mathematical theory of strange attractors

*Lai-Sang Young*
Courant Institute, 251 Mercer St, 10012 New York, USA

Recent developments in the analysis of a class of strange attractors will be reported. I will present a general mathematical theory based on checkable conditions, explain rigorous results on geometric and statistical properties which correspond to standard notions of chaos, and discuss the first applications of this work, including applications to periodically forced oscillators, homoclinic and Hopf bifurcations.

**9:45**

## Attractors and spatio-temporal chaos for parabolic systems on large and unbounded domains

*Alexander Mielke, Sergey Zelik*
Mathematisches Institut A, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We consider translationally invariant reaction-diffusion systems on large or unbounded domains. Under suitable assumptions on the nonlinearity, a global attractor exists and we study its dependence on the domain. In particular, we study in what sense the attractors for finite domains approximates that on the full space. We discuss the notions of topological entropy per unit volume and provide lower estimates for them. Moreover, we provide an example of a reaction diffusion system on the real line which exhibits spatio-temporal chaos in the sense that its attractor contains an invariant set such that the discrete space-time shift corresponds to a Bernoulli shift.

**11:00**

# Poster Session

# Pattern Formation & Biological Systems

## Protein folding: a thermally activated escaping process? **L 14:00**

*Alessandro Torcini*[1], *Lorenzo Bongini*[2], *Roberto Livi*[3], *Antonio Politi*[1]
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[2] INFM - Unita' di Fireze, I-50125 Firenze, Italy
[3] Dipartimento di Fisica, Universita' di Firenze, I-50125 Firenze, Italy

A dynamical description of the protein folding process can provide an effective representation of equilibrium properties and allow for a direct investigation of the mechanisms ruling the approach towards the native configuration. A two dimensional off-lattice model made of $N$ amino acids is considered and folding and unfolding processes are investigated via molecular dynamics simulations. The "folding" ($T_F$) and $\theta$ ($T_\theta$) transition temperatures are identified. The analysis of the unfolding dynamics suggests that the escaping process from the native state, at temperatures $\simeq T_F$, can be interpreted as a a thermally activated process. The numerically computed escape probabilities compare nicely with the Langer theoretical predictions for a particle moving in a $2 \times N$ dimensional potential. Therefore the folding process can be described as a sequence of consecutive jumps connecting metastable configurations to the native state.

## Nonlinear dynamics of ion channels in biological membranes **L 14:20**

*Stephan Kramer, Reiner Kree*
Institut f. Theoretische Physik, Uni Göttingen, Bunsenstraße 9, 37073 Göttingen, Germany

The investigation of the physics of physiological regulation processes at the molecular level has many aspects and combines several traditional fields of statistical physics. We focus our attention on the structural changes of molecular patterns in a fluid membrane, which are induced by the interaction between membrane-bound ion channels and the membrane potential.
We present analytical and numerical results for a simple, generic model describing the electrophoresis of mobile, charged ion channels in lateral potential gradients, which are generated by the ionic currents through the channels. Channels may switch between closed and open conformations and the physical properties of the channels — in particular effective charge and the diffusion constant —, depend on their conformation. The model is formulated as a system of reaction-electro-diffusion equations for the channels coupled to a cable-type equation for the lateral transmembrane voltage profile. For time-independent kinetic rates, the primary bifurcations from the homogeneous, stationary state appear as hard-mode, soft-mode or hard-mode oscillatory transitions within physiologically reasonable ranges of model parameters, depending on the changes of electrophoretic charges and diffusion constants with conformation [1]. Numerical simulations of the model verify the analytic predictions and reveal further properties like a secondary bifurcation from the stationary hard-mode instability to an oscillatory one. We will also present numerical results for two non-autonomous situations:
a) time- and space-dependent kinetic rates corresponding to ligand-gated channels subject to ligand pulses and
b) periodically modulated external transmembrane voltages.
Compared with the autonomous system the pattern formation in the chemically driven case sets in already for strongly sub-critical values of the control parameter and reveals several interesting aspects, which will be discussed and compared to typical physiological regulation phenomena.

[1] S. C. Kramer, and R. Kree, *Phys. Rev. E* (2002) in print

**L 14:40**

## Synchronized bursts among heterogeneous, synaptically coupled relaxation oscillators

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Populations of neurons are among the many physical systems modelled by systems of coupled oscillators. Past work has shown that even mild heterogeneities in model parameters destroy synchronized activity in networks of coupled spiking neurons. Here we analyze how heterogeneities actually enhance the tendency to synchronize in networks of synaptically coupled bursting neurons, each modelled as a relaxation oscillator. In particular, we focus on a model for neurons in the mammalian brain stem that are experimentally observed to generate synchronized bursts associated with respiration. Using geometric singular perturbation analysis, we derive consistency conditions for the existence of a form of stable synchronized oscillation in this network. Further, we use maps on a space of parametrized curves to derive formulas for the positions of corresponding periodic solutions in an appropriate phase space.

**L 15:00**

## Morphogenetic oscillations during dynamical symmetry breaking of a cluster of Hydra Vulgaris cells

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Hydra vulgaris, a 1-2cm long sweet water polype, is among the oldest multicellular organisms. It exhibits versatil reproduction and regeneration capabilities and represents a model animal for morphogenesis: lost body parts are replaced, more strikingly, a disorganized cluster of a few thousand Hydra cells may regenerate into a complete animal in appropriate conditions. During the process of regeneration, Hydra first builds a hollow double layer cell ball of about $200-300\mu m$, in diameter and about 2000 cells. We describe and analyze the nonlinear dynamics of this organism. Different types of sawtooth-oscillations have been observed, which accompany the transition of spherical symmetry to elliptical shape. These are classified and discussed in relation with the symmetry breaking and differentiation of the animal. We propose three simple nonlinear decriptions generating sawtooth oscillations, assuming either an elastic membrane burst as a result of pressure going beyond a threshold value, or opening and closing of ion-channels as a function of actively ore passively controlled surface tension. We discuss the implications of our observations in relation to the observed symmetry breaking and with respect to active and passive behaviour.

**L 15:20**

## Lyapunov equation, operator semigroups and random evolutions in population genetics

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Wright-Fisher model is the basic tool used by mathematical geneticists to describe simultaneous action of genetic forces such as drift, mutation, recombination and selection. In a series of recent papers, we demonstrated that time evolution of pairwise distributions associated with the Wright-Fisher model can be described by a finite- or infinite-dimensional Lyapunov-type matrix differential equation. The description applies whether the evolution is neutral or it occurs under

natural selection, as well as under a range of mutation mechanisms. In the neutral case, the linear semigroup generated by the solutions of the Lyapunov equation can be expressed using the Markov semigroups describing the mutation process. When recombination is involved, the resulting quasi-Lyapunov equation involves a mechanism similar to the so-called random evolutions. In all cases described, the asymptotic behavior of solutions depends in nontrivial and interesting ways on the hypotheses concerning past demographic change in the population. We review these results, and apply some of them to analysis of human mitochondrial and microsatellite DNA, under different demographic models of the populations of our prehistoric ancestors.

### Landau theory in finite Taylor-Couette flow **L 15:40**

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(3) Manchester Center f. Nonlin. Dynamics, U Manchester, UK
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Landau theory applied to steady and time-dependent fluid flows does not only predict the attracting solution set close to a bifrucation but also properties of the transient dynamics, particularlly a critical-slowing-down. A numerical and experimental study of transient dynamics at the onset of Taylor cells in a system of finite axial extend is presented. Numerical calculation of Navier-Stokes equations could confirm for the first time a critical-slowing down in a finite system in case of stress-free boundary conditions at top and bottom plate. For realistic boundary conditions a departure from Landau theory could be observed experimentally and numerically. In particular this departure was found to increase with increasing cylinder length. Critical-slowing down at the onset of time-dependent flow was found not to be effected by the finite extend of the system.

## Stochastics and Noise

### Analysis of time-dependent billiards **S 14:00**

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A dispersing billiard (Lorentz gas) and focusing billiards (in the form of a stadium) with time-dependent boundaries are considered. The problem of a particle acceleration in such billiards is studied. For the Lorentz gas two cases of the time-dependence are investigated [1,2]: stochastic perturbations of the boundary and its periodic oscillations. Two types of focusing billiards with periodically forced boundaries are explored [3]: stadium with strong chaotic properties and a near-rectangle stadium. In the phase plane, areas corresponding to decrease and increase of the velocity of billiard particles are found. The average velocity of the particle ensemble as a function of the number of collisions with the boundary is obtained.

[1] A. Loskutov, A.B. Ryabov, L.G. Akinshin, J. Exp. and Theor. Physics, 1999, v.89, No5, p.966-974.

[2] A. Loskutov, A.B. Ryabov, L.G. Akinshin, J. Phys. A, 2000, v.33, No44, p.7973-7986.

[3] A. Loskutov and A. Ryabov. Chaotic time-dependent billiards. Int. J. of Comp. Anticipatory Syst., 2001, v.8, p.336-354.

S 14:20

## Chaotic and random point processes: theory and applications

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Our paper treats the theory of chaotic point processes and based on the work [1]. Processes of this type represent a new process class which has become a topic of research in the last few years. They are interesting both from theoretical and practical points of view and find different applications. In this paper a systematic and comprehensive treatment of chaotic point processes is provided. The basic model is introduced and similarities to and differences from random point processes are shown. A basic statistical analysis is carried out.

The theory of random point processes has a fairly long history [2,3]. It has a wide range of applications in different fields of science such as statistical physics, astronomy, biology, communications theory. Random point processes models are used e.g. in kinetic theory of fluids, cosmic ray theory, population dynamics, theory of queues, renewal theory and reliability theory. Analogously to random point process we treat here a class of point processes with chaotic event arrival times generated by a non-linear return map. Such processes we call chaotic point processes [4]. They have already found different applications in:

statistical signal modeling (chaotic bit-stream pulse generators)[5,6]; power electronics (statistical analysis and chaotic control of DC-DC converter ) [7,8]; communications schemes [9]; hybrid systems [10]. The paper is organized as follows:

In Secs. 2 and 3 the basic definitions statistical characteristics for both random and chaotic point processes are provided. In section 4 typical random point processes are treated, and section 5 is devoted to chaotic point processes. A statistical analysis is carried out: we calculate the joint probability and the probability density function (pdf) of chaotic interval and occurrence times and their characteristic functions. We illustrate the approach by various examples for typical chaotic maps such as tent and Renyi map. We analyze an asymptotic behaviour of the characteristic functions of the occurrence times which are the cumulative sums of chaotic variables. In Secs. 6 and 7 we introduce impulse and pulse shaped processes associated with point processes. For these processes we carry out a statistical analysis and provide examples.

1. A.L. Baranovski, A. Moegel, and W. Schwarz Chaotic and random point processes. Submitted to Int. Journal Bifurcations and Chaos, 2002.

2. I. I. Kuznietsov and R. L. Stratonovich On mathematical theory of correlated random points, Izv. A.N. U.S.S.R., 20, 1956, 167-178 (in Russian).

3. L. Takacs On secondary stochastic processes generated by recurrent processes, Acta Math. Acad. Sci. Hung.,7,1956, 17-29.

4. A. L. Baranovski, A. Moegel and W. Schwarz Chaotic pulse processes. Spectral analysis and signal generation, Proc. of 7th International Workshop on Nonlinear Dynamics of Electronic Systems, Ronne, Denmark, 1999, 69-72.

5. A. L. Baranovski and W. Schwarz Statistical analysis and design of continuous-discrete chaos generators, IEICE Trans. Fundamentals, E82-A,1999, 1762-1768 (invited paper).

6. Yu. K. Rybin and A. L. Baranovski The synthesis of dynamical system with stochastic auto-oscillations, Journal of the Academy of Sciences of the USSSR Radiotechnics and Electronics 8, 1988, 1643-1651 (in Russian).

7. A. L. Baranovski, A. Moegel, W. Schwarz and O.Woywode Statistical Analysis of a DC-DC converter, Proc. of 7th International Workshop on Nonlinear Dynamics of Electronic Systems, Ronne, Denmark,1999, 77-80.

8. A.L. Baranovski, A. Moegel, W. Schwarz, and O. Woywode. Chaotic control of a DC-DC-converter. In Proceedings of the IEEE International Symposium on Circuits and Systems, ISCAS 2000, vol.II, pages 108-112, Geneva, Switzerland, May 2000.

9. M.M.Sushchik, N.F.Rulkov, L. Larson, L. Tsimring, H.D.I.Abarbanel, K. Yao and A.R. Volkovskii Chaotic Pulse Position Modulation: A Robust Method of Comminicating with Chaos, IEEE Communications Letters, 4, 2000.

10. A.L. Baranovski, A. Moegel, and W. Schwarz. Control of chaos in hybrid systems. Journal of Latin American Applied Research, Special theme issue: Bifurcation Control: Methodologies

and Applications; in honour to the 65th Birthday of Professor Leon O. Chua, 31(3):193-198, 2001 (invited paper).

## Investigation of closed trajectories in near-conservative dynamical systens

**S 14:40**

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Analysis of closed trajectories of near-conservative nonlinear systems includes the following supposition: along the trajectories a lost of energy (on the average) is absent, so the nonconservative systems under consideration behaves like a conservative ones. The supposition is used here as an important part of the trajectories construction.

1. Nonlinear normal vibration modes (NNMs) are a generalization of normal vibrations in linear systems. In this case all position coordinates can be well defined from any one of them.In broad classes of nonlinear systems, curvilinear trajectories of the NNMs in a configurational space, can be obtained of the form of power series. Assume that in a conservative system the potential energy is a positively definite polynome of coordinates. At small energies, trajectories of NNMs can be determined as power series of amplitude value, while at large energies,as power series of inverse amplitude value. In order to join together local expansions and to investigate behavior of normal vibration trajectories at arbitrary values of amplitude, fractional rational Pade approximants (PA) can be used. Necessary condition for convergence of a succession of PA have been obtained and that allow to establish a relation between quasilinear and essentially nonlinear expansions, that is to decide which of them corresponds to the same solution and which to different ones.

The perturbation methodology and power series are used to the analysis of NNMs in broad classes of finite-dimensional nonautonomous and self-exited systems close to conservative ones too. It is assumed that along the closed trajectories of NNMs,the nonconservative system behaves like a conservative ones having a single DOF,and all position coordinates can be analytically parametrized by any one of them. Rauscher's ideas and the power series are used to construct the NNMs trajectories in a configurational space. The analytical construction is realized for some concrete problems, such as nonlinear vibrations of plate in a flow, nonlinear vibrations of viscoelastic mechanical systems in a supposition that elastic interactions are dominant. Theory of nonlinear normal vibrations can be used in different applied problems, in particular, in problems of dynamics of nonlinear elastic shells using the Donnell's theory. The corresponding model is digitizated by the Bubnov-Galerkin procedure, and is investigated by using models involving two or three DOF, describing some principal response of the shell. Namely, it is possible to study localized and non-localized NNMs; to consider the companion vibration mode; to study a stability and bifurcations of the NNMs etc.

2. Similar approach is used to construct closed homoclinic and heteroclinic trajectories (HT) in nonlinear dynamical systems with phase spaces of dimension equal to two or three.The approach includes an utilization of PA and quasi-Pade' approximants (QPA),which contain powers and exponential functions,as well potentiality and convergence conditions. This makes possible to solve a boundary-value problem formulated for HT. Some principal dynamical systems are considered here. In particular, it is analyzed HT of the nonlinear Schrodinger equation, nonautonomous Duffing equation, parametrically excited non- linear pendulum system etc. The formation of HT can be considered as a beginning of a chaotic behavior in the system under consideration. It is possible, using the approach proposed here, to obtaine with a good precision, amplitude values of the homoclinic orbits and of the corresponding external (or parametric) action from a system of algebraic equiations, as a function of a friction coefficient. There is a good correspondence of the analytical results and a checking numerical computation. The approach proposed here is more exact than the generally accepted one, because it is not necessary to use here a zero approximation of the separatrix trajectory.

1. A. F. Vakakis, L. I. Manevich, Yu. V. Mikhlin, V. N. Pilipchuk and A.A. Zevin. Normal Modes and Localization in Nonlinear Systems.Wiley, New York, 1996.

2. Yu. V. Mikhlin. Matching of local expansions in the theory of non- linear vibrations. J. of Sound and Vibration 182 (4), 1995, 577-588.

3. Yu.V.Mikhlin. Analytical construction of homoclinic orbits of two- and three-dimensional dynamical systems. J. of Sound and Vibration, 2000, 230 (5), 971-983.

4. Yu.V.Mikhlin, B.I.Morgunov. Normal vibrations in near-conservative self-exited and viscoelastic nonlinear systems.Nonlinear Dynamics,25, 2001, 33-48.

5. G.A.Baker and P.A.Graves-Morris. Pade Approximants.Addison-Wesley, London, 1981.

**S 15:00**

## Noise-induced propagation in monostable media

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We report the effect of noise-induced propagation in monostable media, in which external fluctuations are able to induce propagation of harmonic signals through monostable media. This property is based on the phenomenon of doubly stochastic resonance, where the joint action of multiplicative noise and spatial coupling induces bistability in an otherwise monostable extended medium, and additive noise resonantly enhances the response of the system to a harmonic forcing. Under these conditions, propagation of the harmonic signal through an unforced portion of the medium is observed for optimal intensities of the two noises. This noise-induced propagation is studied and quantified in a simple model of coupled nonlinear electronic circuits.

**S 15:20**

## Measurement of scaling laws in a stochastic, multiplicatively driven, spatially extended system

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We report experiments of stochastically driven nematic electroconvection and compare the results with numerical simulations of the electro-hydrodynamic equations. The most striking feature of the system are short, large amplitude bursts which intermitted by long quiescent, convection free states. The driving (control) parameter is the applied stochastic electric voltage, which is generated in a computer. During a burst, the convection rolls appear simultaneously in the spatially extended (2D) sample. Under certain simplifying assumtions the relevant stochastic PDE system can be reduce to an ODE system, which has many similarities of 1D processes like $\dot{y} = \xi_t y + \sigma_t$; $\xi_t$ - stochastic driving, $\sigma_t$ - additive noise.

A important factor in the comparison of experimental data with general predictions is the limited dynamical range for $y(t)$ due to the presence of additive noise and upper limits by saturation. We have confirmed some essential predictions for multiplicatively driving processes, viz the distribution $p \propto \tau^{-3/2}$ of durations times between two consecutive bursts or the distribution $p \propto A^{-1+\eta}$ of amplitudes of strength of convection. In addition, modifications from limited dynamic range for $y$ have been dicussed. Also, the $PSD \propto \sqrt{\omega}$ for low frequencies in the power spectral density was confirmed from experimental data. From the theoretical point of view, for 1D processes this dependence should only appear for an *unlimited* dynamical range. We suspect the spatial extension of the system is the reason that this characteristic is not covered by the presence of additive noise. The unexpected $PSD$ characteristics should stimulate further analytical und numerical investigations of spatially extended noise driven systems.

[1] Th. John, R. Stannarius, and U. Behn, Phys. Rev. Lett. **83**, 749 (1999).
[2] Th. John, U. Behn and R. Stannarius, Phys. Rev. **E.** in press.

## Extracting macroscopic stochastic dynamics. with applications to biomolecular dynamics

**S 15:40**

*Christof Schütte, Wilhelm Huisinga*
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The function of many important biomolecules comes from their dynamic properties and their ability to make statistically rare switches between different conformations. Recent investigations demonstrated that (a) these conformations can be understood as metastable or almost invariant sets of certain Markov chains related with the dynamical behavior of the molecular system and that (b) these sets can efficiently be computed via the dominant eigenvectors of an appropriately defined transfer operator. Hence, one can reformulate the effective dynamical behavior: in a certain sense it just is a simple low-dimensional finite state space Markov chain that describes stochastic hops between the metastable conformation sets of the system. This Markov chain can explicitly be derived even for "real" biomolecules like peptides and RNA systems by means of novel algorithmic techniques.

# Life Sciences

16:30

## Kinetic dissection of intracellular protein trafficking

*Robert Phair*[1], *John F. Presley*[2], *Jennifer Lippincott-Schwartz*[2]
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Green fluorescent protein (GFP) technology is transforming cell biology. The Lippincott-Schwartz lab has pioneered the use of GFP as a tracer of intracellular protein trafficking. This talk outlines our general approach, which is to combine fluorescence microscopy with kinetic analysis, and illustrates it with a recent example (Nature, May 2002). ARF1, a small GTPase and COP-I, a coat protein complex, are thought to mediate intra-Golgi transport. Photobleach and brefeldin A experiments yielded kinetics that could not be accounted for by the current theory that ARF-GTP hydrolysis is coincident with release of the COP-I coat. A new model postulating separation of GTP hydrolysis from coat release was, however, found to fit the data well. These results not only require revision of a textbook theory, but also demonstrate the advantages of a multidisciplinary approach that merges experimental cell biology and kinetic analysis supported by a relational database of model elements, ProcessDB.

17:00

## Coherent collective dynamics in networks of protein machines

*Alexander Mikhailov*
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A cell is populated by active protein machines that communicate via small molecules diffusing through the cytoplasm. Mutual synchronization of machine cycles can spontaneously develop in such networks - an effect which is similar to a transition to coherent laser generation or onset of synchronization in oscillator ensembles. As an example, molecular networks formed by allosteric enzymes with product-regulated reactions in microvolumes are considered. Coherent intramolecular dynamics in these networks is manifested in synchronous release of product and strong correlations in conformational states of individual protein molecules.

17:30

## Problems and perspectives of systems biology

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Although it is one of the most important challenges in modern biology, a system-level understanding of how cells and organisms function is actually very rudimentary. This is mainly due two the following two reasons:

The overwhelming part of experimental investigations can be characterized as qualitative and descriptive, directed towards the understanding of biomolecular details. The concomitant lack of quantitative data will certainly be reduced by further development and wider application of massively parallel experimental methods in functional genomics and proteomics. Furthermore, due to the complexity of cellular systems even a complete measurement of the systems' states per se will not enable an integrated understanding of the observable dynamic behavior. Recent efforts for a system-level understanding in biology rely on interdisciplinary approaches combining concepts from biology, information sciences and systems engineering. They especially stress the importance of mathematical modeling of complex biological systems in order to come to a virtual representation of cells and organisms. In the end, this representation should allow for computer experiments similar to experiments with real biological systems. Formulation and systematic testing of biological hypotheses as well as purpose-driven design of cellular functionality are important perspectives of these approaches.

It will be shown that the notion of a living cell being composed of subunits of limited autonomy (functional units) plays an important role for modular modeling of complex cellular systems. The modeling process can be supported by a modeling concept interconnecting elementary modeling objects assigned to elementary biomolecular components. This assignment allows for biological transparency and facilitates interdisciplinary cooperation between biology and system sciences as an important precondition to enable a deeper understanding of signal transduction and regulatory processes. The important role that regulation and signal transduction play in the dynamics of cellular systems is demonstrated by means of two typical functional units, the cell cycle regulation in Saccharomyces cerevisiae and the EGF induced MAP-kinase cascade. The cell cycle regulation shows how nonlinearity is used to realize biological functionality. The second example suggests that decomposition of a complex network of signal transduction into subunits of elementary signal transfer may be a promising approach to cope with the problem of complexity. In this context robustness as a prominent structural property of cellular functional units plays an important role.

## Swimming in a sea of data: forward and inverse modeling of biochemical dynamics **18:00**

*Pedro Mendes*

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Biochemical reactions form intricate networks, where the state variables are the concentrations of the various molecules involved. The dynamics of biochemical networks have been studied throughout the last century, with computer simulation taking a prominent role. Modeling biochemical dynamics has been carried out by puting together knowledge on the properties of individual molecules studied in isolation (a bottom-up approach). Current genomic technologies are capable of measuring the concentration of thousands of molecular species in parallel, making it feasible to use a top-down approach to study the dynamics of biochemical systems. Issues related with the top-down approach using genomic data will be discussed. Particular focus will be put on methods based on global optimization.

## Patterns and Waves

**9:00**

### Period doubling of 1D and 2D spiral waves

*Bjorn Sandstede*[(1)], *Arnd Scheel*[(2)]
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[(2)] Department of Mathematics, University of Minnesota

Rigidly-rotating spiral waves and their transition to meandering or drifting spirals are well documented. Recently, spatio-temporal period doubling of 2d spiral waves has been observed in light-sensitive Belousov-Zhabotinsky reactions. The resulting 2d spirals exhibit a line defect that is needed to accommodate the period-doubled wave trains in the far field. These observations are puzzling since period-doubling bifurcations of spirals appear to be impossible since spirals are equilibria rather than periodic orbits. We report on a preliminary explanation of these phenomena. It involves the computation of spectra, and of the associated eigenfunctions, of spirals on bounded and unbounded domains as well as a nonlinear analysis of the absolute instability that causes the period doubling. Our analysis predicts that the bifurcating spirals should begin to drift — this prediction has been corroborated using numerical simulations.

**9:45**

### Travelling waves in random media

*Hiroshi Matano*
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Travelling waves in heterogeneous media have gained much attention in the past decade in various fields of science such as ecology, physiology and combustion theory. Previously most of the mathematical studies were focused on spatially periodic cases, and little was known about the nature of traveling waves in spatially aperiodic media. This is in cotrast with the case of temporally varying media, for which there is a comprehensive study by Shen (1999).

Recently I have introduced the notion of travelling waves in spatially recurrent media, including quasi-periodic ones as special cases. The concept is a natural extension of the classical notion of travelling waves, and I have discussed existence, uniqueness and stability of those travelling waves. In this lecture I will mainly discuss two variational problems associate with travelling waves:

The first is the **mini-max characterization** of propagation speed, which is introduced by Volpert *et al* for one-dimensional homogeneous problems and later extended to periodic problems in higher dimensions by Heinze, Papanicolaou and Stevens in the case of bistable nonlinearity. This method enables one to obtain fine rigorous estimates of propagation speed. This method can be extended to quasi-priodic or even almost periodic problems, but it raises a very intriguing question, which I will discuss in my lecture. This part is a joint work with S. Heinze and A. Stevens.

The second is concerned with the minimal speed of travelling waves for KPP type equations. As conjectured by Kawasaki-Shigesada (1986), and later proved by Hudson-Zinner (1995 for 1-dim) and Berestycki-Hamel (2002 for higher dim), **the minimal speed is characterized by a positive eigenfunction** of a certain elliptic eigenvalue problem. In the case of quasi-periodic inhomogeneity, however, the corresponding eigenvalue problem may no longer have a positive eigenfunction, because of the degeneracy of the differential operator. Nonetheless, one can still use this eigenvalue problem to prove the existence of pseudo-travelling waves and obtain estimates of their minimal speed. This part is a joint work with F. Hamel and H. Berestycki.

# Engineering and Optimization

## Analysis of elastic and kinematic coupled vibration on internal combustion engine — 11:00

*Mizuho Inagaki*[(1)], *Atsushi Kawamoto*[(1)], *Takayuki Aoyama*[(1)], *Nobuyuki Mori*[(1)], *Kenichi Yamamoto*[(2)]

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The calculational method of engine vibration is getting more important to match the lighter weight of automobile with the low vibration level. Under running condition, the engine component such as a crankshaft vibrates elastically with the rotational or translational rigid motion caused by the combustion and inertia force of the piston-conrod system. The components are connected by the nonlinear spring and damper element such as the oil film bearings. In this study the new formulation using a local observer frame and eigenmodes was proposed to calculate the elastic and kinematic coupled vibration of engine components. In addition, some kinds of force elements were developed to express the nonlinear interaction between the components such as a oil film bearing element based on hydrodynamic lubrication theory. The developed program was applied to the real engine model and verified by the experiments under running condition.

## Dynamically dexterous locomotion on multi-locomotive robot — 11:30

*Toshio Fukuda, Yasuhisa Hasegawa*

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In this presentation, I introduce a new multi-locomotive robot that can achieve multiple locomotion ways: brachiation, biped walking and quadruped walking like an ape. I show some designing approaches for these motions that are employed both in a numerical simulation and experiment. In addition to them I show a learning algorithm that is embedded in a robot controller so that it could compensate modeling error and could adjust its motion to various types of environment including robots mechanism.

## Optimization based prediction of progressive structural degradation — 12:00

*Wolfgang Achtziger*

University of Erlangen-Nuremberg, Inst. Appl. Math, Martensstrasse 3, 91058 Erlangen, Germany

We discuss the problem of changing material properties in mechanical structures. An application is the localization of critical parts of the structure which need to be re-inforced. Since classical problem formulations are hardly tractable, we focus on simple optimization based model problems providing just an over- or underestimation of the structural effects of material degradation. In these models, at each single time-step local material parameters are optimized in a worst-case or best-case sense where structural compliance serves as a global measure of degradation. In this way, dynamic, i.e., progressive structural degradation can be estimated from time step to time step. We will relate several problem formulations for discrete structures in view of their computational tractability. Another question is the optimal design of structures w.r.t. their ability to resist the loss of total stiffness due to material degradation. This question can be answered if just some initial degradation is considered.

# Fluids

**14:00**

## Dynamic boundaries in fluid flows

*Jun Zhang*
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Interesting phenomena arise when hydrodynamic forces are strong enough to change the shape or position of a submerged object. The fluid flow deforms such an object as it responds to the fluid's local pressure and drag forces. In turn, such deformations give rise to forces acting back upon the fluid itself. In this talk, I shall discuss two examples of systems with deformable (movable) boundaries, where the boundaries become part of the dynamics. The first experiment, a system akin to the flag-in-the-wind problem, studies a thin flexible body (silk thread) in a quasi-two-dimensional fluid flow (soap film). The system exhibits an interesting bi-stability and the motions can be related to the undulation of a swimming fish. In the second experiment, a thermally driven convective fluid interacts with a freely moving floating plate, providing a simple model of the interaction between the continents and Earth's mantle. The experimental results support the fact that the Atlantic Ocean has closed and re-opened several times in a quasi-periodic fashion over the past two billion years.

**14:30**

## Drop formation: From dripping faucets to nanojets

*Jens Eggers*
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We owe the ubiquitous presence of drops in daily life, science, and technology to surface tension. When a drop falls from a faucet, surface tension drives an increasingly rapid motion of the fluid neck down to a radius of molecular size. Because of the absence of any characteristic scale, one finds self-similar solutions of the equations of motion, independent of initial conditions. This universality imposes powerful constraints on the manner in which drops form. As a function of time the minimum radius follows different scaling regimes, all of which have by now been confirmed experimentally. On a scale of nanometers, thermal fluctuations take over as the dominant driving force, and once more change the character of the fluid motion.

**15:00**

## Chaotic dynamics in nonlinear flow of wormlike micellar systems

*Ajay Sood*
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Several surfactant molecules self-assemble in solution to form long, flexible cylindrical micelles. At concentration larger than the micelles overlap concentration $C^*$, these get entangled with each other to form a viscoelastic gel. This talk will discuss our ongoing experimental studies on the nonlinear rheology of the cylindrical micellar system for surfactant (CTAT) concentration c below [1] and above [2] the overlap concentration $c^*$.

For $c < c^*$, the solution of cylindrical micelles shows a pronounced shear-thickening transition above a concentration - dependent critical shear rate. An analysis of the time-series of the stress relaxations at controlled shear rates in the shear-thickening regime shows the existence of correlation dimensions greater than two and positive Lyapunov exponents. This indicates the existence of deterministic chaos in the dynamics of stress relaxation at these concentrations and shear rates. The observed chaotic behavior may be attributed to the stick-slip between the shear - induced structure (SIS) formed in the sheared surfactant solution and the coexisting dilute phase. At still higher shear rates, when the SIS spans the Couette, there is a transition to higher-dimensional dynamics arising out of the breakage and recombination of the SIS. For $c > c^*$, the shear stress $\sigma$ shows a plateau as a function of the shear rate above a certain value. Under controlled shear rate conditions in the plateau regime, the shear stress and the first normal stress difference shows interesting time-dependence, which has the signatures of deterministic chaos.

[1] R. Bandyopadhyay and A.K. Sood, Europhys. Lett. 56, 447 (2001).
[2] R. Bandyopadhyay, G. Basappa and A.K. Sood, Phys. Rev. Lett. 84, 2022 (2000).

### Two phase flows patterns in microchannels **15:30**

*Patrick Tabeling, R. Dreyfus, H. Willaime*
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When two immiscible fluids flow in a straight channel, complex patterns develop, as the result of hydrodynamic or interfacial instabilities or both. Such patterns have been described in the litterature for decades, and a considerable body of observational, numerical and theoretical work exists on the subject. As the channel is miniaturized, hydrodynamic instabilities get damped, but still some interfacial dynamics survive, giving rise to rich patterns : bubbles, slugs, pearl-necklace structures, tailed drops, disordered phase, ... These patterns are worth being investigated, perhaps because of their intrinsic beauty, but also because they call for a general understanding. The goal of the talk is to present the phenomenology of these systems, their dynamics, and sketch the underlying physics. The experiments are peformed in microchannels, 20 microns deep, etched in glass, anodically bonded to Silicium wafers; the working fluids are tetradecane and water, with SPAN80 as the surfactant.

## Closing Session **16:30**

# Poster Contributions

## On limits of chaotic simulations by classic software — application to the step motor **P. 1**

*Francois Alin, Robert Bruno*
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Chaotic dynamic systems simulation is a difficult to solve problem with usual simulation tools. The particularly high initial conditions sensibility implies that any rounding error can provide a bad simulation result. This is not a simple question of simulation precision decreasing but more seriously qualitative simulated solutions nature changes. We show that a sharp analysis of the numerical integrator manage to justify the *manual* rewriting of the algorithm. In this study, the dynamic system is a hybrid two-phased step motor. We describe the motor model and present classic simulation with Matlab and experiment results. Then we show strange and non significant behaviours appearing during long time simulations. We will analyse the numerical reasons of this divergence. At last we explain how eliminating those defaults and present the improved results. The final goal of this study is to achieve stepping motor control in chaotic dynamic in order to extend its usual application field.

## Periodic solutions of linear systems **P. 2**

*Makhlouf Amar, Sellami Abdelmagid*
Department of Mathematics, Faculty of Sciences, University of Annaba; Elhadjar, BP12, Annaba, Algeria

The existence and stability problems of periodic solutions of linear systems are treated. Linear systems are used as models of phenomena in nature, in mechanics, in physics. The asymptotic stability of a periodic linear system can be deduced from the Routh-Hurwitz criterion. We study second order differential equation with periodic coefficients called Hill's equation. We present a method due to Lyapunov for the determination of the general solution and the condition of stability. The Lyapunov stability of the Hill's equation depends on the value of the Lyapunov constant. We consider two important special cases of the Hill's equation.

## Continuous feedback control of scleronomous mechanical systems **P. 3**

*Igor Ananievski*
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A problem of designing a feedback control for a Lagrangian mechanical system of general form is considered. We assume that the control forces are bounded and the system undergoes uncontrolled disturbances. The desired control must drive the system to a prescribed terminal state in a finite time.

Most of the known approaches for constructing such algorithms lead to control laws that are in general discontinuous functions of time and, therefore, are not applicable in practice. The aim of this study is to design a continuous feedback control which guarantees the desired performance of the system under consideration.

The proposed algorithm employs a linear feedback control with the gains which are functions of the phase variables. The gains increase and tend to infinity as the phase variables tend to zero; nevertheless, the control forces are bounded and meet the imposed constraint. The approach developed is based on Lyapunov's direct method.

P. 4

## Spatial bias in transport dynamics of molecules in the cell-nucleus

*Chaitanya Athale, Dietmar Volz, Roland Eils*
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The principles governing nuclear architecture have been recently approached by studying the transport-dynamics of flourescent molecules in the nucleus. The most recent modeling approaches (Phair and Misteli 2000 Nature v404, p604-9) have shown that the "well-mixed" compartmental assumption fits the quantitative dynamics data, contradicting long held models of nuclear organization. In order to overcome this contradiction, anisotropy effects have to be taken into account, thus needing data with a higher spatial resolution. Without specific a priori knowledge about the structure of sub-nuclear structure providing for a directed flow, the dynamics of inherent molecules has to be described by a macroscopic model that neglects the microscopic propagation of such molecules. One suitable approach to serve this purpose is the diffusion approximation of transport which in the present study has been applied to bleaching data of high resolution in order to estimate an appropriate diffusion tensor. The inverse problem of parameter estimation has been solved using the fundamental solution of a time-dependent diffusion equation. All implementation has been done in MATLAB.

P. 5

## A two-particle system exhibiting both liquid-solid transition and glasstransition, – basic mechanism and its implication to the dynamics of friction

*Akinori Awazu*
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The appearances and the change of the frictional force of a system with two hard spheres in a two-dimensional rectangular box are discussed. With controlling the pressure or the supply of energy from the wall, the solid-like state, the solid-liquid temporal coexistence state, and the liquid-like state are observed. The frictional force and the fluidity of the system are measured under the shear. By varying the shear, a marked change of frictional forces is observed with similar characteristics to those of the static and dynamic frictions of a solid-on-solid system. Moreover, the relationship between the above frictional force and the shear is found to show strong temperature dependency. The hysteresis loop in the friction-velocity relation on granular layers [S. Nasuno et al.: Phys. Rev. Lett **79** (1997) 949] is discussed on the base of these results.

P. 6

## Quantitative description of dewetting scenarios by thin film models

*Jürgen Becker, Günther Grün*
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In physical experiments on the dewetting of thin polystyrene films on silicon wafers, a variety of rupture scenarios is observed which ranges from spinodal dewetting to the formation of generations of satellite holes around an initial dip (cascade effect). In this contribution we demonstrate that thin film models based on lubrication approximation are capable to capture those phenomena. To this scope we compare dimensionalized numerical simulations based on convergent, entropy-consistent finite element schemes with experimental results by K. Jacobs et al.. A pattern analysis based on Minkowski functionals further underlines the fine accordance between experimental and simulation data.

## Flip-flop oscillations in a adiabatic homogeneous and heterogeneous chemical reactor with recycle $f$ mass — P. 7

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The work deals with flip-flop oscillations in a adiabatic heterogeneous tubular recycle reactor. This mode of oscillations presented in [1] is generated by the existence of multiple steady states in the system and at minimum two lags (no bifurcations are requested). In such a case an assumption of two different profiless for delay elements results in generation of flip-flop oscillations by the system. When one of the steady states is stable and the second one generates autonomous oscillations (f.i. chaotic resulting from dynamic bifurcation) flip-flop jumps between stable steady state and these oscillations are observed. In such a system semichaotic oscillations may be generated in the result [1].

[1] M. Berezowski, A. Grabski, Chaotic and non-chaotic mixed oscillations in a logistic systems with delay and heat-integrated tubular chemical reactor. Chaos, Solitons & Fractals, 14/1, 97–103, 2002.

## Rolling of rigid body on plane and sphere. Hierarchy of dynamics — P. 8

*Alexey V. Borisov, Ivan S. Mamaev*
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In this paper we consider cases of existence of invariant measure, additional first integrals, and Poisson structure in a problem of rigid body's rolling without sliding on plane and sphere. The problem of rigid body's motion on plane was studied by S. A. Chaplygin, P. Appel, D. Korteweg. They showed that the equations of motion are reduced to a second-order linear differential equation in the case when the surface of dynamically symmetric body is a surface of revolution. These results were partially generalized by P. Woronetz, who studied the motion of body of revolution and the motion of round disk with sharp edge on the surface of sphere. In both cases the systems are Euler-Jacobi integrable and have additional integrals and invariant measure. It turns out that after some change of time defined by reducing multiplier, the reduced system is a Hamiltonian system. Here we consider different cases when the integrals and invariant measure can be presented as finite algebraic expressions.

We also consider the generalized problem of rolling of dynamically nonsymmetric Chaplygin ball. The results of studies are presented as tables that describe the hierarchy of existence of various tensor invariants: invariant measure, integrals, and Poisson structure in the considered problems.

## Scale-dependence of spatiotemporal filters inspired by cellular automata — P. 9

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We discuss analysis tools of spatiotemporal patterns. These tools are based on nearest-neighbor considerations similar to cellular automata. Application of these methods to a spatiotemporal data set means selecting certain scales in space and in time. Focusing on spatial length we show that the dependence of the results on this scale can be used to quantify seperately the contribution to the dynamics of measurement noise and of dynamical (internal) noise, respectively. In particular we test the spatiotemporal filters using sample data generated with a network of coupled Sel'kov oscillators. Possible application of our results to biological systems are briefly discussed.

## P. 10 Pattern formation in fungal colonies: General features and possible mechanisms

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Under a variety of conditions the process of fungal colony development can result in the emergence of four main types of spatiotemporal patterns: concentric rings, sparse lawn, dense lawn and fractal-like structures. It has been suggested to consider this phenomenon as an adaptation of the colony during its development to the changing environment due to the existence of feedback between fungal system state and control parameters (environmental factors). We have proposed a general mechanism of fungal pattern formation, which is based on two simultaneous processes: consumption of substrate (activator) by mycelium and suppression of mycelial growth by diffusible metabolites (growth inhibitors). A system of reaction-diffusion equations has been used to model the growth of the fungal colony, which is able to describe properly the development of such types of macroscopic patterns as "concentric rings" and "lawn".

## P. 11 Dynamics of groundwater flow with dual porosity aspect

*Hana Cermakova, Jan Novak, Jiri Muzak*
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Paper summarizes the results of research in field of the dynamics of groundwater flow with dual porosity. The dual porosity means the fact that in porous medium pores are partly active and partly inactive. The inactive pores are filled with solution but the velocity of flow in pores is neglecting compared with velocity in active pores. Transport of dissolved solids is considered in next basic processes Ũ convection and dispersion in active pores and diffusion exchange between active and inactive pores. The direct modelling application of the formula for diffusion rate $Q = k.(c^l_A - c^l_N)$, where $c^l_A$ and $c^l_N$ are concentrations in active or inactive pores, is non suitable because the numerical solution put a condition on the time step and its splitting. Final modelling solution of transport mechanism is made by the FVM, by explicit time scheme. Flow is calculated by the mix-hybrid model. Finally the application in real conditions of uranium deposit Stráđ in the Czech republic is presented.

## P. 12 1/f noise in Sierpinski signals

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The extremely simple Sierpinski automaton $x_i(t+1) = (x_{i+1}(t) + x_{i-1}(t)) \bmod 2$ which can generate complex patterns, is investigated on its capability to generate 1/f-noise. By definig a sum signal $X(t) = \sum_i x_i(t)$, we obtain a time series which power spectrum (periodogram) can be calculated analytically giving a power law with exponent 1.15. In some cases Sierpinski-like

structures can be observed in nature: Sierpinski patterns occur in reaction diffusion systems, pmost prominent in the patterns generated by sea shells. A Sierpinski-sum-signal-like time series has also been measured in a catalytic process. Other recent measurements have reported 1/f noise in chemical reactions. Although our model describes an infinitely growing process (which is limited by system size), it gives an interesting viewpoint on an interesting observable of fractal generating processes.

## Floquet stability analysis of OGY and difference control: influence of the impulse length **P. 13**

*Jens Christian Claussen*
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Poincare-based control of instable periodic orbits can be done by the OGY and Difference control scheme, where (in contrast to Pyragas control) a control amplitude is calculated at each Poincare section. However, the mathematically higly convenient time-discrete Poincare iteration x(t+1)=f(x(t),r(t)) is unique only for fixed control impulse shape and length, and may vary in a nontrivial way if the control impulse shape is changed. An important question in experimental control is the influence of the control impulse length. Usually the control amplitude is computed after crossing the Poincare plane, and is kept constant within a part of, or during the whole orbit period. For difference control, a Floquet analysis shows that stabilization is only acheivable if the duration of the control impulse is kept shorter than half of the orbit length; a limitation that does not appear for the OGY scheme.

## A control method for interacting tumoral and healthy tissue **P. 14**

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**Introduction**: Healing cancer disease is closely connected to a complete understanding of tumor growth under continuous interaction with the surrounding healthy tissue. Prediction of therapy outcome depends qualitatively and quantitavely on modelling mathematically this interaction. Such models can rely on the tools offered by the frame of non-linear dynamics and be expressed within the frame of first-order differential equations. Their singular points represent equilibrium states of the system and may be of therapeutic relevance. They are locally stable or not depending on the system's biological parameters. Unstable singular points with positive therapy outcome can be stabilized using the OPCL control method [1] which is applied to the generalized Lotka-Volterra equations (GLVE) [2] in this work. The OPCL control method can be interpreted as a clinical therapy method.
**Methods**: The system studied in this work contains competing tumoral and healthy tissue cell populations. It is described by the following GLVE:

$$\begin{aligned}\frac{dN_1}{dt} &= r_1 N_1 \left(\frac{K_1 - N_1 - \alpha_{12} N_2}{K_1}\right)\\ \frac{dN_2}{dt} &= r_2 N_2 \left(\frac{K_2 - N_2 - \alpha_{21} N_1}{K_2}\right)\end{aligned}$$

where

$N_1$: population of tumor cells;

$N_2$: population of normal cells from which the tumor arises;

$r_i N_i \quad (i = 1, 2)$: intrinsic population growth;

$-N_i^2 \quad (i = 1, 2)$:intrinsic inhibation which preserves the population from surpassing $K_i$ (maximum population allowed by environment);

$-\alpha_{ij} N_i N_j (i, j = 1, 2; i \neq j)$:inhibition or stimulation arising from contact with competing population.

These equations cannot be solved analytically. Their steady states are represented by the following points:
1. extinction of the normal cell population: $(N_1, N_2) = (K_1, 0)$;
2. co-existence of both cell populations: $(N_1, N_2) = (n_1, n_2)$;
3. extinction of the tumor cell population: $(N_1, N_2) = (0, K_2)$.
The population values for the co-existence point are given by

$$n_1 = \frac{K_1 - \alpha_{12} K_2}{1 - \alpha_{12}\alpha_{21}}$$

and

$$n_2 = \frac{K_2 - \alpha_{21} K_1}{1 - \alpha_{12}\alpha_{21}}$$

These points are locally stable when the following conditions are satisfied:
1. $(K_1, 0)$ is stable if $K_2/K_1 < \alpha_{21}$;
2. $(n_1, n_2)$ is stable if $K_1/K_2 < \alpha_{12}$ and $K_2/K_1 < \alpha_{21}$;
3. $(0, K_2)$ is stable if $K_1/K_2 < \alpha_{12}$.
The stability conditions for the co-existence point are identical to its existence conditions for positive cell populations. The co-existence point is always stable when existent while both other singular points are locally unstable under these circumstances. At least one of the other two singular points is stable if the co-existence point does not exist. The stability conditions do not depend on the intrinsic growth rates and but only on the ratio of the maximal populations and on the coupling constants between the two populations in concordance to the results in [3]. We are interested in the basins of entrainment for the locally stable singular points and the way the OPCL control method can stabilize locally unstable points. Linearizing the GLVE for small deviations from the singular points we obtain differential equations for these deviations. The basins of entrainment of the stable singular points can be obtained solving these equations numerically for every fixed point. The OPCL control method, which is defined by the following equation can stabilize an unstable singular point:

$$\frac{d\vec{N}}{dt} = \vec{F}(\vec{N}) + S(t)\vec{K}(\vec{x}, \vec{N})$$

where

$$S(t) = \begin{cases} 0 & : \quad t < t_0 \\ 1 & : \quad t \geq t_0 \end{cases}$$

$$\vec{K} = \frac{d\vec{x}}{dt} - \vec{F}(\vec{x}, t) + C(\vec{x}, t)(\vec{x}(t) - \vec{N}(t))$$

$$C(\vec{x}, t) = \frac{d\vec{F}(\vec{x}, t)}{d\vec{x}} - A$$

$\vec{x}(t)$ is the goal function to which the system should evolve. This goal function is one of the singular points herein. A is a matrix with negative real parts of the eigenvalues. When applying this control method to the GLVE the first component of $\vec{K}(\vec{x}, \vec{N})$ must be negative and the second equal zero because the former acts on the tumor cell population reducing its number while the latter acts on the normal cell population without any possibility to increase their number. Control is of interest for our system if at least one of the singular points $(K_1, 0)$ or $(0, K_2)$ is unstable. There is no way to stabilize $(K_1, 0)$ under OPCL. The control upon $(0, K_2)$ results in a large increase of the basin of entrainment of $(0, K_2)$.

**Results**: We have determined the basins of entrainment for the singular points under the assumption that the co-existence point exists and the OPCL control method is applied to the point $(0, K_2)$ representing total remission from disease. The results were obtained by numerical integration using the Matlab software. We used the Runge-Kutta method with a fixed step-size. An initial deviation point was considered to belong to the basin of entrainment if its components were not larger 0.001 at the end of the integration. The calculations were done for the following values of the biological parameters: $r_1 = 10$; $r_2 = 5$; $K_1 = 100$; $K2 = 200$; $\alpha_{12} = 0.3$; $\alpha_{21} = 0.6$. For this choice the co-existence point exists. The OPCL control parameters were chosen as $a_{11} = 2$ and $a_{12} = 4$. We observed that the basin of entrainment of $(0, K_2)$ was massively enlarged by applying the OPCL control.

**Conclusions**: The basin of entrainment of $(0, K_2)$ is largely increased when applying the OPCL control method. The particular form adopted for this method can be interpreted as a continuous, long-term therapy, for instance chemotherapy. The free terms in the matrix A can be interpreted as the drug concentration which acts upon the tumoral tissue. The fact that $(K_1, 0)$ cannot be stabilized using this method coincides with the common experience that chemotherapy leads to a reduction of the number of tumoral cells. The increase of the basin of entrainment of $(0, K_2)$ under OPCL control shows that chemotherapy leads to a positive disease outcome for most of the intial population sizes within the frame of this simple model. Further studies have to be undertaken in order to assess the effects of radiotherapy which may be modelled as a sum of delta functions representing the different fractions applied during therapy. The model used to describe the system built by tumoral and healthy tissue has to be improved in order to account for the complex biological reality. The biological parameters for clinical well understood tumors have to be used in order to check our predictions.

[1] E. Atlee Jackson and I. Grosu, *Physica D*, 85: 1-9, 1995.
[2] R. A. Gatheby, *Journal of theoretical Biology*, 176: 447-455, 1985.
[3] A. Wikan, *Journal of Mathematical Biology*, 43: 471-500, 2001.

## Comparative computational versus experimental study of the influence of noise on a system of two electrical discharges **P. 15**

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The purpose of this work is the study of the influence of noise on the behaviour of an electrical discharge plasma. The plasma is generated by a device consisting of two coupled electrical discharges. They are situated in the same glass tube with the anodes facing each other separated by a distance of a few cm and biased relative to one another by a d.c. voltage source. An additional biasing by an a.c. source could be added. The tube is filled with argon at low pressure. Increasing the relative biasing potential from 0 to 40 V, sequences of periodic-to-chaotic behaviour can be observed. The ordered and disordered dynamic states for the perturbed space charge configurations are revealed by a time-series analysis. By increasing the relative biasing potential, unstable (chaotic) regimes develop under conditions that two or more space charge configurations are formed in the space between the two anodes and their dynamics are not correlated. In our model, this biasing potential plays the role of control parameter. The van der Pol equation has been successfully used to the modelling of various oscillatory phenomena in plasmas. We present a numerical model of the dynamical behaviour of the plasma based on two coupled perturbed van der Pol equations including noise terms. Addition of a small white noise signal induces significant changes in the spectrum of the global current response.

The main goal of this work is the study of these changes. We investigate the influence of a white noise on the unstable regime in a restricted interval of values of the control parameter. The spectra with and without noise show that the presence of noise determines a change in the amplitudes of the main maximums and a transition to a higher order of bifurcation. Contrary to a clear "rule of thumb", instead of strengthening the unstable behaviour, the noise increases the order in the dynamics of the system or emphasises some hidden dynamics, much like in the case of stochastic resonance. This behaviour can be understood in the following terms: for large enough noise applied to a chaotic attractor, the noise pushes the trajectory out of the basin of the chaotic attractor and into the basin of a periodic attractor. One can then speak of "controlling the chaos" by increasing noise. Of course, one can completely obliterate deterministic dynamics by adding enough noise, but in this example the system is still "mainly deterministic" after adding the noise. According to previous results, that such a thing is possible is not surprising, and it is fairly straightforward to find a model to exhibit it. However, the close connection of the model with the plasma experiment is striking. We find good agreement between the experimental data and the computation results for the following types of analysis: time series, spectra, phase portraits, Lyapunov exponents and correlation dimensions. The work demonstrates that the addition of noise terms to the system of equations modelling this double discharge plasma improves the model extending the agreement with experiment to the whole range of values of the experimental control parameter studied. Particularly, we show that the added random noise with certain characteristics re-establishes the agreement in a domain of the control parameter where the experiment shows period three dynamics and the noiseless equations show chaotic behaviour, without destroying the agreement corresponding to other values of the control parameter. Clearly, the situation is equivalent to a control of chaos by random noise. We extended the study of this aspect by changing the characteristics of the added noise. Ranges of parameters were identified corresponding to dynamics of $3 \times 2^n$ type. Unlike the suddenness of bifurcations caused by the variation of the control parameter, in the case of bifurcations induced by noise variation, there exists a small but definite range of noise parameters for which an almost periodical transition from one stage of bifurcation to the next is taking place.

## P. 16 Closures in the inverse cascade regime of 2d turbulence

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Inverse energy cascade regime of two dimensional turbulence is investigated by means of high resolution numerical simulations. Numerical computations of conditional averages of transverse pressure gradient increments are compared with a low order closure which is consistent with Gaussian transverse statistics. A similar low order closure model for the longitudinal pressure gradient is proposed and its validity is numerically examined. In this case numerical evidence for the presence of higher order terms in the closure is found. The fundamental role of conditional statistics between longitudinal and transverse components is highlighted.

## Self-consistent quantum-Fokker-Planck systems: Wellposedness and numerical approximation — P. 17

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The Wigner-Poisson-Fokker-Planck model is a non-linear dissipative quantum evolution equation in a kinetic phase-space framework. It is used for semiconductor device simulations, quantum Brownian motion, and quantum optics. We discuss the model, present a global-in-time existence and uniqueness result for the 1D periodic case, and analyze a numerical scheme based on mixed operator splitting & spectral collocation. Macroscopic (hydrodynamic and drift-diffusion) quantum evolution models for semiconductors can be obtained from the WPFP equation by taking velocity moments.

We present simulation results of the I-V-curve of resonant tunneling structures based of the WPFP model and compare it with simplified macroscopic models.

## An efficient nonlinear model predictive-control algorithm and feedback control of a looping kite — P. 18

*Moritz Diehl*
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Nonlinear model predictive control is a technique for feedback control of nonlinear systems that is based on an online optimization of the predicted future system behaviour. A practical application of NMPC has to overcome the difficulty to solve the occuring dynamic optimization problems reliably and in real-time, during the runtime of the process. In this talk, a newly developed algorithm to achieve this aim is presented. The approach is based on the direct multiple shooting method and is characterized by a dovetailing of the iterative solution procedure with the system dynamics in a very fast real-time iteration scheme. The scheme was successfully applied for the NMPC of a pilot plant distillation column using an optimization model with over 200 states. Here, we present recent numericel results of an application of the algorithm for the NMPC of a looping kite. The kite can be controlled by two lines, and shall automatically fly prespecified loops, despite disturbances that are due, e.g., to gusts. As the looping kite is a highly unstable nonlinear system, feedback to disturbances has to be applied in fractions of a second, if the kite shall not fall onto the ground. It is demonstrated that the proposed algorithm is able to achieve this aim, robustly and with good closed loop performance.

## Some solutions to the Poisson-Nernst-Planck equations — P. 19

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Impulse propagation on axons strongly depends on the dynamics of ionic channels. Here we study the contribution of convection in ionic channels upon the transmembrane electric current. The model suggested includes two ionic species of differing valence numbers and diffusion constants. Convective flow is modelled assuming Taylor-Aris dispersion; it modifies the form of the Hodgkin-Huxley equations for nerve impulse propagation. Some results are given in terms of similarity solutions. Possible biological implications are discussed.

**P. 20**

## Hebb-like learning rule based on the principle of extremal optimization

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We present a novel Hebb-like learning rule for multilayer neural networks. The learning rule is an extension to the classical Hebbian rule and consists of an additional degree of freedom which is assigned to each neuron. We show that there is a mapping, from the parameters of synapse memory, introduced by [Klemm 1999], to the parameters of neuron memory. Because the inverting of this mapping leads to none local relations we introduce a stochastic approximation for the synapse memory based on extremal optimization introduced by [Boettcher 2001].

We investigate the convergence behavior of our Hebb-like update rule for the exclusive-or (XOR) problem as in [Klemm 1999]. We demonstrate that our learning rule based on neuron memory combined with extremal optimization is able to learn the exclusive-or (XOR) problem comparable well as in [Klemm 1999] but under usage of less resources in form of the number of parameters.

**P. 21**

## The dynamics of energy demand — energy efficiency and the role of governments

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The role of governments is crucial in order to reduce the growth in energy demand. Authorities have several instruments to impose its policy. The instruments can for instance be regulations or energy taxes. In particular the dynamical aspects of timing is assessed, by introducing a nonlinear dynamic model, based on differential equations. The simulation of the model shows that applying taxes without a feedback control to the actual system, is inefficient, and can in some cases make a system instable and chaotic. On the other hand, if the government use a dynamic control parameter, like for instance the Rössler band, which has been applied here, the control of the system is much more likely to be successful. To carry out these policies can be difficult, one possibility that is discussed here, is the development of an early warning system, in order to give the public policy makers the chance to register the development of the energy demand on a disaggregated level. The implementation of an early warning system can do policymaking more dynamic, and should probably be considered as a tool in doing better dynamic adjustment to unexpected growth in the demand of energy.

**P. 22**

## Analysis of chaotic calcium oscillations in a three-store mathematical model

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A three-store mathematical model of intracellular calcium oscillations, based on CICR mechanism, is presented. The calcium stores considered are endoplasmic reticulum, proteins and mitochondria. In contrast to other similar models it assumes a linear rate law for calcium release from mitochondria. In spite of such simple description mitochondria retained their role in maintaining constant amplitudes of cytosolic calcium oscillations. Furthermore, the interplay among the three calcium stores leads to complex calcium oscillations such as bursting and chaos. This interplay is analyzed in terms of net calcium fluxes among the stores and cytosol. A bifurcation diagram is worked out and analyzed into details. Diverse representations such as time series, phase diagrams and return maps are presented to explain transitions from simple spiking to chaotic behavior via period doubling as well as between different types of bursting through intermittent phases of chaos in bursting.

## Waveletons and pattern formation — P. 23

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We consider applications of nonlinear local harmonic analysis to a number of wave motion problems (nonlinear wave, Navier-Stokes equations), turbulence model problem (Kuramoto-Sivashinsky equations), nonlinear Schroedinger-like equations (optical gap solitons, coherent matter waves in optical lattices). We consider different variational–wavelet approaches for constructing different representations in multiresolution framework via reduction from initial dynamical problems described by partial/ordinary differential equations to a number of algebraical problems. We present constructions, based on multiscale expansions, which give explicit representations for dynamical variables in different types of high–localized bases (compactly supported wavelets, wavelet packets, etc) As a result we obtained explicit representation for well localized wave/coherent structures: waveletons. Numerical modeling shows the creation of different internal coherent structures from localized modes, which are related to stable/unstable type of behaviour and corresponding pattern/waveletons formation. Because our approach started from variational formulation we can control evolution of instability on the pure algebraical level of reduced algebraical system of equations. It helps to control stability/unstability scenario of evolution in parameters space.

## Rational dynamics in nonlinear localized modes — P. 24

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Computational methods based on the exact fast convergent expansions in high-localized wavelet-like bases are used for construction of solutions for dynamical systems with rational type of nonlinearities. As examples we consider rms-like (envelope) dynamics, which can be used for the description and modeling of important features of collective type behaviour in momentum approximations for distribution functions and related to description of different space-charge effects in high intensity transport systems in accelerators and plasma physics problems. Our method is based on the generalization of variational-wavelet approach which allows to consider both polynomial and rational type of nonlinearities without perturbations or/and linearization. All dynamical variables are represented as expansions in the bases of maximally localized modes and are parametrised by a number of solutions of reduced standard algebraical problems which can be solved by scalar or parallel algorithms. Best convergence properties and minimal cost of algorithms lead to saving CPU time and hdd space as on the level of scalar as on the level of parallel algorithms inside.

## Chaotic geothermal flow in the north-east German basin — P. 25

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We present results of numerical simulations of thermoconvective flow in the sedimental basin in the north-eastern part of Germany carried out in a joint project between the Weierstrass

Institute and the GeoForschungsZentrum Potsdam. We model the basin as a heterogeneous porous medium with heat and fluid flow coefficients varying between the sedimental layers, heated from below by the Earth core, with insulated sides, open top and impermeable bottom. It is known that in this setting, flow instabilities can occur. Indeed, in our numerical experiments we found such instabilities, and moreover, the flow regime even might be chaotic, a fact which could explain such phenomena as vagabonding saline springs which have been observed in the Berlin-Brandenburg region. In the talk, we describe the numerical method used, and we present estimates of embedding dimensions and Lyapunov exponents based on a time series analysis of the Nusselt number time series.

## P. 26 How fast elements can affect slow dynamics

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A chain of coupled chaotic elements with different time scales is studied. In contrast with the adiabatic approximation, we find correlations between faster and slower elements when the differences in the time scales of the elements lie within a certain range. For such correlations to occur, three features are essential: strong correlations among the elements allowing for both synchronization and desynchronization, bifurcation in the dynamics of the fastest element by the change of its control parameter, and the cascade propagation of the bifurcation. The relevance of our results to biological memory is briefly discussed.

## P. 27 All volume-expanding dynamical systems have positive topological entropy

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One major significance of the topological entropy is its strong relation to other dynamical invariants such as Lyapunov exponents and Hausdorff dimension which provides our primary motivation. Almost all previous investigations of the topological entropy have been concerned with upper bounds, exact formulas have been derived under strong smoothness assumptions only. In this talk we will give lower bounds of the topological entropy of $C^1$-smooth dynamical systems on Riemannian manifolds which are in some cases sharp bounds. They are formulated in terms of the phase space dimension and of the exponential growth rates of a certain function of the singular values of the tangent map. These rates correspond to the deformation of $k$-volumes and can for instance be estimated in terms of Lyapunov exponents. Examples address Hénon maps, the Lorenz system, the geodesic flow on a (not necessarily compact) Riemannian manifold without conjugate points, and skew product systems.

## P. 28 Non-linear dynamics of protein folding: The anti-chaos of life

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We have used a well known computer lattice model to generate a time series of protein unfolding data. We show how the output data from the model can be used with mathematical techniques of non-linear dynamics to obtain important information about the complex underlying protein dynamics. We calculate Lyapunov exponents for protein behavior under different biochemical conditions. Highly organized proteins in their native state can be followed under conditions

in which the protein remains folded but executes small scale thermal fluctuations. For these computer runs that do not unfold, the Lyapunov exponent is close to zero. However, when conditions are changed such that the protein unfolds, we find positive Lyapunov exponents implying chaotic dynamics.

## Uniqueness of attracting sets in forced reversibly damped fluid mechanics **P. 29**

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Recently Gallavotti proposed an equivalence principle (EP) in hydrodynamics, which states that forced-damped fluids can be equally well represented by means of the Navier-Stokes equations (NS) and by means of time reversible modifications of NS called gaussian Navier-Stokes equations (GNS). The EP received numerical support in a paper by Rondoni and Segre. These reults are based on the assumption that the NS and GNS systems only have one attracting set. In this paper we investigate this issue in detail, and we find that indeed there are condition to be met by the GNS system in order to have uniqueness. In particular we find the counter intuitive fact that greater Reynolds numbers do imply greater order. Hence the coexistence of different attractors is possible for larger Reynolds numbers and same other parameters. The loss of uniqueness of the steady states can be removed by enlarging the number of simulated modes. We present a systematic classification of the cases with and without unique steady states.

## Lattice-Boltzmann simulations of domain growth in ternary amphiphilic fluids in three dimensions **P. 30**

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We simulate the growth kinetics of ternary amphiphilic fluids in three dimensions using a modified Shan-Chen lattice-BGK model in three dimensions for immiscible, incompressible and isothermal fluid mixtures with an extra phase consisting of surfactant molecules. The initial configurations we use are deep quenches below the spinodal point of thorough mixtures of two immiscible fluids when surfactant is added throughout. We find that the presence of surfactant reduces the usual oil-water interfacial tension in accord with experiment and consequently affects the nonequilibrium growth of the two immiscible fluid phases. As the density of surfactant is increased we observe a crossover from the usual binary mixture scaling laws in 3D to a growth that has been considerably slowed down, and we find that this slow growth can be characterised by a logarithmic time scale. With sufficient surfactant in the system we observe that the domains cease to grow beyond a certain point; we find that this final characteristic domain size is inversely proportional to the interfacial surfactant concentration in the system and that a stretched-exponential accurately describes the data across the whole timescale of the simulations in these cases.

P. 31

## Solitons in diatomic chain with cubic and quartic nonlinearities

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One-dimentional diatomic chain with nonlinear potential of atoms' interaction ("in-site" potential) and nonlinear external potential ("on-site" potential) is considered. Both potentials include cubic and quartic nonlinear terms. The modified asymptotic procedures are proposed to obtain soliton solutions in the low-aplitude resonant approximation. Such the procedures account the existence of antisymmetric (cubic) nonlinear terms in potentials. It is shown, that for aplitudes of the main harmonics the resulting differential equations are similar to those, which were obtained in the models with pure symmetric nonlinear potentials. However, the structure of general solution is significantly different. In the particular cases of pure cubic "in-site" and "on-site" nonlinearities gap and out-gap solitons were studied. New types of such solitons, which exist only in modulated system with asymmetric nonlinear potentials, were described.

P. 32

## The role of toxicants on food chain dynamics: A theoretical analysis

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Many ecosystems contain toxic stressors; nevertheless, the way foodweb interactions interfere with the effect of pollutants is poorly understood. Here it is shown how food chain dynamics can be affected by progressive contaminations and how predation mechanisms can distort and magnify pollutant effects in surprising ways. The aim is obtained by systematically determining the bifurcations of a third order nonlinear system describing a 2 preys - 1 predator model, in which two parameters have been introduced for indicating the concentrations of toxicants for preys and predators ([1] and [2]). The analysis shows that increasing values of toxicants implies a transition from cyclic to stationary coexistence and that this transition is facilitate by increasing superpredator densities and decreasing productivity. Moreover, multiplicity of dynamic behaviors and catastrophic transitions may arise. Finally, the evaluation of the population average values has shown a surprisingly increase of the intoxicated species' biomass against an increase of the toxic concentration. The extrema are reached on the 'edge' of the most complex behavior.

P. 33

## Analysis of dynamic behaviors of cascade of bioreactors with recycle

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In this work a quantitative and qualitative analysis of dynamic behaviors for a cascade of stirred tank bioreactors with partial recirculation and thickening of biomass has been placed. The calculations have been carried out for the process of phenol biodegradation with two trophic levels according to predator-prey scheme. The calculations of static and dynamic behaviors for broad range process parameters have been performed. The regions of single and multiple steady states, the periodic solutions as well as the Hopf bifurcation points have been specified. The dynamic behaviors of the cascade of bioreactors have been analyzed on the base of time trajectories calculations. The results of calculations have been presented on bifurcation diagrams. The occurrence of regions of slow and quick dynamics has been observed. The double period cascades as well as the regions of multicycles have been found. On the base of obtained results

the conclusions on the influence of process parameters on dynamic behaviors of analyzed systems have been formulated.

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## Counting closed geodesics **P. 34**

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We establish an asymptotic formula for the number of homotopy classes of periodic orbits for the geodesic flow on a rank one manifold of nonpositive curvature. This extends a celebrated result of fields medalist G.A. Margulis to the nonuniformly hyperbolic case and strengthens previous results by G. Knieper.

While proving this result, we also manage to carry out Margulis' construction of the measure of maximal entropy without requiring strong hyperbolicity.

## Porous media solute transport — accuracy of advection-dispersion computation and non-equilibrium effects **P. 35**

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We present the numerical experience with the model of solute transport in dual-porosity medium, governed by the advection-dispersion equation coupled with. The advection is solved by finite volume method with upwind flux approximation, which brings an artificial numerical dispersion to the model, comparable with the real physocal dispersion. We use quite simple model meshes (one-dimensional canal and centrally symerical cylinder with sink in the centre) to study the behaviour of the model. We study the spreading of impuls change of concentration from two aspects - accuracy of advection and dispersion calculation and the influence of the parameter describing the rate of mobile-immobile exchange. The results show, that under reasonable conditions on mesh geometry and time step, the model represents appropriately the real processes, measured by global quantities.

## A constructive approach to traveling waves in chemotaxis **P. 36**

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The poster will summarize the results from my joint paper with Angela Stevens on the existence of traveling wave solutions for chemotaxis or Keller-Segel models of the form

$$\left.\begin{array}{rcl} u_t &=& \nabla(k(u)\nabla u - u\phi(v)\nabla v) \\ v_t &=& k_c\Delta v + g(u,v) \end{array}\right\} \qquad (2)$$

in one and higher space dimensions. This system is known as one of the classical models to describe chemotaxis, the active motion of a population $u$ towards a chemical signal $v$, a phenomenon which is well known in microbiology. Many different patterns can be observed in chemotactic species. One of them are traveling waves or pulses which spread trough the population. These can occur due to growth of the respective population but also due to the dynamics of motion of populations especially when they are in a non-reproductive stage. The poster is concerned with the later phenomenon. The intention of the presented constructive approach is to give modelers a choice of sensitivity, production and decay functionals at hand.

The poster will show the existence of traveling wave solutions for the system with homogeneous Neumann boundary conditions in case of space dimension one. Our results allow a general class of nonlinearities. Furthermore it is shown that for space dimensions larger than one there exist traveling wave solutions for (2) in the cylindrical domain $\Omega = \mathbf{R} \times \Gamma$, where $\Gamma$ is a bounded domain in $\mathbf{R}^{N-1}$ $(N \geq 1)$, with no-flux-boundary conditions for the first equation and homogeneous Dirichlet boundary conditions on $\partial\Gamma$.

## P. 37 A simple dynamical model with history dependence for a sand-pile experiment

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Recent experimets exhibit the dependece of the pressure distribution at bottom of sandpile on its piling procedure. We investigate a lattice dynamics model for the history dependence observed in sandpile experiments. The dependence of the stress distribution on the preparation of the sandpile is explained as a dependence of certain attractors on the preparation of the system. The model has three phases, but the history dependence is shown to exist only in the phase where a perturbation is amplified selectively rather than globally when propagating in the downflow direction. The condition for this history dependence is given in terms of the spatial Lyapunov exponent.

## P. 38 Transport phenomenon due to chaos on periodically forced pendulum

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The diffusion of chaotic orbits is one of the most important transport processes in a variety of physical systems. We study about the diffusion of chaotic orbits on a periodically forced pendulum without friction. The phase space for this system is usually divided into chaotic and regular components. The average velocity on the Poicare section for this system has a periodicity. The anomalous diffusion occurs due to the intermittent sticking to a hierarchical structure of islands around islands, and the time-correlation function of this system decay slowly. We would like to discuss the statistics of chaotic orbits in the system.

## P. 39 Giant improvement of time-delayed feedback control through synchronisation between controller and target orbit

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Time-delayed feedback schemes are the most important methods for noninvasive control of chaos. Such approaches have been widely used in quite different experimental settings for stabilising unstable periodic orbits. We report on an improvement of those control methods by several orders of magnitude.

We derive control forces, i.e. a suitable control matrix, from a single Floquet eigenmode of the target orbit. In autonomous systems a huge increase of the control domain is observed, compared to diagonal control methods where all degrees of freedom are measured and controlled. The efficiency of our new scheme is based on a synchronisation mechanism between the phase of the target orbit and the explicit time dependence of the eigenmodes which are used to derive the control forces.

We develop a general analytical theory for our new control scheme. The theoretical predictions are compared to numerical simulations in simple models like the R"ossler equations and to reaction-diffusion systems with global coupling describing the nonequilibrium transport in semiconductor devices. Our numerical findings are in quantitative agreement with the analytical theory.

## Some nonlinear inverse problems and related singular integral equations **P. 40**

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Several nonlinear inverse problems in mathematical sciences are discussed: a friction coefficient identification problem, a nonlinearity identification problem in nonlinear oscillations, a time-dependent thermal conductivity identification problem, inverse bifurcation problem in mathematical ecology (nonlinear reaction kinetics identification problem in a diffusional model of population dynamics from the relation between growth rates and central densities of population distributions). A certain class of singular integral equations plays a principal role in our mathematicai analysis of the inverse problems; some existence results of the solutions to the integral equations are established and applied to the inverse problems.

## Instability regions and existence of non-hexagonal patterns in a photorefractive feedback system **P. 41**

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Photorefractive single mirror feedback systems display spontaneous formation of transverse patterns. In addition to the predominantly observed hexagonal patterns, other patterns are also observed, such as squares and squeezed hexagons.

A discrepancy between experimental data for the transverse size of patterns and predictions obtained through a linear stability analysis is shown to suggest a mechanism for the stabilization of non-hexagonal patterns. The observed deviation motivates a detailed check of the linear analysis' results against the experiment.

We present experimental investigations of the modulational instability with respect to the control parameter and the phase of the feedback signal. The results are compared to predictions obtained by means of the linear stability analysis. Finally, the relevance for the formation of non-hexagonal modes is reviewed.

## Synchronous and chaotic response of an excitable dynamical system on pulse stimulation **P. 42**

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We analyze the response of an excitable dynamical system on pulse stimulation. The system represents the FitzHugh-Nagumo like neuron model with a threshold manifold. The stimulus is taken in the form of periodic pulse sequences with a variable inter-spike interval. It is found that the response of the model displays selectivity on number of pulses and on the inter-spike frequency. It is shown that the inter-spike interval of the response signal represents a staircase with the plateaus corresponding the synchronous response. The plateaus are alternating with regions of chaotic response where the spikes appear with some probability distribution. It is shown that the response can be described by 1D and 2D nonlinear Poincare point maps whose stable fixed points and limit cycles corresponds to the synchronous output spiking and chaotic attractors to the chaotic response signal.

**P. 43**

## Heterogenic solutions for a model of skin morphogenesis

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In the early stages of embryonic growth the skin of vertebrates consists of two layers: the epidermis with its cells densely packed and the dermis with its cells more loosely packed. The epidermis and the dermis are separated with a thin fibrous basal lamina. One of the models of skin morphogenesis was proposed by Cruywagen and Murray (1992). In this model the epithelial layer is treated as a visco-elastic medium with a small Reynolds number, whereas the motion of the dermis cells is described by reaction-diffusion-chemotaxis equations. The interaction of the dermis and epidermis is taken into account by introducing morphogens. The morphogens are secreted separately in these two layers. Diffusing through the basal lamina they cause motions of the cells and deformations. The above model is analyzed from the point of view of travelling wave solutions. Two simplifying conditions are introduced:

1. traction produced in the epithelial layer by the morphogen secreted in the epidermis is much weaker than the elastic forces and the force exerted by the basal lamina
2. The force exerted by the basal lamina is much bigger than the forces acting on the epithelial.

The existence of travelling wave solutions is proved. These waves connect two characteristic states of the dermis cell densities (with zero dilation and the same epithelial densities). The dependence of the speed of the waves on the parameters of the system is analyzed.

**P. 44**

## Symbolic analysis of high-dimensional time-series

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In order to extract and to visualize qualitive information from a high-dimensional time-series, we apply symbolic dynamics. Counting certain ordinal patterns in the given series, we obtain a time series of matrices whose entries are symbol frequencies. This matrix series is explored by simple methods from nominal statistics and information theorie. The method is applied to detect and to visualize qualitative changes of EEG data related to epileptic activity.

**P. 45**

## Oxygen effect on time-delayed bifurcations in the Belousov-Zhabotinsky oscillating chemical reaction in batch reactor

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We have performed a detailed study of an oxygen effect on time-delayed bifurcations that occur in the Belousov-Zhabotinsky oscillating chemical reaction (oxidation of malonic acid by bromate ions catalyzed by ferroin) in a batch reactor. Analysis of oscillation attributes (oscillation period and amplitude) shows that time-delayed Hopf bifurcation occurs at low concentrations of oxygen. If oxygen concentration is less than 30% (vol/vol) we found that square of amplitude is proportional to the oscillation frequency. Experimental data allowed us to find all parameters that describe time-delayed Hopf bifurcation using normal form representation. At higher oxygen concentrations oscillations disappear through the SNIPER bifurcation (saddle-node infinite period bifurcation). We propose a kinetic scheme that describes all experimental data quantitatively.

## Investigation of dynamical systems described by differential equations with quadratic right-hand side — P. 46

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Systems with quadratic right-hand side are considered. Stability investigation has carried out with aid of quadratic Lyapunov function. Critical cases are investigated when the matrix of linear part has either one zero eigenvalue or one pair of pure imaginary eigenvalues. Sufficient conditions of stability are obtained. Critical case with zero matrix of linear part is investigated also. Sufficient conditions of both stability and instability are obtained. Instability investigation has carried out with aid of linear Chetaev function.

## Low-dimensional chaotic dynamics in dripping taps — P. 47

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The beat of a dripping water tap is not always regular, exhibiting a variety of complex behavior including chaos. Although a lot of researches have been reported on this subject, most of theoretical models have assumed ad hoc low-dimensionality, suggested by experimental data of dripping time intervals. We numerically simulated chaotic behavior of the dripping tap by tracking the drop formation at a given flow rate. The results were verified by our experimental observation using a high-speed camera, namely, the low-dimensional chaotic attractor in the continuous state space was presented not only by the simulation but also by the experiment for the first time. From detailed analysis of the simulation, we found that the state of the drop is well described by an approximate potential function with only two variables, the drop mass and its position. The global potential surface provides a clear picture of the low-dimensional dynamics. Similar potential landscapes are expected for other systems involving drop formation, which might be useful for understanding of basic dynamics and modeling based on it.

## Stability of spatially homogeneous solutions in two-dimensional lattice dynamical systems — P. 48

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We investigate the stability of the steady state solutions of the Coupled Maps Lattices with two-dimensional lattice. The using of two-dimensional shift give us the possibility to obtain the spectrum of the linearized operator or at least to estimate the spectral radius of this operator and in this way to determine the stability of the steady state solutions.

## P. 49 Multiple steady states in an RFR reactor under forced temperature oscillations

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The Multiple Steady States (MSS) in RFR chemical reactors were a subject of investigation in several papers [1,2]. It is believed that models based on plug flow, neglecting axial dispersion mechanisms exhibit only one or three steady states for irreversible first order exothermic reaction on a catalyst surface. However, when such a reactor is forced by temperature oscillations (by cycling inlet temperature) phase plots may by changed and this aspect of dynamic behavior is a subject of the work presented. The mode of oscillations is given by two integer numbers $m_n$. The first integer $m$ denotes number of cycles when inlet temperature is constant and equal to $T_{01}$. The second integer $n$ denotes number of cycles with the same inlet temperature $T_{02}$. This convention limits the investigations to some extent but having in mind that cycling time is usually very small, this limitation is not too restrictive. A plug flow model for an adiabatic fixed bed reactor was used. A single first order reaction was assumed.

Oscillations of type $1_1$ were applied with $T_{01} = 0.9$ and $T_{02} = 1.1$.
A comparison between the standard operation and the case with temperature oscillations was presented. The comparison suggests that temperature oscillations do not change the number of existing steady states, however they influence the region of parameters in which the MSS are observed. This region is going to be slightly smaller than in the case with no oscillations at all.

We have not observed complex spatiotemporal patterns even in the presence of forced temperature oscillations.

[1] Rehacek, J., Kubicek, M., Marek, M., (1998). Periodic, quasiperiodic and chaotic spatiotemporal patterns in a tubular catalytic reactor with periodic flow reversal. Chem. Eng. Sci. 22, 283-297.

[2] Ŕukowski, W., Berezowski, M., (2000). Generation of chaotic oscillations in a system with flow reversal. Chem. Eng. Sci. 55, 339-343.

## P. 50 Stationary theory of the Grinfeld instability

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We investigate the interface dynamics of the two-dimensional model of the Grinfeld instability. By introducing a new ansatz — multicycloids — we are able to describe the shape of stationary solutions even at large amplitudes.

We verify numerical solutions presented earlier by Spencer et.al. and complete the picture of the two-dimensional model by considering arbitrary gravity.

## P. 51 Modelling of biochemical reaction-diffusion-convection systems: Waves and complex dynamics

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The occurrence of moving spatiotemporal patterns in spatially distributed systems is caused by an interplay of nonlinear internal dynamics (chemical reaction) combined with mass transport. We show that in these reaction-diffusion-convection systems travelling pulse and front waves can exist as well as complex periodic or nonperiodic travelling patterns. In the first part we introduce a moving coordinate transformation so that reaction-diffusion-convection system (the system of partial differential equations) converts to a system of ordinary differential equations and problem for accurate location and continuation of front and pulse waves converts to a boundary value problem for homo/heteroclinic orbits. In the second section complex (nonperiodic) solutions of corresponding partial differential equations are studied. Effects of choice of initial conditions on the wave pattern and the effect of convection on the emergence of complex patterns are also discussed.

## Chaos based assessment of the software development process state **P. 52**

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Complex systems share certain features like having a large number of elements, possessing high dimensionality and representing an extended space of possibilities. Such systems are hierarchies consisting of different levels each having its own principles, laws and potential structures shortly called emergent properties.

Computer programs, including popular information systems, usually consist of (or at least they should) number of entities like subroutines, modules, functions, etc., on different hierarchical levels. Concerning laws of software engineering or the concepts of programming languages the emergent characteristics of above entities must be very different from the emergent characteristics of the program as the whole. Indeed, the claim that programming techniques as stepwise refinement, top-down design, bottom up design or more modern object oriented programming are only meaningful if different hierarchical levels of a program have distinguishable characteristics and clearly qualify computer programs as the class of complex systems that should be developed using a complex development process [10].

Concluding from the last assumption we can state that software development process can be analysed by techniques and concepts used in the analysis of complex systems. In the poster we introduce the "Chabás", an approach which enables us to assess the current state of the software development process based on the chaotic theory of bifurcation and information content of programs (i.e. alpha metric). That further enables us to control the software development process in more efficient ways. The empirical study using Chabas on more then 100 programs with number of version ranging form 50 to 300 has been analysed with surprisingly good results.

## Thermomechanical contact problem compartible with "solid-shell" element **P. 53**

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The article presents a construction of a couple field thermal-structural solid element and couple-field thermal structural contact element. The presented approach aimed at extension of the 'solid-shell' concept into describing couple-field thermomechanical dynamic problem as well as thermal-contact problem. The thermal part of the element based on the multiplicative decomposition of the deformation gradient into elastic and thermal parts. It is shown that this decomposition is compartible with second law of thermodynamics. Various contact techniques based on "node-to-node" and "node-to-surface" procedures are considered for the implementation. Numerical results show well-known examples as well as new ones describing delamination of the two-layered shell.

**P. 54**

## On the effect of size on the occurrence of chaos in diluted neural networks

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The ranges of chaotic evolution of a neural networks of Hopfield type, consisting of the neurons with $\tanh(gx)$ as the activation function is analysed for the networks with different number of neurons $N$ ($N = 2; 10; 1600$). Random, uniform distribution of synaptic connections is assumed. The dilution of synaptic connections is defined by the number of neighbours $k$. Dynamics of the network with different $N$ and control parameters $k$ and $g$, is examined. Conditions for chaotic evolution of the network $N = 2$ are calculated. For greater networks simulations indicate three types of network's dynamics. For the values of $g$ and $k$ small enough, there are periodic or fix point attractors. When $g$ or $k$ is larger, quasiperiodic motion is observed in a narrow, transition region in which DFT shows a number of characteristic frequencies and the return maps show that the trajectory lays on the torus of a complex shape. An increase of $g$ or $k$ parameters leads to a decay of the torus, which means the appearance of the chaotic evolution. For large enough values of $g$ and $k$ that depend on the size of the network the chaotic evolution occurs.

**P. 55**

## Nonlinear filtering of EEG and its effect on complex measures estimation

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This contribution is related to the poster "Dynamics of EEG during brain entrainment" (Michal Teplan, Anna Krakovska, Svorad Stolc). We investigated certain effects of popular Mind machines. The entrainment of group of volunteers consisted of 30 single trainings with Mind machine during 2 months. Before and after each training the EEG signal was recorded from two channels. The study was designed to explore changes in linear and nonlinear measures. The computation of complex measures is problematic since it requires long time series of high-precision, noiseless, stationary data. Its hardly fulfilled for EEG. Therefore, we decided to suppress the undesirable effect of noise in data. We tried to filter EEG by the nonlinear method which was originally developed for chaotic signals, despite the fact that brain was not proved to be following chaotic behavior. The poster will show the impact of noise reduction on different characteristics estimation.

**P. 56**

## Symmetry-breaking cascade to spiral vortices in finite Taylor-Couette flow

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Spiral vortices appear in Taylor-Couette flow from a Hopf bifurcation in circular Couette flow for sufficiently high couterrotation rates in a system of infinte axial extend. The appearence of this time-dependent flow is accompanied with a simultaneous breaking of both the axisymmetry and the mirror symmetry of the basic flow. Experimental evidence is presented that in a finite system the transition to spiral vortices can occur as a cascade of bifurcations breaking respectively the axisymmetry and the mirror symmetry of the flow. In particular a time-dependent mirror symmetric flow appears that has neither been predicted theoretically nor been observed experimentally as a consequence of the first instability in the Taylor-Couette system. Properties of the flow and the transition cascade are presented.

## A collection of the simplest synchronized chaotic systems P. 57

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In this work the Open-Plus-Closed-Loop (OPCL) method of control for chaotic systems (E.A. Jackson and I. Grosu, Physica D 85,1,1995) is used in order to control and synchronize the Sprott's collection of the simplest chaotic systems. The method is general and unambiguous. The conditions for the convergence of the method are obtained using the Routh-Hurwitz conditions. This approach allows one to choose the simplest coupling term possible. The intervals of parameters where the control is satisfied are obtained analytically. These results are numerically verified for the I system from the Sprott collection. The influence of noise on the method is also analyzed.

## Application of OPCL for the control of population and ecological dynamics P. 58

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OPCL method of control for dymamic systems (E.A. Jackson and I. Grosu, Physica D 85,1,1995)is applied to control and synchronization of a population and an ecological model. The control obtained with this method is general and unambiguous. It is shown that a chaotic dynamics can be synchronized to a pre-recorded one, overpassing the unpredictability of population dynamics. The method also gives the possibility of stabilizing an Unstable Periodic Orbit (UPO) of any period embedded in the chaotic attractor. The method can be applied also to control periodic dynamics to other types of periodic dynamics. The influence of noise on the stability of control is also verified and the system is proved to be robust.

## Generalized Swift-Hohenberg equation: localised, periodic and quasi-periodic solutions, travelling fronts and their stability. Exact results P. 59

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The generalized Swift-Hohenberg equation is one of the basic model equations in the theory of pattern formation. We study this gradient-like equation in one dimensional spatial infinite domain by means of methods of the theory of dynamical systems that allow us to prove the existence of localised, periodic and quasi-periodic solutions. Its stationary solutions are described by a Hamiltonian system that is studied in details, including bifurcational analysis. We construct bifurcational curves in the parameter plane of the birth of first localised solution (first homoclinic tangency to the related saddle-focus equilibrium of the system). Also we construct the curve corresponding to the appearance of travelling fronts for the equation and describe the mathematical reason of their appearance. Using methods of spectral analysis of one-dimensional differential operators we show that some of localised stationary and travelling wave solutions are temporally stable.

## P. 60 Evolution of rotations of a rigid body under the action of perturbing moment

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We investigate perturbed rotational motions of a rigid body, similar to regular precession in the Lagrange case, under the action of restoring and perturbing moments that are slowly changed in time. The restoring moment also depends on the angle of nutation. It is assumed that: the angular velocity of the body is large; restoring and perturbing moments are small with definite hierarchy of smallness of components. A small parameter is introduced in a special way. After performing the manipulations, we obtains a system of equations which contains two rotating phases and the corresponding frequencies are variable. The averaging method is used. We show that averaging of nonlinear system is equivalent to averaging of a quasi-linear system with constant frequencies. The averaged system of equations of motion is obtained in the first approximation for the essentially nonlinear two-frequency system in nonresonant and resonant cases. We consider the perturbed motion of a rigid body in the Lagrange case with allowance for the moments applied to the body from the external medium. We assume that the perturbing moments are linear-dissipative and slowly changed in time. We consider the problem of reduction of the top in state of regular precession by use of the small control moments. Thus, the new class of motions of axially symmetric body with regard to nonstationary restoring and perturbing moments is investigated. Problems of mechanics and control of rotations of a rigid body, meaning for applications are solved.

## P. 61 Modeling noisy dynamical systems

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For a dynamical system one has often a model consisting of ordinary differential equations and on the other hand just a noisy time series of some observables of the system. In this contribution we treat the identification of parameters in the model from measured time series.

We apply a method known from the literature — the multiple shooting technique — for fitting of parameters for differential equations on clean as well as on noisy time series from numerical simulations and from experiment. For the simulated data from the Lorenz and the Rössler model we show that it is possible to fit the data to an universal three dimensional quadratic ansatz and to reconstruct here the true parameters of the original systems. We show also the improvement of the fit for data conterminated with dynamical noise (i. e. noise that interacts with the dynamics) by recontructing the deterministic part of the dynamics with a simple one-step prediction. Finally we apply the fitting algorithm to experimental data of an intracavity frequency doubled solid state laser.

## P. 62 Quasi-static brittle fracture in inhomogeneous media and iterated conformal maps: Modes i, ii and iii

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We study the geometrical characteristic of quasi-static fractures of mode III in disordered brittle media. The evolution of the fracture pattern is achieved by using iterated conformal maps. This

method allows an efficient and accurate solution of the Lamé equations without resorting to lattice models.

Typical fracture patterns exhibit increased ramification due to the increase of the stress at the tips. We find the roughness exponent of the experimentally relevant backbone of the fracture pattern; it crosses over from about 0.5 for small scales to about 0.75 for large scales.

Furthermore we study the changes in the fracture patterns due to the effect of quenched noise as well as the dependence on different velocity rules for the fracture propagation.

[1] F. Barra, H.G. Hentschel, A. Levermann and I. Procaccia in Phys. Rev. E, **65** (March 2002)

[2] F. Barra, A. Levermann and I. Procaccia (unpublished) see
www.weizmann.ac.il/chemphys/anders

## Nonlinear kinetics of biomolecules' binding on microchips with gel-associated probes **P. 63**

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The accumulation of target molecules in a gel pad containing specific probe is described by kinetic equations taking into account the diffusional migration of target molecules within the gel layer, the association reaction between target and probe molecules and the dissociation of target-probe complexes. Different types of kinetics can be observed. In case of moderate target-probe affinity the association and dissociation reactions are fast enough to ensure local binding equilibrium. The target accumulation follows (nonlinear)"retarded diffusion", i.e. diffusion interrupted by transient binding to immobile probe molecules. The retardation depends on local target concentration (which determines the occupancy of binding centers). A change in binding strength (e.g. by temperature variation) is shown to oppositely affect the kinetics at low and at high target concentrations. In case of very high target-probe affinity the irreversible binding is shown to propagate as a travelling wave with constant velocity.

## Dynamic regimes and bifurcations in a reduced model of blood coagulation **P. 64**

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Blood coagulation can be viewed as an autowave process. We have previously described this process by the reaction-diffusion system of three equations. Diffusion coefficients are equal for all variables in this model. Several regimes well known for active media can be excited in the model by a local increase in the concentration of the first variable (an activator). Such regimes include (i) impulses running with the constant velocity and profile (an autowave), (ii) oscillating waves, (iii) moving fronts, which can switch medium from one spatially uniform state into another (switching fronts), as well as (iv) motionless, spatially localized structures. There are also more complicated regimes: (v) replicating impulses, (vi) impulses that run at some distance from the place of activation before they stop (stopping impulses) and (vii) even more complex impulses, in which the leading front does not change, while the rest of the impulse sways aperiodically. All these enumerated regimes could be obtained by varying only two parameters, characterising the chemical part of the model. Here, we describe the region on this parametrical plane, which contains stable autowaves bordering on the region of the stopping impulses (1), the region of oscillating waves (2) and the region of replicating impulses (3). This region also overlaps with the region of the complex impulses. We found Hopf bifurcation for autwowaves at the border (2), and fold bifurcations for autowaves at borders (1) and (3). For given parameters values the velocities and profiles of the leading parts of the replicating and complex impulses coincide very accurately with the velocities and profiles of the unstable switching fronts.

## P. 65 A numerical scheme for stochastic pdes with gevrey regularity

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We consider strong approximations to parabolic stochastic PDEs. We propose a numerical scheme which is more accurate and less stiff than traditional algorithms. To achieve this we need to assume that the noise lies in the smallest space in which the deterministic part of the PDE is known to have solutions, namely a Gevrey space of analytic functions. We show that our numerical scheme has solutions in a discrete equivalent of this space. We illustrate the scheme by looking at the effect of noise on travelling wave solutions.

## P. 66 Triggering syncronized oscillations through arbitrarily weak diversity in close-to-threshold excitable media

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It is shown that an arbitrarily weak (frozen) heterogeneity can induce global synchronized oscillations in excitable media close to threshold. The work is carried out on networks of coupled van der Pol-FitzHugh-Nagumo oscillators. The result is shown to be robust against the presence of internal dynamical noise.

## P. 67 Time series analysis of turbulent bubbly flow

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Hot-wire anemometry is one of the standard techniques for measurements in turbulent two phase flows. The time series contains valuable information about the local properties of the fluid as well as the gaseous phase. However, the disentanglement of the fluid and gaseous part of the signal is intricate. Hitherto methods require an a priori knowledge of probability distribution of the signal or its derivatives. At low Reynolds number this distribution is bi–modal and therefore an optimal (Bayesian) classifier can be derived. At high Reynolds number turbulent flow, this assumption is in general not valid. This leads to faulty classification due to intermittency or strong velocity fluctuations. We propose a novel algorithm which reformulates the problem of local phase detection as an general pattern recognition task. The algorithm consists of an optimal signal decomposition using adaptive wavelet transform. The classification is done with neural network based trained classifier. The performance of the algorithm is validated for turbulent bubbly flow at various Reynolds numbers and void fractions. We compare methods to disentangle the bubble signal from that of the continuous phase. In particular, we discuss the evaluation of structure functions and velocity spectra, focusing on the scaling properties.

## Spatio-temporal dynamics of acoustic cavitation P. 68

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Acoustically driven cavitation bubble fields consist of typically $10^4$ micron–sized bubbles. Due to their nonlinear hydro-acoustical interaction, these extended multi–scale systems exhibit the phenomen of spatio–temporal structure formation. Apart from its significance for the theory of self-organization, it plays a major role in design and control of many industrial and medical applications. Prominent examples are ultrasound cleaning, sono–chemistry and medical diagnostics. From a fundamental point of view the key question to ask is: How does the fast dynamics on small length scales determines the global slow dynamics of the bubble field? To clarify the complex acoustical and hydrodynamical bubble-bubble interaction, we employ high-speed Particle Tracking Velocimetry. This technique allows the three dimensional reconstruction of the bubbles' trajectories on small and fast scales as well as the measurement of the bubble density on large and slow scales.

## Generalization of the Goraychev-Chaplygin case P. 69

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In this paper we present a generalization of the Goraychev-Chaplygin integrable case on a bundle of Poisson brackets, and on Sokolov terms in his new integrable case of Kirchhoff equations. We also present a new analogous integrable case for the quaternion form of rigid body dynamics' equations. This form of equations is recently developed and we can use it for the description of rigid body motions in specific force fields, and for the study of different problems of quantum mechanics. In addition we present new invariant relations in the considered problems.

## Intermittencies and symmetry in reverse-flow chemical reactors P. 70

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In this work we discuss how spatio-temporal symmetry influence the dynamics of discontinuously forced chemical reactors. Recent analysis, based on Lie group theory, are related to a dynamical systems that are symmetric with respect to linear transformations that involve the system state and the time. These spatio-temporal symmetries were found in reverse-flow reactors and depend on the type of forcing only. Such symmetry properties can be used to improve efficiency and accuracy of standard bifurcational analysis, in that difficulties due to the discontinuous nature of the forcing are avoided. To this aim, suitable discrete systems based on the Poincaré map for spatio-temporal symmetric systems are constructed. Such discrete systems inherit the symmetry properties of the original systems, and are diffeomorphisms. Spatio-temporal symmetry properties influence the possible bifurcational scenarios: obviously, only some kind of bifurcations are possible, whereas some usually high-codimension bifurcations become generic. Routes to chaos also show peculiar properties: special kinds of intermittency and attractor merging crises are found and analysed.

## P. 71 Reducing the complexity in the nonlinear dynamics of a fluid flow past a movable cylinder

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The model of a two-dimensional fluid flow past a cylinder is a relatively simple problem with a strong impact in many applied fields, such as aerodynamics or chemical sciences, although most of the involved physical mechanisms are not yet well known. This paper analyzes the fluid flow past a cylinder in a laminar regime with Reynolds number, $Re$, around 200, where two vortices appear behind the cylinder, by using an appropriate time-dependent stream function and applying nonlinear dynamics techniques. The goal of the paper is to analyze under which circumstances the chaoticity in the wake of the cylinder might be modified, or even suppressed. And this has been achieved with the help of some indicators of the complexity of the trajectories for the cases of a rotating cylinder and an oscillating cylinder.

## P. 72 Mean flow effects in the Faraday instability

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We analyze the onset of the Faraday instability in a 2D container that is vertically vibrated. In the small viscosity limit the evolution of the waves on the free surface is coupled to a non-oscillatory mean flow that developes in the bulk of the container. The corresponding equations (Navier Stokes for the mean flow and Amplitude equations for the surface waves) are derived and analyzed numerically. The numerical simulations indicate that the mean flow plays an essential role in the dynamics of the waves. The different states found numerically will be presented and compared with experimental results.

## P. 73 Tip splittings, characteristic angles and phase transitions in the dielectric breakdown model

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We show that the fractal growth described by the dielectric breakdown model exhibits a phase transition in the multifractal spectrum of the growth measure. The transition takes place because the tip-splitting of branches forms a fixed angle. This angle is $\eta$ dependent but it can be rescaled onto an "effectively" universal angle of the DLA branching process. We derive an analytic rescaling relation which is in agreement with numerical simulations.

## P. 74 Coarse-grained entropy and information dimension in dynamical systems

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A coarse-grained entropy is defined for dynamical systems which is shown to be analog of thermodynamic entropy. The steady state saturation value of the coarse-grained entropy is found to

scale with the resolution. In dissipative maps the saturation value is proportional to the information codimension of the chaotic attractor. This property provides a highly accurate method for determining the information dimension. As an example the field driven Lorentz gas is considered.

## Wavelet analysis of electropolished surfaces **P. 75**

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Electropolishing is a technical treatment to obtain bright and shiny surfaces by electrochemical removal. The interplay between raising gas bubbles and a falling film of electrolyte with higher specific gravity leads to the removal of microscopic irregularities from metal surfaces and at least to pattern formation. The choice of the electrolyte has a significant influence on the surface structure on a microscale. Wavelet techniques have now become well established for analysing the regularity properties of signals. The Continuous Wavelet Transform allows to extract the scaling properties of irregular functions, which may even follow different (power) laws in different regimes. The wavelet transform maxima lines contain the essential information about the evolution of scaling properties of irregularities across scales. Thus, they can be considered as a fingerprint of the signal. The aim of the work is to classify electropolished surface profiles resulting from different electrolytes.

## Phase synchronization and coherence analysis of Morbus Parkinson and Essential Tremor in humans **P. 76**

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The Hilbert transform expands real time series to the complex plane ending up with a slowly varying amplitude time series and a rapidly oscillating phase time series, the instantaneous phase. Phase synchronization can be examined plotting the differences of those instantaneous phases between different time series. Time series with broad-band spectra have to be preprocessed by filtering them with a narrow band-filter at maximum of coherence.

We investigate simultaneously measured electromyograms of several muscle combinations in humans suffering from Morbus Parkinson and Essential Tremor. Significant phase synchronization and significant coherence between them can be found in many cases but not always simultaneously. In most cases of joint significance in both features the prominent difference of the instantaneous phase is equal to the phase at the maximum of coherence. Additionally, we investigate those cases of joint significance in which the phases are not equal.

## P. 77 Nonlinear dynamics of the voice — modelling the role of vocal membranes in bats and primates

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We study the dynamics of upward extensions of the membranous portion of the vocal fold (termed 'vocal membranes'). Such morphological changes occur extensively in non-human mammals. The analysis of vocal membranes is of clinical and biological interest, as local morphological changes of vocal folds found in vocal fold pathologies like tumors and polyps resemble non-human vocal membranes.

We use an extensively studied two-mass model adding thin light rigid upward extensions to the upper masses connected by a hinge, that incorporates elastic restoring forces and viscous damping.

We study the effect of the vibrating membranes on the phonation onset, on the interaction of high-frequency oscillation of the light vocal membranes with low-frequency vibrations of the two-mass model, and on the production of irregular and chaotic vibration of the whole vocal fold. In contrast to the simplified two-mass model we find subcritical Hopf bifurcations at phonation onset. Furthermore, coexisting fixed point solutions and oscillating states, and irregular vibrations within biologically resonable parameter regions can be found. Thus, this vocal membrane model, although a rough sketch of mammalian sound production organs, is capable of reproducing the high diversity of non-human acoustical signals.

## P. 78 Many-particle models and reaction-diffusion equations for chemical systems

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The relationship between two different approaches to the mathematical modeling of particular chemical reactions is investigated. Supposing the knowledge of the elementary reactions for some complex chemical system we first establish a *microscopic model* in terms of *many-particle systems*, whose dynamics is given by coupled stochastic differential equations for individual particles. Especially, we study a situation, where the range of the interaction is large in comparison to the typical distance between neighbouring particles and small relative to the spatial size of the whole system. Consequently, we obtain *moderately interacting* many-particle systems. Next, we determine a *system of partial differential equations* governing the time evolution of the mass densities of the various chemical species, i.e., we deduce a *macroscopic model*. As main result a limit theorem is proved, which demonstrates that asymptotically as the particle number tends to $\infty$ certain *empirical processes* reflecting the microscopic dynamics converge to the solution of the system of partial differential equations constituting the macroscopic dynamics.

## P. 79 Controlling spatio-temporal complexity: Simulations, experiments and possible applications

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We present numerical and experimental results exhibiting the suppression of spatio-temporal complexity via external forcing. Under the influence of periodic forcing applied locally the natural chaotic behavior of the extended system was converted to periodic dynamics. For the numerical results we chose a spatially extended model system used for the description of CO-oxidation on a Pt(110) single crystal surface. Using an electrochemical cell set-up to study the potentiostatic electrodissolution of an array of iron electrodes in a sulfuric acid buffer the experimental verification was achieved. Furthermore we used a time series from a human electroencephalogram (EEG) as a local perturbation to a reaction-diffusion model (Goldbeter's) exhibiting spatio-temporal chaos. For certain finite ranges of amplitude and frequency it is observed that the strongly irregular perturbations can induce transient coherence in the hyper-chaotic system. This could be interpreted as "on-line" detection of an inherently correlated pattern embedded in the EEG.

## Diffraction in numerical methods for two dimensional conservation laws **P. 80**

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Diffraction is the bending of waves around an obstacle such as the edge of a slit; it is the characteristics of waves of all types regardless of their nature or means of creation. In wave propagation studies when the lateral dimension of the area under consideration is not much greater than the wavelength, we can not describe some behaviors of the waves like bending round the obstacles and must take their nature specifically into account. That is, use the Huygens principal, which states that "every point in a wave front is a source of wavelets". This description enables us to see how the waves can hit and partially pass an obstacle. Hyperbolic equations are the mathematical means of describing wave propagation phenomena's and when approximated numerically they should carry out the same nature. In this paper we investigate the application of the Huygens principal when approximating two dimensional conservation Laws numerically, we use different discretization methods in space and in each case numerical results are presented.

## Occurrence of multiple-period-doubling bifurcation route to chaos in periodically pulsed chaotic dynamical systems **P. 81**

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I consider the effect of discrete time signal or periodically pulsed forcing on chaotic dynamical systems and show that the systems can undergo novel multiple period-doubling bifurcations prior to the onset of chaos, followed by a rich variety of dynamical phenomena including enlarged periodic windows, attractor cirses, distinctly modified bifurcation structures and so on. Under certain circumstances, these systems also admit transcritical bifurcations preceding the onset of multiple period-doubling bifurcations. These properties are demonstrated for the case of Duffing oscillator and logistic map subjected to periodic pulses.

## Embedded solitons **P. 82**

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Embedded solitons form a novel class of generalized solitary waves who exist despite having their internal frequency in resonance with ("embedded within") linear radiation waves. This poster reviews prevalent properties of these solutions and, in particular, investigates their dynamics within the framework of an optical three-wave interaction model for second harmonic generation.

P. 83

## Hybrid systems of 'strange' billiard type and their dynamics

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Generally speaking a large class of dynamical systems consist of piecewise defined continuous time evolution processes interfaced with some logical or decision making process. These switches between different evolutions are triggered if the continuous part of the system reaches thresholds in phase space. Such systems are called hybrid systems.
In the present work we investigate hybrid systems forming a new type of dynamical systems, so called strange billiards. They show a rich variety of dynamical behavior including some unusual bifurcations and chaos, even if the continuous part of the system evolution is simply linear.
By means of poincare map techniques we discuss different dynamical behaviors, some invariant measures are given and the symbolic dynamic is considered.
Applications for the simulation of manufacturing systems and consequences for their dynamical behavior are outlined.

P. 84

## Reconstructing ordinary differential equation from a time series with observational noise

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In this paper a problem of reconstructing dynamics of analytic time series with obseravtional noise is formulated and solved. We suppose the noise is Gaussian (white). The investigation is presented in terms of classical theory of dynamical systems and modern time series analysis. We confine our considerations on time series obtained as a numerical analytic solution of autonomous ordinary differential equation, solved with respect to the highest derivative and with polynomial right side. Three concrete problems are solved when the highest derivative of reconstructed equation is of first, second and third order, i.e. the given solutions are monotonous, periodic and chaotic functions respectively. In case of sufficiently exact numerical solution (with very small noise), we propose a geometrical basis and mathematical algorithm including computer procedure of reconstructing low-order and low-power polynomial differential equation having for numerical solution the given one. The small Gaussian noise (with variance of 1%) is preliminary reduced to very small value. For this purpose, the given time series is smoothed on every point by moving polynomial averages and least squares method. Then a specific form of the least squares method is applied for reconstructing polynomial right hand side of unknown equation.

P. 85

## GMM-based speaker verification using lyapunov exponents

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The characterization of biological signals using nonlinear dynamical features has been focus of intense research. The information provided by these techniques when they are applied to speech signals can improve the accuracy of speaker recognition systems. In this work, the results obtained with time-dependent largest Lyapunov exponents (TDLEs) in a text-dependent speaker verification task are reported. The baseline system used Gaussian mixture models (GMMs), obtained from the adaptation of a universal background model (UBM), for speakers voiceprint representation. 16 cepstral and 16 delta cepstral features were used in the experiments, and it is shown how the addition of TDLEs can improve the systems accuracy. Cepstral mean subtraction was applied to all features in the tests for channel equalization, as well as silence removal. 91

different speakers compose the telephone speech corpus used for testing, obtained from a subset of CSLU Speaker Recognition corpus.

## Simulation of genetic networks in multicellular context P. 86

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Genetic networks can be used to collect and analyze information about regulatory processes in cells. Mathematical methods allow the analysis of these networks, givin information about attractor states that correspond to differentiated cell types. However most software available so far deals with single cells. But if multiple, interacting cells are considered, state transitions depend not only on network topology but also on cell neighbourhoods. Early embryonic development of the nematode C. elegans is a good example to study cell differentiation in multicellular context. While some cells develop cell-autonomously, others rely on inductive events from neighbouring cells to specify their fate. We present Gene-O-Matic, a genetic network tool that can be used to simulate and study differentiation processes in multi-cellular organisms. A model describing C. elegans embryonic development is proposed.

## Spatially unstable relaxation oscillations in small systems with global coupling P. 87

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Experimental observations of the Benjamin-Feir (BF) instability in reaction-diffusion systems are very rare. One example is the electrochemical oxidation of $H_2$ on Pt-ring electrodes in the presence of electrosorbing ions [1]. A limited system size allows to study the transition from a periodic, inhomogeneous limit cycle to turbulence. Adding a global coupling to the system in the BF unstable oscillatory state yields a variety of different, to a large extend novel, spatiotemporal patterns, including a spatiotemporal intermittency-type transition to phase clusters. We present a realistic model of the electrochemical processes displaying almost quantitative agreement with experiment in the homogeneous case. The spatiotemporal investigations were performed in the regime with global coupling. Many of the patterns could be reproduced, yielding a new understanding of the bifurcation sequences leading to these unusual structures.

[1] P. Grauel, H. Varela, and K. Krischer. *Faraday Discussions*, 120:165–178, 2001.

## Electric field contribution in spatio-temporal dynamic near cell membrane P. 88

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Most of physiological processes on the cell membrane are conditioned on interaction of charged molecules. This fact determines the necessity to account for the contribution of self consistent electric field (the field that is due to moving and interaction of charged particles) in modeling of dynamics of cell membrane processes. The proper models must contain reactionelectrodiffusion equations. The aim of this work is to show on the simple model that taking into account self-consistent field contribution in the system with nonlinear chemical kinetics can give rise to various patterns of electric potential and ion concentration in near membrane layer. We considered electro-diffusion equations for positively and negatively charged ions. Brusselator equations were used to describe chemical interaction. It was found that the influence of self-consistent electric field changes the conditions of Turing instability. Such spatio-temporal regimes like sole waves irregular dynamics can arise. The system became bistable a certain domain of parameters. The electric field effects in the domain of bistability lead to the ion redistribution between two stable steady states and to the rise of large potential gradient along the cell membrane.

## P. 89 Dynamical properties of the oscillatory systems with the saddle-node and Hopf bifurcations

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Dynamics of the two oscillating systems unperturbed and subject to the external perturbations are considered. The various patters of oscillations have been obtained depending on the type of bifurcation and on the different perturbation frequencies. These are analyzed in a way of 1-D transfer maps, Fourier transforms and statistical methods. Kinetics of studied reactions are described through an nonlinear ordinary differential equation system (ODE) with the modeled kinetics parameters. Transitions from the steady state to the oscillations and the effect of parameter modulation on the system's trajectories are investigated.

## P. 90 Evolutionary dynamics of single nucleotide polymorphisms under constant and time-varying population size

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Single Nucleotide Polymorphisms (SNPs) are single-base changes in DNA sequences. They are densely distributed across the genome (on average, every 300-500 nucleotide sites) and therefore very promising as genetic markers. Methods for SNP discovery are constantly improved along with growth of publicly available SNP databases.

In order to understand sampling distributions of SNPs, it is necessary to develop population dynamics models of SNPs evolution. Assuming no selective pressure against mutant alleles the dynamical process of SNP evolution includes the following genetic forces: genetic drift, recombination and mutation. Genetic drift shrinks genetic diversity by random loss of alleles, while recombination (of lower or higher intensity) results in higher or lower correlation between distributions at neighboring SNP sites. Mutation events described by a Poisson process, of intensity $\mu$, introduce new polymorphisms and define SNP loci. Two mutation models for SNP generation are used in the literature: single hit model with distribution conditioned on number of mutations equal to one, and low intensity model, which is based on computing limits $\mu \to 0$.

Mathematical construction of evolutionary models for SNPs distributions is based on the coalescence method in which one looks at the past of a sample of DNA sequences taken from population at present. Coalescence process depends on the assumptions concerning the past demography of the population size. Assumption of constant population size leads to a simpler model. However, coalescence with time varying population size is more realistic, since most populations undergo size changes in their history. The aim of the talk is to review recent results in SNP modeling in view of available data, with special focus on comparing cases of time-constant and time-variable population size. Based on the comparison between the two cases, the problem of detection of signatures of population growth in SNP data will be addressed.

## Amplitude equations for driven ferromagnetic films: The effect of the dipolar interaction **P. 91**

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The long range dipolar interaction plays an important role for pattern formation in ferromagnetic films. A homogeneous, stationary solution of the magnetization becomes unstable by a periodically driving field. In the weakly nonlinear regime a multiple scale analysis is performed taking into account in each order the additional equation for the magnetostatic potential. The well known complex Ginzburg-Landau equation is not sufficient to describe the slow spatio-temporal dynamics above threshold: Due to singular contributions of the dipolar field a new, nonlocal term arises. The effect differs substantially from mean drift effects in Rayleigh-Benard convection because of the influence of the dipolar field outside the film.

## A noisy Hopf-bifurcation in the real world: The vortex flow-meter **P. 92**

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The noisy Landau-Stuart equation

$$\dot{A} = (\epsilon + i\omega_0)A - (1 + ig_i)|A|^2 A + \eta(t) + \text{external forces} \tag{3}$$

($\eta(t) \equiv$ white noise) universally describes noisy oscillations near a Hopf bifurcation. It is well known from laser physics. In vortex flow-meters oscillations in von-Karman vortex streets are used to measure the (turbulent) flow through a pipe. Mode locking and phase stability are important problems just as for lasers. *In principle* Eq. (3) applies near threshold. It turns out that *in practice* it also applies far above. The power and the limitations of this normal-form approach are discussed.

## Continuation of connecting orbits in a reversible hamiltonian system **P. 93**

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We consider a 2-parameter family of Hamiltonian ODEs in $\mathbf{R}^4$ being reversible w.r.t. two distinct reversibilities. This equation is related to the problem of searching soliton waves in the field of nonlinear optics.

The system under consideration has a fixed point which undergoes a Hamiltonian pitchfork bifurcation. Further it is known that there is a homoclinic orbit to that fixed point before as well as after the pitchfork bifurcation.

The subject of our work is the numerical continuation (using the software package AUTO97, HomCont) of both this homoclinic orbit and the heteroclinic cycle arising in the course of the pitchfork bifurcation. It is (numerically) shown that the homoclinic orbit is also object of a pitchfork bifurcation (in harmony with the bifurcation of the fixed point). We call this scenario reversible homoclinic pitchfork bifurcation. The numerical continuation of the heteroclinic cycle shows that it undergoes a saddle-node bifurcation. The continuation heads back towards the pitchfork bifurcation point. The shape of the heteroclinic orbit for parameter values close to the critical one (where the pitchfork bifurcation takes place) suggests that there is a path connecting the homoclinic orbits and the heteroclinic cycle.

## P. 94 The power spectrum does not tell you the frequency

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Two kinds of frequency measures for time series can be distinguished: (1) *Spectral measures*, which characterize particular features of the power spectral density $S(\omega)$ or, equivalently, the autocorrelation function of a signal. Examples are the spectral peak frequency and the mean frequency $\omega_{\text{mean}} := \int_0^\infty \omega S(\omega) / \int_0^\infty S(\omega)$. (2) *Period-counting measures*, which denote the average number of oscillation periods per unit time. Various criteria for counting individual periods are in use (maxima, zero-crossings, etc.). A generalized period-counting measure, the *topological frequency* $\omega_{\text{top}}$, is defined as the frequency of transitions through a Poincaré Section in the delay space of the time series. As was shown recently [arXiv.org: physics/0203081], $\omega_{\text{top}}$ is invariant under linear filtering. A time series with a given $\omega_{\text{top}}$ can have practically any arbitrary spectrum $S(\omega)$. The proofs are outlined, examples are given.

## P. 95 Experimental evidence for directed percolation in spatiotemporal intermittency

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A new experimental system showing a transition to spatiotemporal intermittency is presented. It consists of a ring of hundred oscillating ferrofluidic spikes. The measured critical exponents of the system agree with those obtained from a theoretical model of directed percolation.

## P. 96 Analysis, visualization and modelling of craniofacial growth dynamics

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In many medical or biological fields, it is intended to understand and exert influence on the growth of organisms. Growth is a highly complex mechanism resulting not only in a major change in size, but also in minor changes in shape. In the medical context, the change in shape of the craniofacial skeletal structures is of particular interest because a pathological growth of certain anatomical regions may lead to functional and esthetic problems. The clinical aim in orthodontics is identifying and treating these anomalous tendencies as early as possible so as to provide a coordinated development and to avoid surgical intervention.

Thus a new technique is presented which analyses and visualizes the shape changes due to growth or orthodontic treatment. This method is based on an adapted Karhunen-Loève decomposition of time-discrete data based on landmarks in lateral X-rays of the skull. It allows for a reduction of the high-dimensional dynamic problem to a few modes representing synchronous growth patterns with time-dependent mode coefficients. The growth-related shape changes as well as the orthodontic treatment effects are visualized by overdrawing the underlying growth mechanisms to "caricatures".

## Intermittencies and symmetry in a reverse-flow chemical reactor **P. 97**

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In this work we discuss how spatio-temporal symmetry influence the dynamics of discontinuously forced chemical reactors. Recent analysis, based on Lie group theory, are related to a dynamical systems that are symmetric with respect to linear transformations that involve the system state and the time. These spatio-temporal symmetries were found in reverse-flow reactors and depend on the type of forcing only. Such symmetry properties can be used to improve efficiency and accuracy of standard bifurcational analysis, in that difficulties due to the discontinuous nature of the forcing are avoided. To this aim, suitable discrete systems based on the Poincaré map for spatio-temporal symmetric systems are constructed. Such discrete systems inherit the symmetry properties of the original systems, and are diffeomorphisms. Spatio-temporal symmetry properties influence the possible bifurcational scenarios: obviously, only some kind of bifurcations are possible, whereas some usually high-codimension bifurcations become generic. Routes to chaos also show peculiar properties: special kinds of intermittency and attractor merging crises are found and analysed.

## Dynamics of inhomogeneous coupled map lattices **P. 98**

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Systems of coupled map lattices (CML) are used to describe distributed media and investigate the processes in systems that have essentially discrete structure on time and space. Such models appear in different problems concerning synchronization of radio generators, biology, medicine and also cellular automata and neural networks.

A new method for coupled map lattices analysis is proposed in this work. In contrast to other ones, it permits to investigate the local behavior of particular site of distributed system and evolution of global dynamics. This approach is based on full time dividing on small parts, on which orbit degree of unperiodic behavior of each elements is developed. This enable to define the synchronization regions, their time period, temporal transformation and destruction by means of spatial chaotisation. The effectiveness of the proposed method is demonstrated on inhomogeneous ring models of diffusively coupled quadratic maps.

## Thermal convection in binary fluid mixtures with a weak concentration diffusivity but strong solutal buoyancy forces **P. 99**

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Thermal convection in binary liquid mixtures is investigated in the limit where the solutal diffusivity is weak but the separation ratio is large. Representative examples are colloidal suspensions such as ferrofluids. With a grain size being large on molecular length scales, the particle mobility is extremely small, allowing to disregard the concentration dynamics in most cases. However, this simplification does not hold for thermal convection: Due to the pronounced Soret effect of these materials in combination with a considerable solutal expansion, the resulting solutal buoyancy forces are dominant. Indeed, convective motion is found to set in at Rayleigh numbers well below the critical threshold for single-component liquids. A nonlinear analysis demonstrates that the amplitude quickly saturates in a state of stationary convective motion.

## P. 100 Nonlinear dynamics of a single ion in perturbed penning traps

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In the frame work of classical mechanics, we investigate the dynamics of a single ion trapped in a realistic perturbed Penning trap. Imperfections in the desing or implementation of the trap give rise to electrostatic perturbations that introduce non linearities in the motion. In particular, we assume two different axial–symmetric perturbations: the sextupolar perturbation and the octupolar one. By using a Hamiltonian formulation, we see that the system is governed by three parameters: the $z$ component of the canonical angular momentum $P_\phi$ –which is a constant of the motion because the perturbation we assume is axial–symmetric–, the parameter $\delta$ that determines the ratio between the axial and the cyclotron frequencies, and the parameter $a$ which indicates how far from the ideal design the electrodes of the trap are. By means of numerical methods (Poincaré surfaces of section and continuations of families of periodic orbits) we show that the system suffers several bifurcation which change dramatically the phase space structure.

## P. 101 Autocatalytic reaction front propagation

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Autocatalytic reaction front between two reacting species is able to propagate as a solitary wave, that is at a constant velocity and with a stationary shape concentration profile resulting from a balance between molecular diffusion and chemical reaction. On the other hand, in laminar flow the association of molecular diffusion and convection leads to an overall diffusion effect, the so-called Taylor dispersion, with a flow dependent enhanced dispersion coefficient. We analyze experimentally the effect of laminar flow on the propagation and on the shape of the fronts in the Iodate-Arsenous acid autocatalytic reaction in tubes and Hele-Shaw cells. The results are in reasonable with our lattice BGK simulations.

## P. 102 Emergence of soliton ensembles from KDV-like systems

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Wave propagation in nonlinear dispersive media is studied making use of two KdV-like equations — (i) the hierarchical KdV eq. and (ii) KdV eq. having a driven term $\alpha \sin \beta u$ in the r.h.s. Both equations are integrated numerically by pseudospectral method under periodic boundary conditions and harmonic initial conditions. In the case (i) two soliton ensembles emerge simultaneously — one is very similar to the train of $n-$solitons in the case of the KdV eq. and another is formed by $m$ solitary waves having near equal amplitudes and speeds. The number of solitons

in an ensemble is determined by parameters of the system. In the case (ii) up to three soliton ensembles emerge — amplitudes of solitons in each ensemble are practically equal. Dispersion parameter determines the total number of solitons and parameters $\alpha$ and $\beta$ determine the number of ensembles as well the number of solitons in each ensemble.

## Computation and stability analysis of travelling wave solutions in delay PDEs **P. 103**

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We study travelling waves in delay partial differential equations (DPDEs) in one spatial variable, and with a number of fixed, discrete delays. The computation of a travelling wave is then reduced to finding a connecting orbit in an ordinary delay differential equation (DDE). This orbit is approximated using projection boundary conditions [1], which involve the stable and unstable manifolds of a steady state. The stable manifold of a steady state of a DDE is infinite-dimensional. We circumvent this problem by reformulating the end conditions using a special bilinear form. The resulting algorithm is implemented in DDE-BIFTOOL, a Matlab package for bifurcation analysis of DDEs [2]. Stability is analysed by computing the spectrum of the DPDEs, linearized around the zero steady state. For PDEs, Sandstede showed that the essential spectrum of the exact travelling wave on the infinite domain is not approximated on truncated domains. Instead, as the domain goes to infinity, the continuous limit of the spectrum approaches the absolute spectrum. Numerical results show that this property remains valid for DPDEs [3].

[1] G. Samaey, K. Engelborghs and D. Roose, Numerical computation of connecting orbits in delay differential equations, Technical Report TW-329, Department of Computer Science, K.U. Leuven, Leuven, Belgium, October 2001. Submitted.
`www.cs.kuleuven.ac.be/publicaties/rapporten/tw/TW329.abs.html`

[2] K. Engelborghs, T. Luzyanina and G. Samaey, DDE-BIFTOOL v. 2.00: a Matlab package for bifurcation analysis of delay differential equations, Technical Report TW-330, Department of Computer Science, K.U.Leuven, Leuven, Belgium, October 2001.
`www.cs.kuleuven.ac.be/publicaties/rapporten/tw/TW330.abs.html` [3] G. Samaey et al., Determining stability of travelling wave solutions of delay partial differential equations, in preparation. Preliminary results:
`www.cs.kuleuven.ac.be/ giovanni/research/DD02/preliminary.html`

## Time series analysis in water drop formation **P. 104**

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We constructed a new type of a dripping faucet experiment [1]. Usually, the water drop formation has been studied having the water flux as a control parameter many chaotic behaviors has been observed, such as bifurcation, crises, homoclinic and heteroclinic chaos [2]. We can also obtain similar results by keeping fix the water flux and by applying high voltage (Vapp) around a metallic nozzle. Therefore, the voltage (Vapp) is a new control parameter. We applied metrical and topological methods[3] to characterize some attractors obtained with the two different control parameters. We thank FAPESP and CNPq for partial support of this work.

[1] T. N. Nogueira, J. C. Sartorelli and J. Procopio, Electrical charges in the water drop dynamics, VII LAWNP-LatinAmerican Workshop on Nonlinear Phenomena, Cocoyoc, Mexico, (2001).

[2] J. C. Sartorelli, W. M. Gonçalves and R. D. Pinto - Crisis and intermittence in a leaky faucet experiment, Phys. Rev. E 49, 3963-3975 (1994).

[3] W. M. Gonçalves, R. D. Pinto and J. C. Sartorelli, Symbolic dynamics analysis in the dripping faucet experiment, Physica D 134, 267-274(1999).

**P. 105**

## Chaotic dynamics in coupled replicator equations

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Dynamics of a group of adaptive systems are studied and coupled replicator equations are proposed for a model of learning in game. With perfect memory, the dynamics of learning are conservative. When the amount of resources in the environment is fixed, i.e. the game is zero-sum, the collective systems have symplectic structures and exhibit Hamiltonian chaos. For non-zero-sum games, infinitely persistent chaotic transients to heteroclinic cycles are observed. With memory loss, dissipative chaos occurs in a class of non-zero-sum games. The dual aspects of chaos, irregularity and coherence, imply that each adaptive systems may behave cooperatively or competitively in the collective dynamics.

**P. 106**

## Numerical investigation of the influence of the bouncing ball orbits on the parametric autocorrelations of the energy levels in the stadium billiard

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We consider the effect of a family of marginally stable bouncing ball orbits on the parameter-dependent autocorrelation functions of the energy levels $c(x)$ and $\tilde{c}(\omega, x)$ in the stadium billiards. Statistical observables calculated for spectra of chaotic systems often show deviations from predictions of random matrix theory (RMT). The corrections due to the bouncing ball orbits may account for some of this non-generic features.

In order to obtain parameter-dependent eigenenergies of the stadium billiard (radius of a circle $R = 20$ cm, parameter $\gamma \simeq 0.1$) the length of the billiard was chosen as an adjustable parameter. The eigenenergies were calculated using the boundary integral method.

The scaled velocities distribution and autocorrelation functions $c(x)$ and $\tilde{c}(\omega, x)$ calculated for the spectra before and after subtraction of the bouncing ball contribution were compared to the predictions of RMT. This work was partially supported by KBN grant No. 2 P03B 085 22.

**P. 107**

## The leading off-diagonal correction to the form factor of large graphs

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Using periodic-orbit theory beyond the diagonal approximation we investigate the form factor, $K(\tau)$, of a generic quantum graph with mixing classical dynamics and time-reversal symmetry. We calculate the contribution from pairs of self-intersecting orbits that differ from each other only in the orientation of a single loop. In the limit of large graphs, these pairs produce a contribution $-2\tau^2$ to the form factor which agrees with random-matrix theory.

[1] H. Schanz and U. Smilansky, Phys. Rev. Lett. 84, 1427 (2000). [2] M. Sieber and K. Richter, Phys. Scr. T90, 128 (2001). [3] G. Berkolaiko, H. Schanz and R. S. Whitney, Phys. Rev. Lett. 88, 104101 (2002).

## Ant 4.667 — a tool for simulating and investigating dynamical systems **P. 108**

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A software package for the simulation and investigation of the dynamic behavior of dynamical systems called AnT will be presented. Due to its flexible architecture, AnT is able to simulate dynamical systems belonging to various classes, e.g. maps, ordinary and delay differential equations, etc., as well as many sub–classes derived from these. A main feature aimed at the development of AnT is the support of the investigation of the dynamics of the simulated systems with several provided investigation methods, like e.g. period analysis, Lyapunov exponents calculation, generalized Poincaré section analysis and much more. Another important feature of AnT are so–called scan runs, i.e. the ability to investigate a dynamical system by varying some relevant influence quantities, such as the control parameters, initial values, or even some parameters of the investigation methods.

## Quantification of 2D bone structure **P. 109**

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Quantifying microarchitectural bone structure is an important tool for the description of the changes in bone structure due to the bone mass loss, caused for example by osteoporosis or absence of gravitation. The stability of the bone changes dramatically due to bone mass loss and a rapid decline of complexity of bone's microstructure, and therefore fracture risks increase. For detecting osteoporosis already in an early stage, bone microarchitecture was investigated by computed tomography (CT) of human lumbar vertebrae specimens. We characterize the complexity of the microarchitectural bone structure by measuring for example spatial coherence and correlation rates of the bone. We test these measures on bone images corresponding to bones with different bone mass densities and detect a change of the characteristic length scales during progress of osteoporosis. Furthermore, we find that a change of the bone structure is comparable with pattern (de-)formation in chemical reactions.

## The global dynamics of the discretized Cahn-Hillard equation **P. 110**

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The transformation of different states of matter is a fundamental process in the design of new materials. Continuum theories describing the development of such mixtures of matters are baseed on the Cahn-Hillard equation (CHE). Under suitable conditions the CHE possesses a weak solution globally in time the decisive properties of which are the conservation of mass and the decrease of the total free energy. We analyze the behaviour of the discrete dynamics generated by applying several discretizations in space and time to the CHE. It is shown that the conservation of mass and the decrease of the free energy is preserved under discretization. Finally, numerical examples will demonstrate the effectiveness of the proposed scheme.

## P. 111 Pattern formation at a complex interface: The finger-morphology in electrodeposition

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The presence of a small amount of an inert electrolyte in the electrochemical deposition of copper gives rise to the growth of a fingering morphology confined by a smooth envelope. It originates from an interplay of density driven convection rolls and an interfacial tension between miscible fluids. We determine the strength of the interfacial tension by measuring a) the dispersion relation of the growing deposit and b) the flow field (using Particle Image Velocimetry).

## P. 112 On the asymptotic behavior of ground state of not self-adjoint operator in the space $\mathbf{R}^n$

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The problems associated with the asymptotic behavior of ground state for not self-adjoint operators defined in unbounded domains appear in many applications. Among them are mathematical physics, the theory of control in stochastic dynamic systems, financial mathematics.

We are going to study the conditions for existence and uniqueness of a positive eigenfunction of a second order elliptic operator and also the rate of decay of this eigenfunction at infinity. We call this eigenfunction "ground state". We also consider the ground state asymptotics for a singularly perturbed non self-adjoint operator. We want to describe this asymptotic behavior in terms of an auxiliary variational problem. The Lagrangian of this problem will be found explicitly in terms of the coefficients of the original operator.

## P. 113 Simplfying phase sensitivity exponent to characterize strangeness of strange nonchaotic attractors

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Strangeness is one of the two main features of strange nonchaotic attrators (SNA) in quasiperiodically driven maps. It displays the sensitivity of the driven item relaying on the initial value of the phase of the quasipreiodical driving. Phase sensitivity exponent (PSE) was proposed by A. S. Pikovsky and U. Feudel firstly[Chaos 5, (1995) 253]. It is modified in this paper. Using the simplified PSE it is successful to character the strangeness of SNA near the critical point of the birth of SNA continuously and get the scaling of the route of intermittency from torus to SNA in two models. It is expected to apply in a general SNA model.

## P. 114 Cascade chemical reaction in small system

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I study a cascade of chemical reaction, which is a one-directional chain of consecutive chemical reactions. This system shows convective instability while the system is linearly stable. Thus,

the stationary state is stable in the macroscopic limit in which the fluctuation of reaction is not taken into account. However, the fluctuation unavoidably accompanying chemical reactions leads to the development of oscillations in the downstream reactions. Recently, the study of the chemical reactions in small systems has got much attentions, motivated, in particular, by cell biology. It is an important question whether the concepts of nonlinear system developed in macroscopic systems can also be applicable to small systems. I will first present the macroscopic properties such as the bifurcation behavior. Then, I will report the properties when the chemical reactions is described in the *mososcopic scale*. The behaviors of the convective instability and the propagation of instability as the system volume is decresed will be presented.

## Morphological transitions of Xenon crystals in 3 dimensions **P. 115**

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Changes of growth morphologies are induced by variations of supercooling of the melt in the vicinity of growing crystals [1]. The basic building blocks observed are doublons which are arranged as seaweed or more complex structures i.e. triplons or quadruplons. Characteristic parameters of doublons were deduced from experimental data and compared with theoretical predictions. Fractal dimensions (contour and area) have been determined by correlation method and by an optimized box-counting method, minimizing the number of boxes to cover the fractal set. No difference to former investigations on dendritic structures was found. The fractal area dimension is in gratifying accordance to predictions of numerical simulations. A linear dependence of contour length on projection area of seaweed patterns has been found.

[1] I. Stalder and J.H. Bilgram, Europhys. Letters 56, 829 (2001)

## Matematical problems of magnetic insulation **P. 116**

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We study the stationary self-consistent problem of magnetic insulation under space-charge limitation via the Child-Langmuir asymptotics of the Vlasov-Maxwell system. We consider various limit models, which are described singular nonlinear boundary and free boundary problems.

This work is developed with P. Degond and P. Markowich by INTAS Grant: 2000-15

## Nonlinear models for characterisation and prediction of noisy chaotic time series **P. 117**

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We describe a nonlinear modelling algorithm capable of accurately capturing dynamics from short noisy time series. This method utilises an information theoretic model selection criteria and a variant of the artificial neural network (ANN) modelling scheme. The ANN consists of a single hidden layer and a monotonic nonlinear output function. The hidden layer is composed of a relatively small number of carefully selected neurons, the number of neurons in the optimal ANN is determined by the minimum description length (MDL) model selection criteria. The MDL best model is the model that captures only the essential deterministic features of the data.

We apply this modelling algorithm to several computational are experimental systems including chaotic differential equations, the annual sunspot count, and a chaotic laser. In each case we show that the optimal model captures the chaotic dynamics of the underlying system but does not fit deterministic structure to system noise.

P. 118

## Stochastic multiresolution analysis

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A wavelet basis of the function space $L^2(\mathbf{R})$ is obtained by considering translates and dilates of functions. Most of the wavelets that have been investigated to date can be constructed using the notion of multiresolution analysis. Hardin, Kessler and Massopust showed that certain classes of fractal interpolation functions also generate a multiresolution analysis of $L^2(\mathbf{R})$. This multiresolution analysis has certain geometric features that are similar to the multiresolution analysis generated by splines. These results have been generalized to several dimensions. One of the direction of generalization is given by Aubry and Jaffard. They form a fairly broad class of random process, with multifractal properties. Our aim in this part is to generate a multiresolution analysis starting with the constrained Brownian motion.

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## Global existence, blow-up and stability results for quasilinear nonlocal Kirchhoff strings on $\mathbb{R}^n$.

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We discuss the asymptotic behaviour of solutions for the nonlocal quasilinear hyperbolic problem

$$u_{tt} - \phi(x)||\nabla u(t)||^2 \Delta u + \delta u_t = |u|^a u, \quad x \in \mathbb{R}^N, \quad t \geq 0,$$

with initial conditions $u(x,0) = u_0(x)$ and $u_t(x,0) = u_1(x)$, in the case where $N \geq 3$, $\delta \geq 0$ and $(\phi(x))^{-1} = g(x)$ is a positive function lying in $L^{N/2}(\mathbb{R}^N) \cap L^\infty(\mathbb{R}^N)$. It is proved that, when the initial energy $E(0)$, which corresponds to the problem, is non-negative and small, there exists a unique global solution in time in the space $\mathcal{X}_0 =: D(A) \times \mathcal{D}^{1,2}(\mathbb{R}^N)$. When the initial energy $E(0)$ is negative, the solution blows-up in finite time. For the proofs, a combination of the modified potential well method and the concavity method is used (See work [7]). Also, the existence of an absorbing set in the space $\mathcal{X}_0$ is proved and that the dynamical system generated by the problem possess an invariant compact set $\mathcal{A}$ in the same space (See work [8]).

Finally, for the generalized dissipative Kirchhoff's String problem

$$u_{tt} = -||A^{1/2}u||_H^2 Au - \delta A u_t + f(u), \quad x \in \mathbb{R}^N, \quad t \geq 0,$$

with the same hypotheses as above, we study the stability of the trivial solution $u \equiv 0$. It is proved that if $f'(0) > 0$, then the solution is asymptotically stable for the initial Kirchhoff's system, while if $f'(0) < 0$ the solution is unstable. In the critical case, where $f'(0) = 0$, the stability is studied by means of the central manifold theory. To do this study we go through a transformation of variables similar to the one introduced by R. Pego ([10]) (See work [9]).

[1] P D'Ancona and Y Shibata, *On Global Solvability for the Degenerate Kirchhoff Equation in the Analytic Category*, Math. Methods Appl. Sci., 17, (1994), 477-489.

[2] N I Karahalios and N M Stavrakakis, *Existence of Global Attractors for Semilinear Dissipative Wave Equations on* $\mathbb{R}^N$, J. Differential Equations, 157 (1999), 183-205.

[3] N I Karahalios and N M Stavrakakis, *Global Existence and Blow-Up Results for Some Nonlinear Wave Equations on* $\mathbb{R}^N$, Adv. Diff. Equations, Vol 6, (2001), 155-174.

[4] T. Mizumachi, *Asymptotic Behavior of Solutions to the Kirchhoff Equation with a Viscous Damping Term*, Journal of Dynamics and Differential Equations, 9, (1997), 211-247.

[5] K Ono, *Global Existence and Decay Properties of Solutions for some Mildly Degenerate Nonlinear Dissipative Kirchhoff Strings*, Funkcialaj Ekvacioj, 40, (1997), 255-270.

[6] K Ono, *Global Existence, Decay, and Blow-Up of Solutions for some Mildly Degenerate Nonlinear Kirchhoff Strings*, J. Differential Equations, 137, (1997), 273-301.

[7] P G Papadopoulos and N M Stavrakakis, *Global Existence and Blow-Up Results for an Equation of Kirchhoff Type on* $\mathbb{R}^N$, Topological Methods in Nonlinear Analysis, 17, (2001), 91-109.

[8] P G Papadopoulos and N M Stavrakakis, *Compact Invariant Sets for Some Quasilinear Nonlocal Kirchhoff Strings on* $\mathbb{R}^N$, submitted.

[9] P G Papadopoulos and N M Stavrakakis, *Central Manifold Theory for the Generalized Equation of Kirchhoff Strings on* $\mathbb{R}^N$, submitted.

[10] R L Pego, *Phase Transitions in one Dimentional Nonlinear Viscoelasticity: Admissibility and Stability*, Arch. Rat. Mech. Anal., 97, (1987), 353-394.

## Self-organized wave sources in a three-component reaction diffusion system **P. 120**

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A three-component reaction-diffusion system displaying excitable and oscillatory dynamics is proposed. The formation of self-organized wave sources (pacemakers) is predicted analytically. The existence of such objects in confirmed numerically and their stability is studied. Further simulations also show spatio-temporal disorder and drifting wave sources.

## Meningitis, pathogenicity near criticality **P. 121**

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In a model suitable to describe the spread of infectious diseases with competing unharmful and pathogenic mutants of the infective agent we find frequent outbreaks of the pathogenic mutant only near a critical state (Stollenwerk and Jansen, 2002, [1]). A counter intuitively high number of clustered outbreaks at nearly vanishing pathogenicity in our model compares well with observations in diseases with severe and often fatal results for the host, as for example in meningitis. These clustered outbreaks can be described by the typical scaling behaviour around criticality.

The epidemic model is an SIRS-system for the unharmful infective agent, acting as a heat bath to the mutant Y which occasionally creates severly affected hosts X. The full system of SIRYXS is described in the Master equation framework, leading to a directed percolation typ behaviour for the SYRS-subsystem, which was investigated theoretically e.g. in Grassberger and de la Torre (1979, [2]), Cardy and Täuber (1999, [3]), Brunel, Oerding and Wijland (2000, [4]) and Stollenwerk (2001, [5]). Parameter estimation is then possible along the lines of earlier work (Stollenwerk and Briggs, 2000, [6], Stollenwerk, Drepper and Siegel, 2001, [7]).

[1] Stollenwerk, N., & Jansen, V. (2002) The epidemiology of meningococcal disease as a model for accidental pathogens, *submitted*.

[2] Grassberger, P., & de la Torre, A. (1979) Reggeon Field Theory (Schlögel's First Model) on a Lattice: Monte Carlo Calculations of Critical Behaviour, *Annals of Physics* **122**, 373–396.

[3] Cardy, J., & Täuber, U.C. (1999) Field theory of branching and annihilating random walks, *preprint* cond-mat **9704160 v2**, version 20.8.1999.

[4] Brunel, V., Oerding, K., & Wijland, F. (2000) Fermionic field theory for directed percolation in (1+1)-dimension, *J. Phys.* **A 33**, 1085–1097.

[5] Stollenwerk, N. (2001) Directed percolation with hard core bosons, *presented during a talk at CSIC, Madrid, Spain, 8. October, 2001, manuscript in preparation* .

[6] Stollenwerk, N., & Briggs, K.M. (2000) Master equation solution of a plant disease model, *Physics Letters* **A 274**, 84–91.

[7] Stollenwerk, N., Drepper, F., & Siegel, H. (2001) Testing nonlinear stochastic models on phytoplankton biomass time series, *Ecological Modelling* **144**, 261–277.

**P. 122**

## Manifestation of a quantum Lorentz attractor in a tunelling quantum dot

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We calculated the wavefunction of an electron, tunneling through a resonant quantum dot, as a function of energy. The current streamlines were studied in detail. A thin spherical barrier defines the resonant dot, hence meta stable bound states localize in the dot, this is well known. However, just after resonance we find a Lorentz/strange attractor in the quantum current streamlines, which vanishes as the energy moves away from the resonant region. To be precise the charge density and the current define the coupled equations defining the quantum velocity in the three dimensions. This results in nonlinear-coupled equations for the velocity components, which manifests Lorentz attractors under certain circumstances. Furthermore, we graphical illustrate the self-similarity in the classical trajectory paths for many Lorentz attractors in the "allowed" energy windows.

**P. 123**

## Multiplicity of limit cycle attractors in a coupled heteroclinic cycle system

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We study a coupled oscillator system in which each oscillator has a heteroclinic cycle attractor instead of a limit cycle. Oscillators are distributed on a two-dimensional square lattice and coupled with the nearest neighbors diffusively. We employ a replicator system as the heteroclinic oscillator. In this system with a small coupling constant, many kinds of spatially disordered stable patterns are observed in numerical simulations. We investigate these disordered patterns and show that they are limit cycle attractors in the ambient phase space (i.e. not chaotic) and many limit cycles exist dividing the phase space as their basins. In addition, these patterns are constructed with a local law of difference of phases between the oscillators. The number of patterns grows exponentially with increasing of the number of oscillators.

**P. 124**

## Heartbeat dynamics in freely moving bullfrog

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Heartbeat intervals of freely moving bullfrogs were measured using ultrasonic blood flow meter. We found that the fluctuation of the intervals exhibits long-period oscillation, the period of which was characterized by number of heartbeats, about 120 beats. The period was robust, the

oscillation continued for several hours, and not affected by the ambient temperature, although the mean heartbeat interval decreased as the ambient temperature increased. The trajectory in the reconstructed state space built by an embedding technique exhibited a limit cycle generated by low-dimensional nonlinear dynamics. However, if a system involving heartbeat dynamics can be modeled by a low-dimensional dynamical system, the model would not maintain the robustness of oscillation because the long period is sensitive to noise and to changes in control parameters. It appears that collective oscillatory behavior in the complex biological system is reflected in the heartbeat fluctuation.

## Flow-distributed oscillations — complex experimental behaviour **P. 125**

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Chemical pattern formation can arise through a combination of chemical reaction, diffusion and flow. These flow-distributed structures may be important in biological pattern formation (Satanoianu et al). Flow-distributed oscillations (FDOs) have only recently been experimentally realised using the Belousov-Zhabotinsky reaction in a packed bed reactor (Kaern and Menzinger). Further experiments have demonstrated how the stationary pattern arises through a "wavesplitting" mechanism. Using the Oregonator model, a complex pattern development has been predicted under certain conditions (Bamforth et al). We would like to present experimental results of transient complex behaviour in this system.

## Dynamics of EEG during brain entrainment **P. 126**

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One of the most fundamental principles of biofeedback is the necessity of accurate monitoring and feedback of the physiological processes of interest in order to control it. The purpose of this study was to determine certain effects of popular Mind machines. Extraction of the proper features which detect the brain entrainment process was addressed. The study was designed to explore changes in complexity measures, power spectra, coherence and subjective feelings. Volunteers were trained with the Mind machine and EEG signal was recorded. The multivariate and univariate statistics was performed. Correlation coefficients between each pair of measures was counted. We illustrate the changes of the particular measures: approximate entropy, correlation dimension, spectral edge, band relative power spectra density, alpha band coherency and results of subjective assessment. The attention is called to powerful nonlinear measures originally developed for chaotic and complex nonlinear systems.

## Discreteness induced effects in small reaction-diffusion systems **P. 127**

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To study biochemical dynamical processes, rate equations are often adopted. In rate equations, concentrations of chemicals are treated as continuous variables. However, chemicals are composed of molecules, and when the amount of the chemical is small, the discreteness of the number of molecules is not negligible. Previously, we reported discreteness-induced transitions in a small autocatalytic system. We found a novel phase due to fluctuation and discreteness in molecular numbers, characterized as extinction of molecule species alternately. We also found that the transitions also strongly influences on long-term averaged properties of the system, such as the average concentration of some chemicals. In previous model, we assumed that the reactor is always well-stirred. For real systems such as biological cells, diffusion of chemicals is also important. The discreteness of molecules may be significant also in diffusion processes, when the amount of the chemical is small. We discuss some possible effects of the discreteness of molecules, based on discrete particle simulations.

**P. 128**

## Using chaos to detect damage in continuum mechanics

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One of the simplest problems studied in nonlinear physics is that of the forced damped pendulum. Studied extensively in isolation, the pendulum is always attached to some support, such as a stiff rod, and is used in many active control mechanisms, such as vibration absorbers. If the rod is sufficiently stiff, one expects the pendulum dynamics to be slightly perturbed from the ideal infinitely stiff case. It is known that when the rod is sufficiently stiff, the dynamics resides on a global slow invariant manifold; i.e. the rod is slaved to the motion of the pendulum. As a result of this slaving motion, the dynamics is a perturbation of a parametrically driven pendulum.

However, when operating at or near resonance, there exists some critical amplitude of the driving force that causes a discontinuous change from periodic behavior to hyper-chaotic behavior, where there are two or more positive Lyapunov exponents. In contrast, non-resonant dynamics exhibits multiple chaotic attractors, one which is statistically constrained to a low dimensional surface and one which is not. In both cases, multiple attractors as well as long lived chaotic transients exist. Such multiplicity gives rise to an obstruction in predicting the type of asymptotic behavior due to small uncertainties in parameters and/or data. Either chaotic or periodic behavior may result for given initial data. To eliminate the possibility of periodic resonant behavior, the results of a new parametric control procedure to sustain chaos are presented.

One benefit of having chaotic behavior in continua, either natural or sustained, is that many modes are excited. The spread of multiple frequency excitation dynamically samples the structure at many wavelengths at once. That is, many spatial scales are visited throughout a given structure. Although the structure is linear, since it is coupled to a nonlinear oscillator, the linear modes are all coupled through the nonlinearity of the oscillator. If damage is slowly building up such as internal friction or material softening, then it should be possible to detect statistical changes in the dynamics when the system is in chaos. We verify this hypothesis by using the local expansion rate of the dynamics, which when averaged over the entire attractor is the largest finite time Lyapunov exponent. We find that as a parameter changes in the system, the local expansion rate, as well as the finite time Lyapunov exponent approximately follow the changes of the physical parameter.

We propose a statistical detection method to determine when a physical parameter changes in a continuum mechanic model that is nonlinear. We consider only solutions that are chaotic and by examining the statistics of the local expansion rates a clear trend is revealed which tracks adiabatic parameter changes in a system parameter. In real system one cannot make use of the model to detect changes, one needs to rely on time series analysis of physical quantities such as strain measurement or acceleration. One can use time series delay embedding techniques to create a geometric picture of the dynamics and still compute the local expansion rates statistics as if one had a model. We compare the performance of the detection method in the theoretical case and in the experimental case for internal as well as external system parameters.

## A dynamical systems approach to cognition and perception **P. 129**

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Since the advent of the cognitive shift, the "computational" symbol processing approach has been established as the fundament of cognitive psychology. Accordingly, cognition is viewed as a series of sequentially ordered processing stages. Between perception and the ensuing action, input is processed by higher cognitive functions or modules, such as categorization, memory and planning. We propose an alternative research program, sometimes called embodied cognitive science, that is based on dynamical systems theory and synergetics. Cognition is thus conceptualized as directly originating from the interaction of cognition and environment. Within this research program, the cognitive system is conceived as a complex dynamical system characterized by self-organization and pattern formation. Evolving patterns ("Gestalts") may undergo phase transitions according to changing control parameters. We present an empirical paradigm using various Gestalt perceptual tasks that help evaluate the nonlinear functioning of cognition. As an application to psychopathology, we hypothesize that during psychosis the capability to generate and/or preserve perceptual and cognitive patterns is impaired. This impairment may help explain psychotic symptoms.

## Mathematical and numerical modeling of groundwater flow in fractured environment **P. 130**

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An approach to modeling of the groundwater flow in the fractured environment is introduced. In the first part of the contribution physical description of problem is presented. Then, mathematical formulation of this problem based on the weak solution of the system of three PDEs is described. The third part of contribution is devoted to the description of the process of approximation of equations based on the mixed-hybride formulation of the FEM method. This approximative approach leads to the need of solving the large sparse systems of linear equations in special form. Methods suitable for solving such systems are introduced and discussed in the fourth part of contribution. Finally, some results of calculations of the real-world groundwater flow problems are shown.

## Application of the Bernoulli shift to investigate the stability of spatially periodic solutions in lattice dynamical systems **P. 131**

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We use the shift operator in a certain Banach space to derive the spectrum of a linearized operator which determines the stability of the spatially periodic solution of Lattice Dynamical System. We prove a general theorem, which generalizes the theorem about the image of the spectrum by a polynom to the case when the coefficients of the polynom are matrices. We apply these results to concrete examples of LDS arising in space interactions of the diffusion type.

## P. 132 Reaction diffusion model of the enzymatic erosion of insoluble fibrillar matrices

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In this work we derive and simulate a reaction diffusion model for the enzymatic erosion of fibrillar gels that successfully reproduces the main qualitative features of this process. A key aspect of the proposed model is the incorporation of steric hindrance into the standard Michaelis-Menten scheme for enzyme kinetics. In the limit of instantaneous diffusion the model equations are analogous to the standard equations for enzymatic degradation in solution. Invoking this analogy, the total quasi-steady state approximation is used to derive approximate analytical solutions that are valid for a wide range of in vitro conditions. Using these analytical approximations, an experimental-theoretical method is derived to unambiguously estimate all the kinetic model parameters. Moreover, the analytical approximations correctly describe the characteristic hyperbolic dependence of the erosion rate on enzyme concentration and the zero order erosion of thin fibers. For definiteness, the analysis of published experimental results of enzymatic degradation of fibrillar collagen is demonstrated, and the role of diffusion in these experiments is elucidated.

## P. 133 Vibrational resonance and propagation in excitable systems

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We study the behavior of excitable systems under the action of two-frequency signal, in which the information is carried by a high-frequency and modulated by a low-frequency. We report the effect of vibrational resonance, in which by increasing the amplitude of the high-frequency component as the control parameter, the response at the low-frequency shows a resonance like behavior . We show that high-frequency signal can play the role of white noise as in the effect of stochastic resonance. We confirm experimental measurements in the electronic circuit by numerical simulations of the paradigmatic FitzHugh-Nagumo model. Finally we present vibrational propagation in the excitable media, which consists in the fact that optimal intensity of the high-frequency vibration is able to induce a propagation in space of the low-frequency signal through the excitable medium.

## P. 134 Deterministic diffusion in a gravitational billiard

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We examine numerically the motion of a system of non-interacting particles in a homogeneous gravitational field. The motion is bound from below by a boundary reflecting elastically the colliding particles. The boundary is represented by symmetric wedge which is periodically and continuously extended over the entire $x$-axis. Similarly to the single wedge case (H. E. Lehtihet and B. N. Miller, Physica **D21**, 93 (1986)), when the angle $\theta$ between the boundary and the $x$-axis is less than $45°$, the motion is chaotic, while for angles larger than $45°$, depending on the initial conditions, the motion is either chaotic or quasiperiodic. The mean-square displacement for the system of particles grows asymptotically as a linear function of time $t$. The diffusion coefficient is complex function of the wedge angle and particles energy. We provide evidence that the space distribution of particles for $t$ large tends toward Gaussian function. It is also observed that at some intemediate range of $t$, for small angles $\theta$, the mean-square displacement scales as $t^\alpha$ with $\alpha > 2$.

## Characterization of the local instability in the Henon-Heiles Hamiltonian **P. 135**

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The global Lyapunov exponents are quite useful in analyzing chaotic motion, but in many cases, it is only feasible to use a finite integration time instead of the required infinite time. By making a partition of the whole integration time along a given orbit into a series of time intervals, and plotting the resulting distribution of values, we get information about the overall degree of instability of an orbit. We have computed several prototypical distributions of finite-time Lyapunov exponents in the two-dimensional Henon-Heiles Hamiltonian flow for the smallest available integration interval, and different shapes are obtained depending on the dynamical state. An evolution in the morphology of the distributions and dependency on the initial point is observed in some cases but they still serve for characterizing the dynamical state of the system.

## Extinction dynamics of the Mercury beating heart reaction in acid solution **P. 136**

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The dynamics of the oscillatory Mercury Beating Heart (MBH) reaction in acid aqueous solution with $Ce^{4+}$ as the oxidizing agent was investigated. The reaction slowly runs down over a period of a few hours, until all oscillatory activity eventually ceases. During this period the dynamics slowly evolves, showing qualitatively different forms of oscillations. These oscillations display different modes of oscillations with geometric structures similar to heart, circle, pentagon, hexagon, and 8-, 12-, 16-pointed stars. As time proceeds stabilized limit-cycle oscillations of period-1, period-3 and period-2 appear successively. We propose different oxidation-reduction reactions to explain the appearence of these cycles based on the formation of mercury(I) especies, in the form of free $Hg_2^{2+}$ion or, in molecular form, as a soluble mercurous sulfate or a mercurous sulfate film. The theoretical potential values calculated for these reactions agree well with our experimental values.

An experiment was performed also without adding the $Ce^{4+}$ oxidant, generating *in situ* species of $Hg$ by $\gamma$ irradiating the metallic $Hg$ in the same acid solution as before. It is shown that $^{60}Co$ $\gamma$-rays induce the generation of oscillations. In this way we support our claim that oscillations are due to the formation of chemical species of $Hg(I)$ be it ionic or molecular and that extinction occurs when $[Hg(II)] \gg [Hg(I)]$.

## Relaxation oszillations in phase separation induced by a temperature ramp **P. 137**

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The kinetics of phase separation of low and high molecular binary mixtures showing an upper (or lower) critical point is discussed. When inducing the phase separation by constant cooling (or heating) the mixtures often show pronounced oscillations in the specific heat and the turbidity. This is in line with repeated cycles of nucleation, coarsening and sedimentation. The period of the oscillations shows a systematic dependence on the heating rate. A general model is suggested that explains the origin of the oscillations.

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## Stochastic analysis of road surface roughness

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For the analysis of surface height profiles we present a new stochastic approach which is based on the theory of Markov processes. With this analysis we achieve a characterization of the complexity of the surface roughness by means of a Fokker-Planck or Langevin equation, providing the complete stochastic information of multiscale joint probabilities. The method was applied to different road surface profiles which were measured with high resolution. Evidence of Markov properties is shown. Estimations for the parameters of the Fokker-Planck equation are based on pure, parameter free data analysis.

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## Quantum dynamics of wave packets on coupled adiabatic potentials

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Quantum excitation dynamics of a molecular dimer system with the excitation coupled to the vibronic surrounding is investigated. The system is described by a nonlinear Spin - Boson Hamiltonian in the spectrum of which the adiabatic branches are coupled. Propagation of the time dependent state vector is performed using a large number of eigenstates of this Hamiltonian obtained by numerical diagonalization. Applying Husimi projections to the state vector time dependent phase space densities are constructed which describe the propagation of excitation wave packets on the coupled adiabatic potentials. Spin dependence of Husimi densities is used to associate packet dynamics with definite adiabatic branches. Complex packet dynamics is observed with packet propagation along adiabatic phase space trajectories and packet splittings in the region of avoided crossings of different adiabatic trajectories. Results on packet propagation, time dependence of packet characteristics and packet splittings are presented by analyzing the propagation process.

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## Hints for universality in coupled map lattices

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A wide range of coupled map lattices is shown to have identical pattern sequences providing numerical evidence for some sort of underlying universality.

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## Dendrites and seaweed of Xenon

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Based on our earlier experimental studies it was possible to show that dendritic patterns are a result of selective amplification of thermal noise on atomic scale. Open questions in the field of pattern-formation are: What are the mechanisms by which effects on atomic scale govern the dynamics of pattern formation? What are the interrelations between physics at different length scales in pattern-forming systems? Length scales in our crystallization experiments are a result of non linear processes. They are not given by external boundary conditions. We produce various crystal morphologies: dendrites, seaweed, doublons, triplons etc. The projection area of a crystal

increases with the square of the lifetime $t$ of the crystal and the crystal volume is proportional to third power of $t$. Tip velocity is constant in time, no oscillations can be found.

## Logistical performance of manufacturing processes — opening up new vistas with nonlinear dynamics **P. 142**

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The dynamics of manufacturing systems are obvious in the continuous arrival of unforeseen orders and the occurrence of all kinds of disturbances. Investigations in industry have shown that 20 to 30% of operations is done on other equipment than was originally planned. So far logistic parameters such as throughput time, utilization, work in progress level and schedule reliability are described exclusively by statistical techniques due to their complex interdependencies. As a result, information about the systems dynamics get lost. The transfer of methods of nonlinear dynamics and chaos theory on logistic systems is seen as big chance for a better understanding and respectively control of complex production systems. The poster presents nonlinear logistical problems of manufacturing processes, points out the deficits of classical modeling methods and depicts approaches with methods of nonlinear dynamics.

## Nonlinear approach in studies of the internal DNA dynamics **P. 143**

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The DNA molecule is considered here as a complex dynamical system with many types of the internal motions which are characterized by different amplitudes, energies, velocities, frequencies, and characteristic times [1,2]. We focus our attention on the motions of large amplitudes the description of which requires the nonlinear technique [3]. We discuss how these motions can be modeled mathematically and present the main approximate models used [4].

To illustrate the approach, we describe in details the algorithm of modeling one of the internal motions named local unwinding of the double helix. This motion plays an important role in the processes of transcription, DNA-protein binding, DNA denaturation, DNA destruction due to radiation and so on. We derive corresponding dynamical equations and show that the equations have solitary wave solutions that can be interpreted as local unwound regions. We discuss how these regions can be detected by the method of neutron scattering, and how the approach described above can be used to explain some features of DNA functioning. As examples, we consider two problems: the problem of long-range effects in DNA and the problem of the direction of the process of transcription.

1. J.A. McCommon and S.C. Harvey, Dynamics of proteins and nucleic acids (Cambridge University Press, Cambridge, 1987).
2. L.V. Yakushevich, Quart. Rev. Biophys. 26, 201 (1993).
3. L.V. Yakushevich, Nonlinear physics of DNA (Wiley, New York, 1998).
4. L.V. Yakushevich, J. Biosci., 26, 305 (2001).

## P. 144 Increasing the complexity of structured attractors in low dimensional electrical circuits

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The design of chaotic oscillators has received considerable attention during the past few years in electrical engineering. A main reason is that the possible engineering applications of chaotic systems are becoming available together with theoretical support from many different disciplines. Recently, new families of scroll grid attractors have been proposed in [1]. These families are classified into three sub-families due to the structures of attractor which are 1D-, 2D- and 3D-grid scroll attractors. Previously, n-scroll attractors have been proposed which are higher complex systems in comporison with the classical Chua's double scroll. We succeeded in locating the scrolls also in the second state variable direction leading to 2D-grid scroll attractor families. Using similar idea, 3D-grid scroll families make the possible to locate scrolls in three dimensional space. It might be thought that scroll grid attractors repeat the complexity of a single scroll in origin into the each new location of the scroll. Therefore, the complexity of proposed new attractor families is systematically increased the complexity to the whole space. Scroll grid attractors are a promising candidate for possible applications in engineering with systematically increased structure and implementations.

[1] Yalcin M., Ozoguz S., Suykens J.A.K., Vandewalle J., 'Families of Scroll Grid Attractors,' International Journal of Bifurcation and Chaos, Vol. 12, No. 1, pp. 23-41, 2002

## P. 145 Period doubling bifurcation of heartbeat in the crayfish *Procambarus*

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To understand physically complex biological systems, it is necessary to describe a specific phenomenon in living animals by mathematical method, and this method is biologically of interest. We focused to behavior of cardiac system and measured heart rate for the period of hours. During the course of heartbeat analysis of freely moving wild-type-red crayfish and mutant-white crayfishes, we found significantly different dynamical properties between the two; heartbeat in ĄewhiteĄf but not ĄeredĄf suddenly changed from normal beating to period-2 state. This change was apparently period-doubling bifurcation. The period-2 state lasted for several to 30 beats before returning to normal period-1 state. The bifurcation occurred 9 times during over 12 hours of continuous recording. Taking advantage of the differences between these specimens, we would elucidate the mechanism of dynamical regulation in living animals.

## P. 146 Numerical study of spectrum and scaling properties of decaying Burgers turbulence

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The properties of spectral transfer and scaling in inertial and viscous scale ranges is studied for 1D and 2D decaying Burgers turbulence (BT), being solutions of Burgers' equation with random self-similar initial velocity. The goal is to get more detailed picture of similarity and differences between two types of turbulence, describing by incompressible Navier-Stokes and

Burgers equations. Several ways of treating spectral transfer of BT is considered, including usual expansion in Fourier series and wavelet decomposition. For the account of peculiarities of BT the expansion in series of periodic sawtooth functions is also used, which seems to be more suitable for multiple shock solutions of Burgers equation. In the same representation, the intrinsic property of BT - the stability of large-scale structures to small scale disturbances is expressed well. The intermittency properties of BT is also analyzed by calculation of velocity structure functions of order $0.1 \leq q \leq 10$. The sufficient difference with the case of Navier-Stokes turbulence is revealed, manifesting itself in bifractal character of scaling exponents and in deviations from the extended self-similarity property, depending from scaling of initial random velocity.

## Bone modeling and structural measures of complexity **P. 147**

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We study the application of nonlinear dynamics methods for the quantification of the human bone structure on the base of bone images obtained by computed tomography. The measurements of the mean structural measures, such as Bone Mineral Density (BMD), as routinely performed in clinical settings, do not adequately reflect the bone deterioration, which occurs due to the absence of the gravitation or osteoporosis. Recently new structure measures, based on the calculation of entropy, have been suggested. The aim of this presentation is to test sensitivity and powerfulness of these Structure Measures of Complexity (SMC) with simulated test objects, represented by simple structures or modelled on the basis of a real bone image. We check how these SMC reflect the local and global disordering processes, as well as a deterioration of the bone structure. We show that applications of SMC provide additional information about any changes of the bone structure in comparison to BMD, and that they can be potentially helpful in the diagnosis of osteoporosis. Finally, we compare preliminary results of the experimental measurements with results of bone modeling.

## A new class of quasiperiodic solutions of the Korteweg-de Vries equation **P. 148**

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The purpose of this article is to describe a new class of quasiperiodic solutions (QPS) of the Korteweg-de Vries (KdV) equation, whose existence is not evident due to the widely known complete integrability of the latter. The QPS of any partial (or ordinary) differential equation are those whose spectrum is located near a pair of incommensurable frequences. This makes the phase portrait of the system has a torus character. Another important feature of QPS solutions is that some perturbations of torus can lead to its destruction and transition to a chaotic behaviour of the system described. Hence, the existence of QPS solutions of the KdV equation is very unexpected and astonishing fact. The existence of QPS solutions of KdV equation was predicted in [1] as a result of unlimited sequence of bifurcation points of $n-$th mode of periodic solution of KdV equation arising. More presisely, QPS solutions arise if that sequence has a limiting point while $n \to \infty$. In [2] it was shown that at this point, QPS solutions of the Korteweg - de Vries - Burgers (KdVB) equation arise. This was shown for the KdVB equation which describes the transverse waves of polarisation $P$ in the nonliner dielectric [3] with phase transition of "order -

disorder" type. So the limit $n \to \infty$ means the limit $T \to T_c$ where $T_c$ is a Curie temperature of phase transition.

From the mathematical point of view it is due to the fact that the coefficients of the KdVB equation for the $T > T_c$ become imaginary and the solutions have the form $P = P_1 + iP_2$ with real $P_{1,2}$. Another reason for this is an imaginary speed of long-wave small-amplitude perturbations of KdVB equation which corresponds to the perturbation's frequency $\omega$ is in the gap of opacity. Physically it means the modulation of an initially harmonic wave $P = Re\{(P_1 + iP_2)exp(ikz - i\omega t)\}$ where $k = k(\omega)$ is the wave number of a corresponding frequency $\omega$. Here, the slow-amplitude part of solution is separated from the fast part oscillating at frequency $\omega$. A variation of amplitude part is due to periodic energy exchange between components $\sim P_{1,2}$ $\pi/2-$ shifted one from another.

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## Observations regarding obstacles to integrability

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The normal form expansion of intergrable dynamical systems, to which nonlinear perturbations are added, often encounters "obstacles to integrability". Owing to such obstacles, it is impossible to transform the equation of a perturbed dynamical system into an integrable one. The obstacles arise due to the fact that the perturbative expansion of the solution fails to account for all the terms that are generated by the perturbation. By considering several examples, it is found that the information contained in the normal form (the equation that determines the solution for the zero-order term of the expansion) may lead to the elimination of the obstacles.

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## Multiscale calculation of Wigner functions

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We present the application of variational-wavelet analysis to numerical-analytical calculations of Wigner functions in (nonlinear) quasiclassical dynamical problems. (Naive) deformation quantization and multiresolution representations are the key points. We construct the representations via multiscale expansions in generalized coherent states or high-localized nonlinear eigenmodes in the base of compactly supported wavelets and wavelet packets which are natural nonlinear generalization of standard coherent, squeezed, thermal squeezed states corresponding to quadratical systems (linear dynamics) with Gaussian Wigner functions. As result we calculate quantum corrections to classical dynamics described by arbitrary polynomial nonlinear Hamiltonians such as orbital motion in storage rings or general multipolar fields. We give contributions to our full quasiclassical representation from each scale of underlying resolution.

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## Noise-induced and enhanced synchronization of chaotic oscillators

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We report nontrivial and constructive effects of noise on synchronization of chaotic oscillators, both numerically and experimentally. (i) in a general class of systems possessing a saddle point embedded in the chaotic attractors, i.e. homoclinic chaos, a common noise can induce complete synchronization of two uncoupled identical chaotic oscillators. We observe this behavior

experimentally on CO2 laser with electro-optic feedback (in collaboration with the group of T. Arecchi, Istituto Nazionale di Ottica Applicata, Florence) . (ii) In contrast to coupled periodic oscillators where noise degrades phase synchronization, we demonstrate that noise an enhance significantly phase synchronization of weakly coupled chaotic oscillators, numerically on chaotic Rössler oscillators and experimentally on chaotic electrochemical oscillators (in collaboration with the group of J. Hudson, University Virginia). Mechanisms of these constructive effects of noise are explained and the relevance of our findings to neuroscience and ecology is discussed.

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