NONLINEAR SCIENCE FESTIVAL III

Technical University of Denmark

Kgs. Lyngby, Denmark

June 12-15, 2001

Conference organisors:

Carsten Knudsen
Department of Physics
Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

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Department of Informatics and Mathematical Modelling
Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

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Wednesday, June 13, 2001 - Nonlinear Dynamics of the Brain :

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PROGRAM

Thursday, June 14, 2001 - Nonlinear Optics :

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09.50-10.10	Marcus Ahles, *Higher-order optical spatial vector solitons in a saturable nonlinear photorefractive medium*	Lecture hall 31, bldg. 306
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11.30-12.20	Jean Michel Nunzi, *Periodic phase matching and two color holography aspects of all optical poling of polymers*	Lecture hall 31, bldg. 306
12.20-12.40	Christophe Hubert, *Microstructuring of polymers using light-controlled molecular migration processes*	Lecture hall 31, bldg. 306
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16.00-16.50	Vladimir Mezentsev, *Recent progress in dispersion managed soliton fiber communications*	Lecture hall 31, bldg. 306
16.50-17.10	Rodislav Driben, *Split-step solitons in multichannel communication systems*	Lecture hall 31, bldg. 306
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11.30-11.50	Anders Andersen, *Bathtub vortices*	Lecture hall 31, bldg. 306
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14.00-14.50	Willem van de Water, *Patterns of surface waves*	Lecture hall 31, bldg. 306
14.50-15.10	Miguel A.F. Sanjuan, *Chaotic advection of fluid flow and fractal structures*	Lecture hall 31, bldg. 306
15.10-16.00	Jane Wang, *Unsteady aerodynamics of insect flight*	Lecture hall 31, bldg. 306
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TALKS

BIOLOGICAL AND CHEMICAL OSCILLATIONS

Tuesday, June 12, 2001

Session organisors:

Morten Colding-Jørgensen
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The bursting beta cell. From experiment to model

Patrik Rorsman
Sweden

ABSTRACT NOT AVAILABLE

Coupling between beta cells can increase insulin release

Morten Colding-Jørgensen
Scientific Computing. Novo Nordisk A/S
Novo Nordisk Park, Bygn. B2.2.44. 2760. Måløv, Denmark

The electric behaviour of a beta cell consists of a phase with fast oscillations - the burst, where insulin release takes place - and a slow phase, the inter-burst period. The coupling between neighbouring cells is described. Using a simple model it is shown that there is almost synchrony between the slow phases, while the fast phases normally are completely desynchronised. It is demonstrated that this lack of synchronisation, irregularities and even chaos, can prolong the burst and thus improve the conditions for insulin release.

Chemoconvection: A chemically induced hydrodynamic instability

Antonio J. Pons Rivero

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M.A. Bees

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We describe theory and experiments concerning a chemical reaction, the alkaline oxidation of glucose with methylene blue as a catalyst, that is hypothesized to drive fluid motion via an overturning instability, as an example of 'chemoconvective' process. A theoretical model is developed to explain this phenomenon and linear analyses from steady and pseudosteady states are used to predict the basic length and times scales of the patterns which initially appear. These theoretical predictions, using kinetic parameters from recent independent experiments, are contrasted with the results from pattern initiation experiments. Preliminary comparisons indicate good qualitative and quantitative agreement.

Modeling of beta-cells

Paul Matthias Diderichsen

Department of Physics, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark
Department of Scientific Computing, Novo Nordisk, 2760 Måløv, Denmark

A typical beta-cell model may be constructed using a number of components which define the ionic currents, the variation in intracellular concentrations, and various couplings. In this presentation, a number of bursting beta-cell models will be examined and compared, and the components involved will be explained and discussed.

It will be shown that a majority of the models implement one of two mechanisms to produce the bursting membrane potential oscillations: One involves a calcium dependent activation of a potassium current while the other is based on a slow inhibition of the calcium current.

Quantitative modelling of glycolytic oscillations

Sune Danø

Department of Chemistry and CATS, University of Copenhagen, Denmark

We present a powerful, general method of fitting a model of a biochemical pathway to experimental substrate concentrations and dynamical properties measured at a stationary state, when the mechanism is largely known but kinetic parameters are lacking. Rate constants and maximum velocities are calculated from the experimental data by simple algebra without integration of kinetic equations. Using this direct approach, we fit a comprehensive model of glycolysis and glycolytic oscillations in intact yeast cells to data measured on a suspension of living cells of ¡I¿Saccharomyces cerevisiae¡/I¿ near a Hopf bifurcation and to a large set of stationary concentrations and other data estimated from comparable batch experiments. The resulting model agrees with almost all experimentally known stationary concentrations, with the frequency of oscillation and with the majority of other experimentally known kinetic and dynamical variables.

Nonlinearities in heart rate variability

Jørgen K. Kanters
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The heartbeat is not regular but varies in an apparent irregular matter. This variation termed heart rate variability (HRV) is not only due to changes in activity or respiration, but occurs even at rest or at night. Atropine abolishes most of these variations, indicating the significance of parasympathetic tone. The importance of HRV was demonstrated by Kleiger [1]. He showed that decreased HRV measured in the time domain as the standard deviation of 24-h RR-intervals in msec (SDNN), was a strong predictor of mortality after myocardial infarction. However the clinical utility of SDNN is limited, and only permits the identification of a high risk group, but lacks the sensitivity and the specificity to identify individual subjects at high risk for sudden death.

The drawback of time and frequency domain measures is that they only take linear information into account ignoring any form of nonlinear dynamics. Previous studies have shown that a small but significant amount of nonlinear dynamics exists in HRV [2]. Various methods exist to quantify nonlinearities in HRV. Strange attractors have been postulated by plotting a RR interval against the following one, revealing different patterns in healthy subjects and patients suffering sudden cardiac death. These patterns can be quantified by determining their dimension, ideally giving the minimum number of independent variables needed to describe HRV. Specific structures in HRV can be identified using nonlinear predictability or neural networks showing that some specific dynamics exist in HRV. Newer methods introducing nonlinear autoregressive modelling seems to be able to identify these characteristic patterns. The strength of these methods is the ability to discriminate between inherent dynamics and external perturbations (noise).

There has been much effort to apply these methods in the clinical setting. Preliminary studies has shown that dimension measures can distinguish patients that later developed ventricular fibrillation from those who did not, despite that the groups had the same SDNN. Unfortunately, we still need larger studies to establish the role of nonlinear dynamics in the clinical setting for predicting sudden cardiac death.

1 R.E. Kleiger et al., Am J Cardiol, 59: 256-262, 1987.

2 J.K. Kanters et al. J Cardiovasc Electrophysiol, 5:591-601, 1994

Chaos and synchronization in nephron dynamics

Niels-Henrik Holstein-Rathlou
Department of Medical Physiology, The Panum Institute,
University of Copenhagen, Denmark

The tubuloglomerular feedback (TGF) is an intrarenal mechanism that stabilizes renal blood flow, GFR, and the tubular flow rate. The anatomical basis for TGF is the return of the tubule (the ascending limb of the loop of Henle (ALH)) to its own glomerulus. The macula densa, which is the sensor mechanism for the TGF, is a plaque of specialized epithelial cells in the wall of the ALH. It is localized at the site where the tubule establishes contact with the glomerulus. Because of a flow dependency of NaCl reabsorption in the ALH, a change in tubular flow rate, elicited for example by a change in the arterial pressure, will lead to a change in the NaCl concentration of the tubular fluid. This is sensed by the macula densa, and through unknown mechanisms results in a change in the hemodynamic resistance of the afferent arteriole. The dynamic properties of the TGF system has been characterized in experimental studies in both normo-and hypertensive rats. In normotensive rats, TGF displays autonomous self-sustained regular oscillations, whereas in spontaneously hypertensive rats (SHR) highly irregular, "chaotic" fluctuations are present. Experimental studies has shown that the TGF systems of neighboring nephrons interact so that the oscillations and the irregular fluctuations of the respective nephrons becomes synchronized. We have developed a dynamic model of that includes the major coupling mechanisms between the neighboring nephrons that shares a common interlobular artery. The phase of the synchronized oscillations and irregular fluctuations depend on which coupling mechanism dominates. The hemodynamic coupling leads to out-of-phase synchronization, whereas vascular coupling leads to in-phase synchronization. The two type of synchronization patterns can be found in experimental data from rat kidneys. However, in-phase synchronization is by far the most common, suggesting that under physiological conditions, vascular coupling is the dominating form of coupling between neighboring nephrons.

TALKS

NONLINEAR DYNAMICS OF THE BRAIN

Wednesday, June 13, 2001

Session organisor:

Alwyn Scott
Department of Informatics and Mathematical Modelling
Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

Overview of brain dynamics

Alwyn C. Scott
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2800 Kongens Lyngby, Denmark

As an introduction to "Nonlinear Dynamics of the Brain," a cognitive hierarchy of the human brain will be described, reaching from the lowest level of chemical dynamics through neurons and assemblies of neurons to the influences of human culture. Emphasis will be placed on the intricacy of individual neurons, which may permit information processing in dendritic and axonal trees, and on metaphors for assembly dynamics. Downward causality in this hierarchical structure will be discussed and related to theories of neural determinism.

Non-linear adaptive systems

Lars Kai Hansen
Department of Informatics and Mathematical Modelling,
Building 321, Technical University of Denmark,
2800 Kongens Lyngby, Denmark

Non-linearity is essential to some adaptive systems. So-called independent component analysis (ICA) for reconstruction of random source signals from linear mixtures, is a prominent example. Using linear systems it is only possible to recover the subspace spanned by the columns of the mixing matrix, while a broad class of non-linearities allow full recovery of both the unknown mixing matrix and the source signals, ie., blind signal separation. I will discuss recent progress in our understanding of the ICA problem based on mean field methods and linear response theory.

Cell assemblies in the neocortex

Erik Fransen

Department of Numerical Analysis and Computer Science, Royal Institute of Technology,
S-100 44 Stockholm, Sweden

The cell assembly is a conceptual entity introduced by D. O. Hebb in his classic book The organization of behavior. Within this book, Hebb described how the cell assembly would be formed, and how it could support internal representations of entities in the surrounding world. He also discussed associations between assemblies and sequences of such, as elements of "thought". The hypothesis has been adopted and extended by many. We have studied how this qualitative hypothesis could be formulated in a quantitative computational framework. We have also investigated its support from modern neuroscience in terms of structure and function. In a biophysical model, we have tested the performance for the assembly functions, as well as other computational variables such as speed of recall, unit activity levels, and flexibility of operation. In the presentation, the possibility that assembly-like operations may be present in multiple regions of the cortex, including its relations to the long-term and working memory function attributed to these regions, will also be discussed.

Synergetics of the brain

Hermann Haken

Center of Synergetics, Institute for Theoretical Physics 1, University of Stuttgart,
Pfaffenwaldring 57, 70550 Stuttgart, Germany

In the human brain billions of neurons cooperate to enable us to move, to recognize patters, to produce speech, to think, etc. Who or what steers the cooperation of the neurons? Sometime ago, I suggested that the brain is a synergetics, i.e., self-organizing systems that may spontaneously produce spatio-temporal patters of neuronal activity.

I first re-call by now well-known concepts that allow us to deal with self-organizing systems, e.g., contron parameters, instability, order parameters and the slaving principle. By means of the analysis of experimental data on movement coordination, visual perception, electro- and magnetoencephalograms it is shown how these concepts can be applied. In particular, it is shown how the complex dynamics can, in a number of well-defined cases, be reduced to low-dimensional dynamics that govern the behavior of the many individual neurons.

Neural representation of actions in the basal ganglia

Mikael Djurfeldt
Department of Numerical Analysis and Computer Science,
Royal Institute of Technology, S-100 44 Stockholm, Sweden

The basal ganglia is a set of subcortical brain nuclei which constitutes an important part of the motor system. We have applied the mutual information measure on signals from multiple neurons recorded with tetrode technique from the basal ganglia of the rat during learning of a T-maze task. In this task, the rat learnt to run left or right depending on whether a high-pitched or low-pitched tone was presented. In the presentation, it is shown how the framework of a communications channel can be applied to decoding of neural signals, and that signals in the input nucleus of the basal ganglia, the striatum, carry information about conditions such as whether the rat is turning right or left.

Dynamics of neural circuits

John Hertz
Nordita, Copenhagen, Denmark

Neural circuitry is highly diverse, but almost all of it shares certain universal features, notably high connectivity and competition between excitation and inhibition. Another feature whose imortance has been widely recognized and studied recently is synaptic adaptation: Effective connection strengths between neurons change on the several-hundred-ms timescale, and this additional layer of dynamics has consequences for the network dynamics.

In this talk I will describe two general universality classes of the network dynamics that occur as a result of excitatory-inhibitory conpetition and show the way information may be encoded in the different cases. In the first, neuronal excitation-inhibition loops give rise to oscillatory dynamics, which can then be modulated by the slower synaptic dynamics. The antenna lobe, which encodes olfactory stimuli in insects, offers an interesting example of such a system. In the second class, exemplified by the neocortex of mammals, separately strong excitatory and inhibitory interactions in densely-connected networks lead to a self-consistent "balanced state" in which individual neurons fire irregularly and information is carried by the average firing of large populations. Synaptic adaptation can contribute to this information transmission, making the firing rates subject more to changes in inputs than to the input rates themselves, while generally enhancing the stability of the balanced state of the network.

TALKS

NONLINEAR OPTICS

Thursday, June 14, 2001

Session organisors:

Ole Bang
Department of Informatics and Mathematical Modelling,
Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

Per Michael Johansen
Optics and Fluid Dynamics Department
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Spatial optical solitons

Wieslaw Krolikowski
Laser Physics Centre, Research School of Physical Sciences and Engineering, Australian National University, Canberra ACT 0200, Australia

Propagation of the finite-size optical beam is accompanied by its spreading due to diffraction. Sometimes diffraction can be eliminated via the nonlinear interaction of the beam and the material. When this occurs the beam propagates without changing its shape forming spatial optical soliton. Great variety of solitons and soliton-related effects have been studied theoretically and observed experimentally using various nonlinear physical effects and materials. Spatial solitons appear to be very robust, particle-like objects exhibiting interesting collisional properties. In particular, they may spiral around each other, annihilate or give birth to new solitons. They can also exist in form of composite objects consisting of few mutually incoherent components ("light molecules") creating different optical patterns such as multipole-vector solitons.

In this talk I will discuss the basic concept of the spatial soliton, review various types of solitons, their individual properties and their interactions.

Higher-order optical spatial (2+1)D vector solitons in a saturable nonlinear photorefractive medium

Marcus Ahles
Institute of Applied Physics, Darmstadt University of Technology, Hochschulstrasse 6, 64289 Darmstadt, Germany

Optical spatial (2+1)D solitons are solitary self-trapped light beams that can form in a saturable Kerr-like nonlinear bulk medium. A monochromatic and coherent light beam propagating through a photorefractive SBN crystal induces a refractive index modulation which under certain conditions counterbalances exactly the beam's natural diffraction in both transverse directions. The light propagates as the fundamental mode of its own self-induced waveguide. Self-focused light structures that consist only of one optical field are denoted as scalar solitons. In contrast, higher-order Hermite-Gaussian dipole-like or Laguerre-Gaussian vortex-like transverse modes do not self-trap due to their non uniform transverse phase distribution. But if they co-propagate incoherently with a fundamental Gaussian beam of equal total power, a stationary self-trapped state will form which is denoted as a vector soliton.[1] Vector solitons are multicomponent self-focused structures whose components interact only due to the mediums nonlinearity.

Our aim is threefold. First, we demonstrate that the combination of a Gaussian and a vortex beam with a topological charge of m=2 is unstable and decays into two single-charged optical vortices that will decay into a triple humped structure. Second, we show that this HG(0,2) mode-like triple humped structure co-propagating with a Gaussian beam will self-trap and form a vector soliton. Third, we even succeeded in generating more complex structures consisting only of higher order modes generating more complex structures consisting only of higher order modes that trap mutually without any fundamental Gaussian beam. A triple-humped structure as we mentioned above copropagating with a HG(0,1) dipole-mode will form such a complex vector soliton.[2]

[1] C. Weilnau, W. Krolikowski, E.A. Ostrovskaya, M. Ahles, M. Geisser, G. McCarthy, C. Denz, Y.S. Kivshar, B. Luther-Davies, "Composite spatial solitons in a saturable nonlinear bulk medium", Applied Physics B, accepted for publication.

[2] C. Weilnau, M. Ahles, C. Denz, A. Stepken, K. Motzek, F. Kaiser, "Higher-order optical (2+1) dimensional spatial vector solitons in an anisotropic medium", Phys. Rev. E, submitted.

Nonlinear periodic crystals

Neil Broderick

Optoelectronics Research Centre, University of Southampton,
Southampton SO17 1BJ, United Kingdom

The combination of periodicity and nonlinearity is a powerfull means for controlling the properties of light. In this talk I propose to look at a variety of nonlinear aperiodic media including Bragg gratings photonic, crystal fibres, and quasi-phase-matched materials and show how a wide variety of nonlinear interactions ranging from second harmonic generation to super continuum generation benefit from the additional periodicity.

Periodic phase matching and two color holography aspects of all optical poling of polymers

Jean-Michel Nunzi

ERT Cellules Solaires PhotoVolotaiques Plastiques, Laboratoire POMA - CNRS,
Universite d'Angers 2 Boulevard Lavoisier, F49045 Angers cedex, France

Two laser beams at a fundamental and its harmonic frequency can interfere in materials. It is not usual but it occurs provided there is some coherence properties between excitations at both frequencies. This is the case in polymers containing noncentrosymmetric molecules. (The effect was dicovered in 1986 by sterberg and Margulis in optical fibers). The interference between two beams at different frequencies is particular : we show that it induces an interference grating which is not associated to any index modulation. The interference grating is a phase-matched one (namely the one which is needed to to provide the wave vector mismatch in order to recover constructive interference of the second harmonic amplitudes generated in different rgions of the medium). After a review of the many possibilities and features of the effect, we illustrate an example in which we use the all-optical poling process in order to print and recover an holographic image.

Microstructuring of polymers using light-controlled molecular migration processes

Christophe Hubert

CEA Saclay, DRT-LIST-DECS-SE2M-Groupe Composants Organiques, Saclay, France

The possibility of manipulation and precise control of molecular order is a challenging prospect in the design and realization of devices for photonics applications. A new concept for microstructuration, based on photoinduced molecular migration in polymer films containing azobenzene dye was recently demonstrated. Irradiation with an interference pattern of polarised laser beams was observed to lead to substantial reversible mass-transport. The wavelength of the laser was choosen to be near the chromophores absorption band. We now show evidence that, under specific experimental conditions the interaction between a uniform laser beam from an argon laser and the polymer film induces hexagonal structures on the surface of the polymer. Such self-patterning process was observed to depend on several parameters such as the polarization of the laser beam, the angle of incidence, the wavelength, as well as the nature of the dye. The modulation amplitude of the polymer film can reach 100 nm for an initial film thickness of 300 nm, and the period of the structure is of the order of the wavelength. Understanding the fundamental mechanisms of such photoinduced self-patterning process should open a new route towards optical molecular control of materials microstructuring.

Recent progress in dispersion-managed soliton fiber communications

Vladimir Mezentsev and Sergei Turitsyn
Photonics Research Group, Aston University,
Birmingham B4 7ET, UK

We consider recent developmet in the theory and numerical modelling of dispersion manged solitons in fiber optics. Solitons have been considered as the 'natural bits' in high-speed optical fibre communications for more than 25 years, due to their natural ability to balance the effects of fibre dispersion and nonlinearity. However the implementation of the conventional solitons in homogeneous fibers had no significant advantages against quasi-linear propagation regimes. Only recently, during the last few years the break through happened in utilizing the soliton-based transmission. This rapid progress has been driven by the application of dispersion management techniques to soliton transmission, and the subsequent discovery that dispersion-managed solitons have even superior properties than their conventional counterparts. Today, it is clear that dispersion-managed solitons, are the ultimate carriers for next generation of fiber optical communication systems.

Split-step solitons in multichannel communication systems

Rodislav Driben
Department of Interdisciplinary Engineering, University of Tel-Aviv,
Tel-Aviv, Israel

The basis of my presentation is described in [R. Driben and B.A. Malomed, "Split-step solitons in long fiber links", Optics Communications **185**, 439-456 (2000)]. There was considered a fiber-optical link consisting of alternating dispersive and nonlinear segments, which are separated by a large distance. The existance of solitons with some attractive features for optical communications was discovered in this model. Further,there was also studied a behavior of split-step solitons in WDM systems with multichannel transmission.

Spiral waves in optical second-harmonic generation

Morten Bache[1,2], Peter Lodahl[2], and Mark Saffman[3]

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[2] *Department of Informatics and Mathematical Modelling, building 321 Technical University of Denmark, 2800 Kongens Lyngby, Denmark*

[3] *Department of Physics, University of Wisconsin, 1150 University Avenue Madison, Wisconsin, 53706, USA*

Materials with second order $\chi^{(2)}$ nonlinearity show highly complex behaviour when immersed in a cavity. When diffraction competes with the nonlinearity of the material rich spatiotemporal structures can appear, including various types of transverse patterns, solitons and domain walls. These patterns bear strong reminiscence to the ones observed in chemical reactions and biological and hydrodynamical systems. We consider theoretically second-harmonic generation where the cavity is pumped at frequency ω and second-harmonic photons at frequency 2ω are created through nonlinear interaction in the material. Experimental studies have shown the need for an extended model of second-harmonic generation where the 2ω photons may decay through a parametric process into nondegenerate parametric photons ω_- and ω_+.

This competing parametric oscillation leads to formation of e.g. spirals, dark oscillating solitons and labyrinthine patterns, all novel spatiotemporal structures in optical second-harmonic generation [1]. In this talk we will focus on the spirals appearing in he intensity of the fields [2]. These are observed for the first time in optical systems where until now only spirals appearing in the phase of the fields have been reported. The intensity spirals appear as a second order amplitude instability above the threshold for the parametric oscillations, and we show through numerical simulations that they destabilize from traveling rolls and that a very broad and flat gain band seems to be necessary for them to appear.

[1] P. Lodahl, M. Bache, and M. Saffman, Phys. Rev. A **63**, 023815 (2001).

[2] P. Lodahl, M. Bache, and M. Saffman, Phys. Rev. Lett. **85**, 4506 (2000).

TALKS

STRUCTURES IN FLUIDS

Friday, June 15, 2001

Session organisors:

Morten Brøns
Department of Mathematics,
Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

Tomas Bohr
Department of Physics,
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Scaling Theory of Singularities

Jens Eggers
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45117 Essen, Germany

Owing to the nonlinear character of the equations of motion describing fluid motion, sudden discontinuities in the pressure, the density, or the surface shape of a fluid often occur. Examples are shock waves, the separation of a fluid drop, bubbles rising in a viscous fluid, or drops in strong electric fields. Singularities are the crucial events in the evolution of a flow, and signal the emergence of new structures. Physically, smaller and smaller structures are produced near the singularity, so it lacks a characteristic length scale. Singular solutions thus must be invariant under a change of scale, and have a simple scaling form. Moreover, singularities turn out to be universal, so the same structure is found in a broad variety of circumstances. This talk explores the mathematics and the physical consequences of these two fundamental properties.

Scaling phenomena in electrochemical systems

Lene Oddershede
The Niels Bohr Institute,
Blegdamsvej 17, 2100 Copenhagen, Denmark

We present two very different experiments both involving electrohydrodynamics. One is the electro- chemical etching of a metallic wire and the other is the displacement of an initially horizontal interface between water and oil onto which an orthogonal electrical field is applied. We have observed some common behavior of the two systems: In the dynamical process through which the system is evolving there exists a critical point around which several of the parameters describing the system exhibit scale invariant behavior. One intriguing fact is that the emerging scaling exponents describing the two different systems within the uncertainties are identical.

The elastic behavior of viscous fluids

L. Mahadevan
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France

It is well known that slender elastic filaments and sheets buckle by bending when compressive forces on them exceed a critical threshold. In fact, this type of behavior is also seen in thin layer creeping flows of liquids; an everyday example is evident in the behavior of a stream of honey coiling onto toast. Following demonstrations of folding, coiling and wrinkling patterns in thin layer flows of fluids, I will discuss these pseudo-elastic behaviors and show that they can be explained using geometry and an analogy due to Rayleigh.

Bathtub vortices

Anders Andersen[1,2], Tomas Bohr[2], Jens Juul Rasmussen[1], and Bjarne Stenum[1]
[1] *Department of Optics and Fluid Dynamics, Risø National Laboratory,*
DK-4000 Roskilde, Denmark

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Bathtub vortices, i.e., swirling flows with a free surface which may extend down to the outlet of the fluid container are well known. The properties of such flows are, however, to our knowledge not described in detail neither experimentally nor theoretically. The free surface appears with a very sharp tip for some parameter values, and the flow field around the tip is strongly singular. We present experimentally measured free surface profiles, flow visualisations, and measured velocity profiles for a steady bathtub vortex flow. We describe the flow theoretically, and at a distance away from the vortex center we find that the observed flow agrees with results from boundary layer theory and the theory of rotating flows. We describe how to extend the theoretical predictions to the vortex region close to the axis of rotation where standard boundary layer theory is not valid and discuss how to model the free surface shape.

A vortex pair in a weak external flow: a singular control approach

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The problem of controlling the position of a pair of point vortices using a strain field or a field of a single souce/sink is considered using the methods of singular control and the theory of perturbations of dynamical systems. We show that the averaging over the fast rotation of vortices around the center of vorticity reduces the order of system of evolution equations and allows us to achieve desired control using a single control field. We use the Pontrygin maximum principle to construct an optimal control. We discuss how these results can be applied to a more complicated structures in fluids.

Patterns of surface waves

Willem van de Water

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The spontaneous creation of form is an exciting aspect of hydrodynamic systems that are driven away from equilibrium. We will discuss the birth of quasicrystalline patterns on the surface of a vertically shaken fluid. It turns out that the experiment can be described completely through a nonlinear amplitude equation with coefficients that follow from first hydrodynamic principles (the Navier Stokes equation)

This is not so for a second experiment where surface waves are driven through convection. The presence of a supercritical bifurcation to travelling waves, and its large aspect ratio make this experiment an almost ideal realization of a Ginzburg-Landau description, but with coefficients which are unknown. In fact, this experiment is the biggest Ginzburg-Landau machine in the world. The wave field is characterized by sources, which emit waves and sinks which absorb them. We will demonstrate that highly non-trivial predictions of a generic amplitude equation description of sources and sinks can be experimentally observed.

Chaotic advection of fluid flow and fractal structures

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Chaotic advection of a time-dependent fluid flow tries to model the velocity field of the fluid in terms of the stream function, in such a way that it offers the possibility to describe the motion of the trajectories of a fluid particle in a incompresible fluid flow using a Hamiltonian formulation. From this perspective, we use methods of Nonlinear Dynamics to analyze the invariant sets in the dynamics of the fluid and the fractal structures that appear, typically invariants sets (nonattracting chaotic sets) associated to transient chaotic motions.

Unsteady Aerodynamics of Insect Flight

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Interactions between dynamic boundaries and unsteady viscous flows occur in a wide range of physical, engineering, and biological systems, including fish swimming and insect flight. These problems pose formidable theoretical and computational challenges, due to the tight coupling between the dynamics of the boundary and the fluid, and the presence of multiple interacting time and length scales. On the other hand, Nature has been solving the same problem over millions of years. In a sense, insects are nature's Navier-Stokes solvers, and no doubt they have found some clever answers in the course of evolution. Therefore, studies of the unsteady aerodynamics of insect flight will advance our fundamental understanding of one of most challenging subjects in fluid dynamics.

In this talk I report our recent work on computing and modeling of insect flight. We compute unsteady viscous flows, governed by the Navier-Stokes equation, about a two dimensional flapping wing which mimics the motion of an insect wing. I will present two main results: the existence of a prefered frequency in forward flight and its physical origin, and 2) the vortex dynamics and forces in hovering dragonfly flight. If time permits, I will show the recent results on three dimensional flapping flight driven by muscles.

POSTERS

Wednesday and Thursday, June 13-14, 2001

Poster-1

Analysis of a stochastic model for a pancreatic beta-cell

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The insulin is a basic hormone for humans as it regulates the concentration of glucose in blood. If this hormone is not secreted correctly in the pancreas one can suffer diabetes mellitus a very dangerous disease that eventually can cause death. Studying the behavior of insulin secreting beta-cells from an electrophysiological point of view we find that they present a silent regime alternating with an active regime where they show very characteristical burstings. However these burstings seem to be a collective behavior as can be only regarded experimentally in big clusters of cells. We have studied a stochastic model for the beta-cell in order to better understand this particular collective behavior.

Poster-2

Interacting Hopf oscillators

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We investigate the phenomenon of oscillations in the concentrations of chemical species in a population of living yeast cells. The biological conditions for the transient oscillations of the NADH concentration in yeast cells were discovered by Chance et. al. in 1964. Chance showed that the oscillations had to do with the glycolysis in each of the individual yeast cells. Thus the individual yeast cell functions as an oscillator oand the ensemble of cells works as a conglomerate of independent oscillators. The oscillations can be observed in experiments (Sune Danoe et. al.) collectively or macroscopically only when all yeast cells are oscillating in phase or close synchrony. For the cells to oscillate in a coherent fashion requires that each cell can communicate with the surrounding cells signalling the state of oscillation, that is amplitude and phase. The cell communication is brought about by the exchange of chemical species between the cell and the surrounding extracellular medium. The modelling of this complex yeast cell system is based upon an accurate and rather complete full-scale model of differential equations describing the biochemical reaction network of the glycolysis taking place in the individual yeast cell (Hynne et. al.). The full-scale model has, on the basis of substantial experimental data, been developed and optimized such as to comply with experiments in a quantitative manner. The objective is to apply the concepts from nonlinear dynamics especially the method of amplitude equations to derive a mathematical model, based on the full-scale model for each cell, that captures the key properties of the entire yeast cell ensemble. In this study we will analyse the model and develope synchronization conditions.

Poster-3

Control and forcing of spontaneous optical patterns

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Driven, spatially extended nonlinear systems play an important role in optics. Many of them exhibit unwanted spatial or spatio-temporal instabilities, e.g. beam filamentation. On the other hand, a well directed selection of system-inherent patterns would be desirable both from a basic point of view and for possible applications in information processing. We investigated methods to manipulate the output state of an optical pattern forming system. A single feedback system with a liquid crystal light valve as optical nonlinearity has been used. Pattern formation in this system is already quite well understood.

There are two ways to modify the output state of a pattern forming system: Control or forcing. In the control method, the actual output state of the system is analysed. The difference between the actual state and the target pattern of the control constitutes the control signal. This control signal in turn is fed back to the system. In turn, the output state is moved towards the desired state. Since the system is spatially extended, the actual state, the target state, and the control signal are spatially extended, too. The used control method is the 2D spatial analogon of a classical feedback control in dynamic systems without spatial degrees of freedom. In contrast to purely temporal systems, the two-dimensionality of the system leads to a much larger manifold from which the solutions are to be stabilized, e.g. there can be patterns with the same periodicity, but different symmetries or orientations.

A very compact generation of the control signal is possible in Fourier space and allows, after transformation to real space, a manipulation of the entire transversal plane. Optics provides all means to implement such a highly parallel control scheme experimentally. We verified that the control signal approaches zero when the target state is reached. For this reason, the solutions of the system are not altered, but only their stability. By stabilization of 'hidden' unstable solutions we were able to access their bifurcation diagrams for a comparison with theory. By means of this purely spatial control we even removed spatio-temporal disorder up to a certain degree.

Another approach to influence the output state of a pattern forming system is to force it to a certain state. For this, we added a patterned light field with a certain strength to the input field, regardless of the actual output state. We found that if the periodicity of the forcing signal coincides with unstable wavenumbers of the free running system, it locks to the forcing pattern. Otherwise a competition between patterns of different periodicities induces complex spatio-temporal disorder.

Poster-4

Mel'nikov analysis of a symmetry-breaking perturbation of the NLS equation

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Constance M. Schober
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The effects of loss of symmetry due to noneven initial conditions on the chaotic dynamics of a Hamiltonian perturbation of the Nonlinear Schrödinger (NLS) equation were first numerically studied by Ablowitz, Herbst and Schober, where it was observed that temporally irregular evolution can occur even in the absence of homoclinic crossings. In this article we introduce a symmetry-breaking damped-driven perturbation of the NLS equation in order to develop a Mel'nikov analysis of the noneven chaotic regime. We obtain the following results. 1) Spatial symmetry breaking within the chaotic regime causes the wave form to exhibit a more complex dynamics than in the previous studies: center-wing jumping (which characterizes the even chaotic dynamics) about a shifted lattice site alternates (at random times) with the occurrence of modulated travelling wave solutions whose velocity changes sign in a temporally random fashion. 2) We give a heuristic description of the geometry of the full phase space (with no evennessimposed) and compute Mel'nikov-type measurements in terms of the complex gradient of the Floquet discriminant. The Mel'nikov analysis yields explicit conditions for the onset of chaotic dynamics which are consistent with the numerical observations; in particular, the imaginary part of the Mel'nikov integral appears to be correlated withpurely noneven features of the chaotic wave form.

Poster-5

Algebra representations through the logistic map

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We consider a class of algebras associated with one-dimentional dynamical systems, given by the logistic map. In particular, this class contains algebras comprising unharmonic quantum oscillator. Hilbert space representations of these algebras are classified through certain orbits of logistic map. The goal of the presentation is to give a description of orbit space of these dynamical systems. Topological conjugacy of the dynamical systems with varying the parameter of nonlinearity is also discussed.

Poster-6

Fluxon dynamics in three stacked josephson junctions

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In this work it is presented a system of 3 stacked Josephson-junctions described by a set of 3 coupled sine-Gordon equations. It is shown there are qualitative differences with the well established case of 2 junctions. These nonlinear equations are not Lorenz invariant. We have solved numerically the fully nonlinear equations for different distribution of travelling-wave solutions and we prove the fluxon-antifluxon-fluxon initial condition is the only stable configuration which does not radiate significantly. The interaction produces an "overshoot" in the shape of the antifluxon and its height depends on its velocity and the coupling constant. We obtain analytical solution of the piece-wise linearized equations and it agrees well with the numerical solution of fully nonlinear system when the velocity is small.

Poster-7

Mandelbrot set in coupled iterative maps and in the continuous systems

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One of reach and fascinating sub-disciplines in nonlinear dynamics is a theory of the iterative complex analytic mappings. The well-known example is the complex quadratic map, from which the Mandelbrot set as most popular example of fractal arise.

We reduce the complex quadratic map to the set of two coupled real logistic maps and use this representation to construct an electronic schema with switched capacitors, which gives a possibility to observe dynamical phenomena intrinsic to complex analytic iterative maps in a real physical device. Experimental results demonstrate the Mandelbrot set on the parameter plane of the system. Perhaps, this is the first observation of the Mandelbrot set in a real physical experiment.

The aim of the work is to suggest the examples of physical systems, which manifest phenomena of complex analytic dynamics and is practically realizable.

Hence, it may be expected that properly arranged coupling between two period-doubling elements of any nature might ensure the whole system to demonstrate the phenomena of complex analytic dynamics. For example, we consider Ikeda map, Henon map, Rossler system, non-linear oscilators.

Poster-8

Spatial solitons supported by competing nonlinearities in double-period QPM-structures

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It is well-known that quasi-phase-matching (QPM) gratings on average induce Kerr-like nonlinearities in quadratic media. However, the influence of these cubic nonlinearities on soliton formation in actual physical setups is vanishing. This is due to the dependence on the grating period which normally is engineered to compensate a very large phase-mismatch effectively eliminating cubic terms. We report on numerical experiments in QPM-structures with a superimposed slow second period. We show theoretically that these structures effectively can be engineered to mimic a one-period structure at small phase-mismatches making soliton formation and control supported by competing nonlinearities practically realizable.

Poster-9

Oscillatory standing wave instabilities in Hamiltonian lattices

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Modulational (Benjamin-Feir) instability (MI) of travelling plane waves is a wellknown mechanism leading e.g. to self-focusing in nonlinear optics and hydrodynamics. For discrete systems (e.g. nonlinear optical waveguide arrays or coupled anharmonic oscillators) MI typically occurs for a certain range of wavenumbers only, and is often considered as the first step in the generation of Intrinsically Localized Modes (ILM) ('discrete breathers'). Here, we consider Standing Waves (SWs), which naturally appear e.g. from counter-propagating waves with equal amplitude and frequency, in a general class of nonlinear Hamiltonian lattices. We show how such waves can be uniquely continued from the linear limit to the uncoupled limit as multi-site discrete breathers. Moreover, we show that even for small amplitudes, these SWs are generically unstable through oscillatory instabilities, which appear also for wave numbers where the propagating waves are stable. We analyse the dynamics resulting from these new instabilities, and find qualitatively different scenarios for wave vectors smaller than or larger than $\pi/2$: persisting localized structures are created in one regime but not in the other.

Poster-10

Analysis of absolute and convective instabilities in the one-dimensional Brusselator flow model using Ginzburg-Landau equations

Pavel Kuptsov

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Kuznetsov et. al. in [J. Chem. Phys. **106**, 7609 (1997)] studied an absolute and convective instabilities in the one-dimensional Brusselator flow model. In this work the amplitude Ginzburg-Landau equations are derived for this system. The problem of transition in these equations from absolute to convective instabilities are discussed. The instabilities are considered via two theoretical methods: the pinch-point analysis of the dispersion equation, and the investigation of fully developed time periodic regimes. The results of these linear and nonlinear approaches are appear to be in good correspondence.

Poster-11

Multi-focussing and sustained dissipation in the cubic Schrödinger equation and a dissipative regularization

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The possibility of physically relevant singular solutions of the Cubic Schrödinger Equation having sustained dissipation into a point singularity is considered, through numerical study of a nonlinear dissipative regularization and its small dissipation limit. A new form of such dissipative solutions involving a multi-focussing mechanism is conjectured for certain parameter ranges where this behaviour was previously not expected, including the two dimensional case of laser self-focusing. The space and time structure of such solutions for very small values of the nonlinear dissipation parameter is studied numerically and compared to a conjectured mechanism related to a new family of stationary singular solutions of the CSE.

Poster-12

Modelling of the possible role of glycolytic oscillations in the rapid pulsatile insulin secretion by pancreatic beta cells

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Experimental observations suggest that glycolytic oscillations could underlie the rapid pulsatile secretion of insulin with a periodicity of about 13 minutes. Since the b cells within an islet are synchronized by gap junctions, the question arises as to how b cells from different islets can synchronize to produce a clearly pulsatile secretion. Indeed, if it was not the case, each islet could secrete insulin independently, and give rise to a mean insulin secretion which is constant in time. Using modelling, we studied the coupling between b cells from different islets. Our theoretical approach is based on a two-variable model for the description of the glycolytic oscillations in each of the islets. We demonstrate that it could be possible to explain the synchronization by automodulation of the oscillating blood glucose level induced by the pulsatile insulin secretion.

Poster-13

Order parameters and macroscopic behaviour in a population of nonlinear oscillators

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The macroscopic dynamics of a population of globally and strongly coupled oscillators with natural frequency mismatch essentially reduces to that of few degrees of freedom. Such order paramaters are systematically derived by means of a series expansion around the mean field. This allows to describe the asymptotic as well as the transient behaviour of the population, and in particular the bifurcations among differrent collective regimes.

Poster-14

Dipole-mode vector solitons in anisotropic photorefractive media

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The self-trapping of light in biased photorefractive crystals eventually leading to (2+1)D optical spatial solitons is being intensely studied by numerous experimental and theoretical groups around the world. For theoretical calculations the photorefractive effect is mostly modelled by a local isotropic saturable nonlinearity. Recent research has shown that this model cannot explain some effects experimantally observed, but that a nonlocal anisotropic model is needed[1]. We use the latter model to find vector solitons and compare the results to experimental data. We find that the anisotropic model yields better agreement to experimental results than the isotropic model.

We present numerically exact solitary solutions to the propagation equations of two incoherently coupled light beams in media with nonlocal anisotropic photorefractive nonlinearity. The vector solitons we studied consist of a nodeless beam and a dipole that is oriented perpendicular to the electric field applied to the photorefractive crystal. The solutions form a continuous set that ranges from vector solitons with negligible dipole contribution to vecor solitons with negligible contribution of the nodeless beam[2]. The theoretical results are compared to experimental data, showing qualitative agreement. Furthermore we show that vector solitons consisting of a nodeless beam and a dipole oriented parallel to the externally applied field do exist, but are far more difficult to obtain experimentally and eventually get unstable.

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2 K. Motzek, A. Stepken, F. Kaiser, M. R. Belic, M. Ahles, C. Weilnau, C. Denz, "Dipole-mode vector solitons in anisotropic photorefractive media", Optics Commumications, submitted.

Poster-15

Control of laser light with nonlinear polarization mirrors

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A new method using frequency doubling polarisation mirror (FDPM), for passive mode-locking and Q-switching of high power lasers have been proposed. The new technique is based on the intensity dependent reflection of the FDPM, which is due to the polarisation rotation of the fundamental wave in a nonlinear crystal for second type (type II) second harmonic generation (SHG). The dependence of the properties of the FDPM on the nonlinear charecteristics and the otientation of the nonlinear crystal, as well as on the accumulated phase shift between the second harmonic and the fundamental wave within the space between the nonlinear crystal and the back reflector were investigated. Dynamics of the generation evolution in laser with FDPM, using rate equations has been analized. This new method has a very large spectral range, and the lack of absorption losses make it appropriate for passive Q-switching of high evarage power lasers.

Poster-16

Effects of delays in a nonlinear glucose-insulin feedback system

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The insulin-mediated effect on plasma glucose is somehow delayed. Moreover, in diabetics insulin production and resistance may represent additional delays in the action of insulin. In order to establish the effects of delays on plasma glucose and insulin, various delays were put into a physiology-based nonlinear model for blood glucose regulation. Using linear stability analysis it was found that the model under most conditions exhibited dampened oscillations. Depending on the magnitude and actual placement of delays in the model the period of oscillation could be brought into a range of physiological interest. This finding could have importance in the treatment of diabetes where the effect of insulin shots may be modulated according to the dampened oscillations of the body's own level of plasma glucose and insulin.

Poster-17

Control in chaotic saddles

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We study the possibility of using control for trapping the dynamics of a system inside a chaotic saddle in presence of noise. In chaos control, typically unstable orbits embedded in a chaotic set are targetted. Here instead we present a control technique that exploits the non-attracting nature of a chaotic saddle targetting preimages of the escaping regions. This technique is able to keep the system inside the chaotic saddle indefinitely and is extremely robust against noise: for the tent map, the ratio between maximum noise and maximum control is up to two. Moreover, all the information that is needed can be obtained by simple time series analysis, allowing to apply such technique to real system.

Poster-18

Dual space topology of algebras associated with logistic map

Stanislav Popovych
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Nonlinear dynamical systems are the main tools in study of "dynamical relations" algebars arising in quantum physics models. In particular, Witten's first deformation associated with quadratic two-dimensional map and Quesne's cubic deformation associated with cubic two-dimensional map provide the well-known examples of algebars in this class. The main purpose of this presentation is to give a description of dual space topology of algebars associated with the logistic one-dimensional map.

Poster-19

Chaos in complex astrophysical systems

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The dynamics of some astrophysical systems, such as star clusters (N = 10^2-10^6) or planetary systems (N = 10), can be modeled by a set of differential equations known as the N-body gravitational problem. The impossibility of solving analytically the general problem when $N > 2$ [1] requires the use of numerical integration when studying these systems.

The sensitivity of the trajectories of the stars to small changes (perturbations) on the initial conditions was first reported by Miller [2]. The improved computational power now available allowed a sistematic study of the typical time scale of this instability in terms of the characteristic crossing time of the system [3].

In this work we present results obtained from numerical integration of the N-body gravitational problem and the associated variational equations of motion, using the NNEWTON package [4]. We use the "Lyapunov Characteristic Indicator" [5] to estimate the time scale of the instability associated with the exponential growth of perturbations (variations) on the initial conditions.

Our preliminary results are in good agreement with those of [6] and show a simple relation between the time scale of the instability, the number of particles and the crossing time of the system.

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Poster-20

Investigation of the complex dynamics of nonlinear oscillators by using the scheme of the catastrophe theory

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In present work the behavior of the nonlinear oscillators is considered. New classification for oscillators, based on the scheme of the catastrophe theory, is performed. It allows one to describe the different oscillators, which differ from each other in the quantity of the potential wells and in the possibility to escape, by using the oscillator equation with some elementary Thom's catastrophe at different fixed values of the controlling parameters. The investigation of the oscillators with Thom's catastrophes is developed in full parameter space.

First, the investigation of the dynamics of the systems with escaping solutions is carried out. The basin erosion under the variation of the potential function parameter is shown for the oscillator with fold catastrophe. The escape region and region of the stable periodic or chaotic solutions is estimated for this oscillator and for oscillator with swallowtail catastrophe in the parameter space.

To study the dynamics of the oscillators without the escaping solutions the evolution of the dynamical regimes topography under the increasing forcing amplitude is considered. We investigated the case of the oscillator with cusp catastrophe and the oscillators with the potential function of sixth and eighth degree. The effect of the increasing of the degree of the potential function on the system dynamics is studied. It turns out that the topological configurations of "crossroad area" and "spring area" arise for smaller amplitudes in case of the potential function of higher degree and scenario of its appearance repeat itself several times on the regarded range of the forcing amplitude. So the topographies contain a great number of the "crossroad area" and "spring area".

The basin transformations were considered for the oscillator with utterfly catastrophe. These transformations take place under the increasing of the forcing amplitude and under the variation of the potential function parameters. The topographies of the dynamical regimes on the plane of the different controlling parameters demonstrate the period-doubling cascade to chaos and "crossroad areas" and "spring areas".

Poster-21

Intricacies of nonlinearity and disorder in the random Sine-Gordon model

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We present a comparative numerical study of the ordered and the random two-dimensional sine-Gordon models on a lattice. We analytically compute the main features of the expected high temperature phase of both models described by the Edwards-Wilkinson equation. We then use those results to locate the transition temperatures of both models in our Langevin dynamics simulations. We show that our results reconcile previous contradictory numerical works concerning the superroughening transition in the random sine-Gordon model. We also find evidence supporting the existence of two different low temperature phases for the disordered model. We discuss our results in view of the different analytical predictions available and comment on the nature of these two putative phases. We will also comment on the latest developments and results specifically about relaxation following a quench and the effects of a driving.

Poster-22

Non-linear plume dynamics of a laser ablated plume in a background gas

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Tue N. Hansen, Brendan Doggett, and James Lunney
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Film production by pulsed laser deposition has become a standard technique in laboratories. A target of silver was irradiated with ns-pulses of laser light with a fluence of 2-3 J/cm^2 and at a wavelength of 355 nm. We have for the first time studied the expansion of a laser-produced silver plume into a low-pressure background gas of oxygen and argon for other directions than those along the normal. The flow of the plume was studied with Langmuir ion probes. The plume breaks up into two components, a non-scattered component and a slower blast wave, in all directions.

Poster-23

Stability of weak turbulence Kolmogorov spectra

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As it was first found by A.I. Dyachenko, Y.V. Lvov and V.E. Zakharov, the 1D nonlinear dynamics of deep water surface gravity waves is governed by five-wave interaction processes. In order to get the statistical description of a stochastic wave field one can use a pair correlation function. The kinetic equation for the pair correlators was derived and its stationary solutions were found. This solutions turned out to be power-like, i.e. of quasi-Kolmogorov type. In the present paper we derive the linearized kinetic equation and investigate the stability of stationary solutions with respect to time-dependent 1D perturbations.

Poster-24

On dynamics of the discrete NLS equation

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Recently so called continious-discrete nonlinear systems, where both the discretness and temporal dispersion are taken into account, have attracted a lot of attention in optics and plasma physics. We investigate soliton-like dynamics in the discrete nonlinear Schrödinger equation (DNLSE) describing the generic 3-element discrete nonlinear system with a dispersion. The DNLSE (1+2) is solved on the 3*K discrete lattice, where K is the variable number introduced through the discretized dispersion term. In quasi linear and strongly nonlinear regimes the evolution shows robustness with respect to the K variation. The intermediate regime often exibiting chaos, appears highly sensitive to the number of discrete points, making an exact solving of the DNLSE (1+2) a dubious task.

Poster-25

Chaos, breathers and the geometry of phase space for a DNLS lattice

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We look at the structure of the phase space of a breather solution in a DNLS lattice using both annalytic (averaging) and numeric (Poincare map) methods. We relate this structure to the nature of the breather. In particular we investigate the role of resonant periodic orbits. Regarding the resonant hyperbolic periodic orbits we investigate the effect caused by the tangle/nontangle of the stable/unstable manifolds.

Poster-26

The comparative discription of the kicked Van-der-Pol system in terms of differential equations and maps

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The kicked Van-der-Pol system is studied on three levelsof precision. Fist, we use a corresponding differential equations. Second, the reversible 2D map is considered, to derive it we use the approximate analytical solution between the kicks for the autonomous system. Third, we turn to the irreversible 1D map, which is appropriate for the strongly dissipative case. The main purpose of the present work is a iscription of the original system in terms of these third models. As a result, the domains in the parameter plane, where approximate discription is effective, are determined. Particular attention has been given to the phenomena, which do not survive the passage from invertible 1D maps to invertible 2D maps. The synchronization tongues structure in parameter plane is found for each model, and their evolution is examined as the parameter of dissipation increases. The typical bifurcation trees and phase portraits are presented. The scenarios of transition to chaos, which are predicted based on each model, are discussed.

Poster-27

Controllability of perturbed twist map

Umesh Vaidya and Igor Mezic

In this paper we have shown that for the two dimensional perturbed twist map which satisfy the intersection property (i.e. any curve in the phase space intersect its image curve) no invariant structure will survive if the perturbation is made function of time. Using result from ergodic theory we have shown that global controllability can be obtained using arbitrary small time dependent perturbation.

Poster-28

Nonlinear wavefields in optical fibres with finite time response and amplification effects

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Abstract of poster: A higher order nonlinear integro-differential equation of the Schrödinger type modelling the evolution of finite amplitude wavepackets in the presence of optical amplification and finite material - and polarization time responses is analyzed with respect to the dynamical evolution of localized solutions. Nonexistence of localized travelling and stationary wave solutions is pointed out for certain parameter regimes. The linear stage of modulational instability of plane wave is studied and it is shown that the finite time responses produce finite bandwidth instabilities.

Poster-29

Partial synchronization in coupled time-continuous systems

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We prove the existence of partial synchronization in a model of diffusively coupled three and four Roessler systems. The proposed approach allows us to determine which of the possible clustering structures will be stable. The dynamics of clusters is also investigated. We show how other time-continuous systems can be investigated by the presented method.

Poster-30

Coherence resonance and generation of stochastic oscillations

D.E. Postnov, D.V. Setsinsky, and O.V. Sosnovtseva

A nonlinear excitable system driven by noise can generate oscillations close to periodic that is known as coherence resonance effect. Such system might be considered as stochastic oscillator whose characteristics controlled by the noise intensity. We show that additional couplings between excitable systems can provide multi-mode stochastic oscillations - secondary coherence resonance.

Poster-31

Phase multistability of synchronous regimes

D.E. Postnov, O.V. Sosnovtseva, and A.M. Nekrasov

We investigate the multistability of complex oscillations with fast and slow timescales. Our approach is based on phase map whose stable fixed points correspond to various phase-locking patterns. It is applied to coupled heterogeneous self-modulated systems. With a frequency mismatch, the two-parameter bifurcational analysis reveals a set of synchronization regions inserted one into the other.