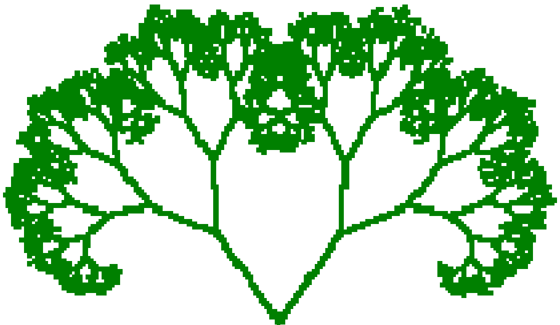

20th International Conference / Summer School

NONLINEAR SCIENCE AND COMPLEXITY

Patras, July 19 – 29, 2007

Conference Center, University of Patras

BOOK OF ABSTRACTS

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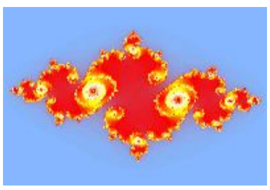

ABSTRACTS OF LECTURES

(IN ORDER OF PRESENTATION)

ORDERED AND CHAOTIC ORBITS IN SPIRAL GALAXIES

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There is an important difference between normal spirals, where the perturbation is relatively weak (usually 2 – 10% of the axisymmetric background) and barred galaxies, where the perturbation is strong (of the order of 100% of the background). In the first case, the spirals consist of ordered orbits, while in the second case they consist of chaotic orbits. We study in some detail the second case, which was introduced by N. Voglis et al. (MNRAS, **373**, p. 280, 2006).

THE THREE-BODY PROBLEM: APPLICATION TO THE EXTRASOLAR PLANETARY SYSTEMS

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I am planning to start with the simplest case, the two body problem, which is a well behaved dynamical system and then add a third body and explain how this destroys the ordered motion and the system becomes chaotic. I will present the basic theory of dynamical systems, using this as an example (this will make things easier to understand, rather than using abstract ideas) and then present examples from the study of the extrasolar planetary systems. Different ways of generation of chaos will be presented. In the first part of my talk, I will present first the basic theory of the three-body problem and then I will devote some time to present its application to a number of examples arising in extrasolar planetary systems.

IS THERE LIFE IN EXTRASOLAR SYSTEMS?

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Recently astronomers found an extrasolar planetary system with a red dwarf and 3 planets. In the international press it was mentioned, that the first terrestrial planet -- a 2nd Earth (!?) in the habitable zone around another star was discovered! In this lecture it will be discussed what kind of extrasolar systems we know up to know, what are the possibilities for terrestrial planets to move in such systems on 'nice' orbits and what do we mean by habitability of a planet. Although up to now we don't have any 'proof' of other life as our own in the universe, the diversity of planets found only in the Solar neighborhood let us (most of my colleagues astronomers) be quite optimistic.

THE FLOW OF MATERIAL THROUGH THE ARMS IN NORMAL AND BARRED SPIRAL GALAXIES

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We examine the stellar flow through the arms of spiral galaxies from a qualitative point of view. In particular we investigate the properties of ordered and chaotic flows. The study attempts to associate morphological and kinematical features with the one or other type of flow, and establish a basis of criteria for future observational projects. We present the features that are related with the "precessing-ellipses flow" using response models with a spiral perturbation. We do the same for the case of chaotic spirals in cases with strong forcing at corotation. We underline the differences that are imposed in the morphology of the galaxies in normal and barred spiral cases.

BEAM STABILITY IN MODERN LIGHT SOURCES VIA FREQUENCY MAP ANALYSIS

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We use Laskar's Frequency Map Analysis method to study the single particle dynamics in synchrotron light sources. The time variation of the betatron frequencies is used to describe the global dynamics of particle's motion both in physical and in frequency space. Frequency maps computed by numerical simulations in theoretical models of particular real accelerators are compared to experimental frequency maps computed by the analysis of real measurements obtained by beam position monitors (bpms) around the ring. In the analysis of experimental data we take special care of the restrictions introduced by decoherence. In particular, due to decoherence only a few turns of the beam provide measurements suitable for the determination of the real tunes. Thus, analyzing data retrieved from several bpm, which are symmetrically placed around the ring, we are able to overcome this problem and determine accurately the real tunes.

CRYSTALLIZATION AND SELF-ORGANIZATION IN COMPLEX MATTER

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A new paradigm of crystallisation arises when complex matter self-organises due to anisotropic interactions and geometrical factors. There is increasing evidence that large classes of colloid materials crystallise via a non-standard nucleation mechanism involving intermediate metastable phases.
In this presentation recent work by the authors on the microscopic derivation of the phase diagram and free energy barriers in the nucleation of protein crystals, and on the kinetics of growth of solid particles in the post-nucleation regime is reviewed. The extent to which combined structural and density fluctuations may give rise to favourable crystallisation pathways in the two order-parameter phase-diagram, where the intermediate fluid phase exerts its enhancing action, is assessed and the connection with experiments (especially under microgravity, at ESA's ISS) is discussed.
I will also present the modelling practises one has to apply and the computational challenges one encounters due to complexity issues and the multi-scale nature of the phenomena at hand.

References:

1. James F. Lutsko and Gregoire Nicolis, “Theoretical evidence of a Dense-Fluid precursor to crystallization”, Phys. Rev. Lett. Vol. 96, 046102 (2006).
2. James F. Lutsko, “First principles derivation of Ginzburg-Landau free energy models for crystalline systems”, Physica A Vol. 366, 229, (2006).

3. V. Basios, “Self-organization and nonequilibrium aggregation phenomena in colloidal matter: why microgravity matters”, Int. J. of Bifurcation and Chaos, Vol. 16, No. 6, 1689-1700 (2006).

NONLINEAR LOCALIZATION IN BIOMOLECULES AND METAMATERIALS

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Nonlinear localization in the form of discrete breathers or polarons appears in strongly coupled translationally invariant systems where nonlinearity is dominant. The nonlinear localized modes may alter statistical properties of systems and also assist in energy transfer processes. We review relevant theoretical and experimental work in biomolecules and related molecular crystals and discuss possible implications in bioenergetics. We also focus on left-handed metamaterials that modify drastically electromagnetic wave propagation and may be used for object cloaking. We show that nonlinear localization may play an interesting role in metamaterials as well.

NONLINEAR BASE-PAIR OPENING DYNAMICS IN DNA

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A nonlinear dynamical model describing base-pair openings (bubbles) in double stranded DNA will be presented. A number of successful comparisons with experiments related to base-pair openings will be discussed. Theoretical predictions for the statistics of thermal openings are compared with experimental results in gene promoter DNA sequences. The most favorable openings occur at transcriptionally relevant sites. Physical properties of the model, like bubble-length distributions, non-exponential fluctuations etc., will be discussed.

CONTROLLING SPATIOTEMPORAL DYNAMICS IN CHEMICAL SYSTEMS

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A network of excitable nodes based on the photosensitive Belousov-Zhabotinsky reaction is studied in experiments and simulations. The addressable medium allows both local and nonlocal links between the nodes. The initial spread of excitation across the network as well as the asymptotic oscillatory behaviors are described. Synchronization of the spatiotemporal dynamics occurs by entrainment to high-frequency network pacemakers formed by excitation loops. Analysis of the asymptotic behavior reveals that a subnetwork selected during the initial transient period governs the dynamics of the network.

In the second part of this talk, we describe studies of interacting particle-like waves in the photosensitive Belousov-Zhabotinsky reaction. Unstable waves are stabilized by global feedback that affects the overall excitability of the medium, and the motion of these waves is controlled by imposing excitability gradients that are regulated by a secondary feedback loop. Waves interact via a Lennard-Jones potential in which there are attractive forces at long distances and repulsive forces at short distances. Processional motion is the most common behavior, where waves align with one another to varying degrees depending on the strength of the potential. Rotational motion is also observed, which may occur for the same parameters as processional motion depending on initial conditions. We also discuss other modes of behavior and an analysis of the wave interaction in terms of the gradient of the potential.
*In collaboration with Mark Tinsley and Aaron Steele.

THE TRANSITION TO CHAOS IN THE PILOT-WAVE APPROACH TO QUANTUM MECHANICS

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The appearance of chaos in quantum mechanics is a controversial issue. The first part of the talk is a short review of the meaning of `quantum chaos' in the orthodox pictures of quantum mechanics, i.e., the Heisenberg and Schrodinger pictures. The second part focuses on the appearance of chaos in the `pilot-wave' (or Bohmian) picture of quantum mechanics. In particular, we study the dynamical mechanisms leading to exponential sensitivity of the `pilot-wave' trajectories on the initial conditions, and discuss the role of nodal points of the wavefunction in the transition from order to chaos.

NON-LINEAR VIBRATIONAL NORMAL MODES OF BIOMOLECULES

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The vibrational harmonic normal modes of a molecule, which are valid at relatively low energies close to a potential minimum, are extended by periodic orbits to higher energies where anharmonicity and coupling of the degrees of freedom set in. The families of periodic orbits which emanate from the equilibria (minima and transition states) of a molecular potential energy function are located with multiple shooting methods and they are continued in energy. The method is well established for triatomic molecules[1], and recently it has been applied to biomolecules such as alanine dipeptide[2]. Long lived localized trajectories associated with specific conformations and non-linear vibrational modes can be traced. The influence of a solvent like water to excited non-linear normal modes is examined.

[1] M. Joyeux, S. Yu. Grebenshchikov, J. Bredenbeck, R. Schinke, and S. C. Farantos, "Intramolecular Dynamics Along Isomerization and Dissociation Pathways", in "Geometrical Structures of Phase Space in Multi-Dimensional Chaos", *Adv. Chem. Phys.*, **130**, 267--303, 2005.
[2] S. C. Farantos, ``Periodic Orbits in Biological Molecules: Phase Space Structures and Selectivity in Alanine Dipeptide", *J. Chem. Phys.*, **126,** 175101, 2007.

MOLECULAR VIBRATIONS: FROM THE SPECTRUM TO THE MOTION OF THE ATOMS

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The normal mode description of molecular vibrations breaks down for high excitation as soon as various degrees of freedom run into resonances. Then frequency and phase locking occurs and creates new nonlinear modes. These are given by organization centers in the classical phase space. We can classify the quantum states as belonging to one of the various organizing centers and can assign quantum numbers of each state relative to its organizing center. Thereby each quantum state is based on some particular mode of motion of the atoms. The example of DCO will be presented in detail, some other examples will be mentioned briefly.

PHASE TRANSITIONS IN VIBRATED GRANULAR MATTER

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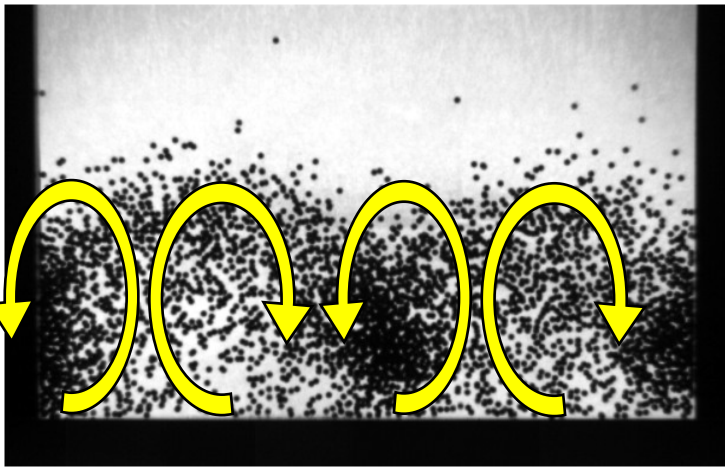
A vertically shaken bed of granular material can behave in a variety of ways, ranging from solid-like behavior when the shaking is weak, to fluid-like and even gas-like behavior at strong shaking.
We survey the various experimentally observed phases and construct a granular phase diagram. Special attention is paid to the so-called "Leidenfrost state", in which a dense cloud of particles is held afloat by a gas-like layer of fast particles near the vibrating floor. Above a critical shaking strength this state becomes unstable and we witness a transition towards buoyancy-driven convection: the particles now form rotating rolls very similar to Rayleigh-Bénard convection rolls in an ordinary liquid.
A hydrodynamic model that takes into account the non-elasticity of the particle collisions explains the experimental observations, qualitatively and quantitatively.



Granular convection rolls in a vertically vibrated bed of millimeter-sized steel beads (Physics of Fluids Lab, University of Twente, The Netherlands).

GRADIENT THEORY, INSTABILITIES AND PATTERN FORMATION: FROM TERRASCALES TO NANOSCALES

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The incorporation of higher order gradients in the constitutive equations modeling the evolution of a system consisting of a continuous distribution of "particles" in space-time is considered. Loss of convexity in the force-displacement rule leads to spatio-temporal instabilities and the role of gradients is to stabilize such spatio-temporal pattern formation. The role of randomness is pointed out and the competition between deterministic gradient terms and stochastic fluctuations are also discussed. Examples from a variety of scales with emphasis on nanotechnology are presented.

MODELING TIP GROWTH IN CELLS

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Tip growth is a mechanism of cell growth that occurs in the kingdoms of the plants, fungi, protista and monera. It leads to uniformly elongating, filamentous cells, remarkable for the stability of their shape. It presents a beautiful example of morphogenesis, which has captured the imagination of experimentalists and theorists alike. In trying to unravel the mechanistic basis of this phenomenon we find that we have deal with a subtly interlocking set of processes: the targeted delivery of the growth material in the form of small intracellular vesicles, the mechanism by which these vesicles are incorporated into the cell wall (exocytosis), the resultant composition of the nascent cell wall and its ageing process and finally the growth itself. In the lectures I will address the mathematical challenges we face in modelling this highly non-linear space-time process.

THEORY AND APPLICATIONS OF REGULAR AND ANOMALOUS DIFFUSION

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The purpose of this tutorial is to introduce very basic concepts on the probability theory in physics, providing an introduction to the problem of the random walk and its applications. In its simplest form, the random walk describes the motion of an idealized drunk man. A thorough account is given of the theory of random walks on discreet spaces (lattices or networks) and in continuous spaces, including those processed with random waiting time between steps. Applications discussed include dielectric relaxation, turbulent dispersion, diffusion through a medium with traps. Prior knowledge of probability theory would be helpful, but not assumed.

HAMILTONIAN AND LAGRANGIAN METHODS FOR SPACE-TIME TRANSFORMATIONS IN PHOTONICS, BOSE – EINSTEIN CONDENSATES AND LIQUID CRYSTALS

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Part I: We will present and discuss the general principles of variational methods applied to various physical problems governed by the Nonlinear Schroedinger (NLS) equation. We will mention ways to treat infinite systems and describe general concepts related to Hamiltonian phase space in the study of NLS systems. In particular, we will discuss the equation of Gross-Pitaevskii, as well as methods of tight-binding approximation and systems of coupled fields.

Part II: In this part, we will introduce the concept of angular momentum in photonics. Then we will discuss nonlinear photonic vortices, nonlinear X – waves, as well as dark and bright soliton vortices. Periodic photonic arrangements and lattices will also be discussed. Finally, we will describe the basic principles of soliton structures in bilayers of different linear and nonlinear materials, liquid crystals and lattices of liquid crystals.

OPTICAL LATTICE SOLITONS

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We present a survey of recent theoretical and experimental results of optical wave propagation in nonlinear periodic systems. Such systems are of particular interest due to the interplay between a Floquet-Bloch structure and nonlinearity in equations of the nonlinear Schrödinger type. The presence of allowed bands and forbidden bands allows for optimal control of the optical wave. The molding of the flow of light is highly desirable for all-optical applications.

CANONICAL PERTURBATION THEORY AND LIE TRANSFORMS: APPLICATION TO NONLINEAR RESONANT WAVE-PARTICLE INTERACTION

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Resonant wave-particle interactions are one of the main paradigms, on which the modern theory of complex dynamics and chaos has been applied. In this work, these interactions are studied in the context of the Hamiltonian formalism and the Canonical Perturbation Theory (CPT) with utilization of Lie Transform techniques (LT). The canonical perturbation method for single particle motion is used for providing results for the collective particle behavior under interaction with wave fields of either localized or periodic profiles. Analytical expressions for the calculation of phase-averaged quantities of physical interest as well as diffusion equations are derived. In the lowest order of perturbation, the method reformulates in a rigorous and unifying context the derivation of well-known results, namely Madey's theorem and quasilinear diffusion equation. Proceeding to higher order the method provides novel results consisting of fourth order accurate analytical expressions for the calculation of phase-averaged quantities as well as the derivation of a fourth order accurate diffusion equation, with higher order derivatives, which is the extension of the well-known Fokker-Planck equation beyond the quasilinear approximation. Finally, the method provides near-symplectic, explicit mappings for the accurate numerical study of long-term behavior of particle orbits.

References:

[1] Kominis Y, Hizanidis K, Ram AK, “Transient dynamics of charged particles interacting with localized waves of continuous spectra”, PHYS REV LETT 96, 025002 (2006)
[2] Dumbrajs O, Kominis Y, Avramides KA, Hizanidis K, Vomvoridis JL, “Hamiltonian map description of electron dynamics in gyrotrons”, IEEE TRANS PLASMA SCIENCE 34, 673 – 680 (2006)
[3] Kominis Y, Dumbrajs O, Avramides KA, Hizanidis K, Vomvoridis JL, “Canonical perturbation theory for complex electron dynamics in gyrotron resonators”, PHYS PLASMAS 12, 113102 (2005)
[4] Kominis Y, Dumbrajs O, Avramides KA, Hizanidis K, Vomvoridis JL, “Chaotic electron dynamics in gyrotron resonators”, PHYS PLASMAS 12, 043104 (2005).

NONLINEAR PHENOMENA IN JOSEPHSON JUNCTION DEVICES

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Nonlinearity and dispersion play a role in the dynamics of Josephson tunneling junctions (S/I/S), as shown in the I-V characteristics and the maximum current with applied field, I_{max} (H). A simple but productive mathematical model is the sine-Gordon system (in the RSJ approximation), which is a statement of current conservation, expressed in terms of the phase difference of the order parameters in the two superconductors. An extension of this is a non-local sine-Gordon system model, which can arise in different physical situations (with different kernels), and describes well a window Josephson junction, where fluxons are inflated (seen experimentally by Ustinov et al) and radiation is emitted, as shown by their sub-steps signature in the ZFS. A special situation of a non-local sine-Gordon is a very narrow and long Junction!!

In S/I/S Josephson junction (JJ), the nonlinearity is of the sinusoidal type. We will end with the exploration of the nonlinearity in hybrid JJ where the intermediate layer can be a normal metal, semiconductor or a ferromagnet. The tunnelling of Cooper pairs is mediated through the Andreeev reflection and the current carrying electron-hole bound states. A diagrammatic approach related to the scattering matrix formalism will be developed for the determination of the bound states. We will also reproduce the result for the insulator interface. The supercurrent shows a **sin (Φ)** form for high temperature, and a "snapping-bond" form at very low temperatures. The current is obtained via the Green's function and the thermal average is done through the Matsubara approach. An interesting result is that we can have a **π**-junction behavior, i.e. a π- phase difference in the ground state of the junction. In the region of transition from 0 to π (by variation of exchange energy, temperature, or thickness) we have a strong 2nd harmonic in the supercurrent. Several applications will be presented, while similar heterostructure forms have an interest in spintronics. In general one can engineer hybrid JJ with a large variety of current-phase relations.

THE FERMI-PASTA-ULAM PARADOX: PROBLEMS, MYTHS, AND SOLUTIONS

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In 1955 Fermi, Pasta and Ulam (FPU) reported on the nonequipartition of a nonlinear atomic chain, with initially one normal mode excited. Modern computational studies show, that on a first, relatively short, time scale the energy is distributed among a few neighbouring modes in modal space, with more distant modes being exponentially weakly excited - i.e., one observes localization in normal mode space. On a much larger second time scale (which was not reachable with the MANIAC I), the tail modes are slowly growing, and finally the system does equilibrate. The problem then is to explain: i) the exponential localization of energy in modal space on intermediate time scales, and ii) the way the time scales depend on the essential parameters (wave number, energy density). Despite its strong impact on nonlinear dynamics and statistical physics, the paradox remained essentially unexplained for decades - ideal grounds for the appearance of myths.
Recent studies show that the model allows for exact time-periodic solutions (q-breathers), which are exponentially localized in the space of normal modes. The trajectory initially computed by FPU is a slight perturbation away from an exact q-breather orbit. Consequently most of the key observations related to the FPU problem (localization of energy in normal mode space for long times, recurrence on relatively short times, system size and energy thresholds) are captured by the properties of q-breathers and the phase space flow nearby. The underlying concept is much more general, and can be easily extended to two-and three-dimensional finite lattices. A scaling approach leads to nontrivial predictions in the limit of infinite system sizes.

MODELING AND HEDGING ELECTRICITY PRICE RISK IN COMPETITIVE MARKETS

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Electricity prices dynamics in deregulated markets can be described by modeling the movements of the power margin level in a stochastic environment. Within a demand-supply context, we present a regime-switching approach to capture the main characteristics of electricity prices dynamics as the presence of stable periods, in which prices fluctuate around some long-run mean, and turbulent periods in which prices experience jumps and short-lived spikes of very large magnitude. Empirical distributions of log-returns are characterized, in fact, by high, non-constant volatility as well as positive skewness and large values of the kurtosis. The proposed approach is flexible enough to incorporate shortages in electricity generation, forced outages, peaks in electricity demand, and the empirical analysis, performed estimating the model on market data by maximum likelihood, offers an interesting agreement with the properties of observed log-returns distributions. Finally, we show that regime-switching models can be very useful for financial applications and for energy risk-management: option prices, as well forward and futures prices, can be obtained as solutions of well defined partial differential equations and are smooth functions of the spot price.

EXTENSIVITY VERSUS ADDITIVITY OF THE ENTROPY, AND GENERALIZED CENTRAL LIMIT THEOREMS IN THE PRESENCE OF STRONG INTERACTIONS

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Additivity and extensivity of the entropy are two relevantly different properties that are frequently confused in the literature. They will be discussed in the context of nonextensive statistical mechanics (a current generalization of Boltzmann-Gibbs statistical mechanics) and illustrated with both mathematical and physical examples. Recent theorems will be presented which, within the same context, generalize the Central Limit Theorem and the Levy alpha-stable distributions.

Bibliography:

[1] M. Gell-Mann and C. Tsallis, eds. *Nonextensive Entropy - Interdisciplinary Applications*, Oxford University Press, New York, 2004.
[2] J.P. Boon and C. Tsallis, eds., *Nonextensive Statistical Mechanics: New Trends, New Perspectives*, Europhysics News 36 (6) (European Physical Society, 2005.
[3] C. Tsallis, M. Gell-Mann and Y. Sato, Proc. Natl. Acad. Sc. USA 102, 15377, 2005.
[4] S. Umarov, C. Tsallis and S. Steinberg, cond-mat/0603593, 2006.
[5] C. Tsallis, *Entropy*, Springer Encyclopedia of Complexity and Systems Science (2007), in press.

NAVIER-STOKES EQUATIONS WITH APPLICATION TO WIND ENERGY PROBLEMS

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The importance of the Navier-Stokes equations (NSE) in applied sciences cannot be overestimated. The content of the talk consists of three parts of about equal length.

1.) Basic elements of the NSE, and open questions related to uniqueness of solutions and to turbulence.
2.) Methods of computational fluid dynamics: Galerkin approximation, cellular automata, finite differences on dynamical grids.
3.) Hydrodynamics of wind energy: Upper limit of wind turbine efficiency, energy meteorology. Part three is related to one of the main research topics in Oldenburg.

AMPLITUDE EQUATIONS FOR STOCHASTIC PARTIAL DIFFERENTIAL EQUATIONS

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We present some results on the approximation of SPDEs by amplitude equations. In the first part of the talk we derive amplitude equations for stochastic PDEs with quadratic nonlinearities on a bounded domain, under the assumption that the noise acts only on the stable modes and for an appropriate scaling between the distance from bifurcation and the strength of the noise. In the second part of the talk we consider the stochastic Swift-Hohenberg equation on a large domain near its change of stability. We show that in this case the amplitude equation is a stochastic PDE, the stochastic Ginzburg-Landau equation. This is joint work with D. Blomker(Augsburg) and M. Hairer(Warwick).

SECOND- ORDER, THIRD-ORDER AND NTH-ORDER ORDINARY DIFFERENTIAL EQUATIONS: HOW THE EXCEPTIONAL BECAME UNEXCEPTIONAL

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Second– and third– order scalar ordinary differential equations of maximal symmetry are noted for possessing Lie symmetries additional to those possessed by such equations of general order. A second-order equation possesses two additional symmetries and a third-order equation three additional symmetries. In both cases the subalgebra is abelian. We show that all scalar equations of the nth-order of maximal symmetry possess n symmetries in addition to those usually found in the literature.

INTEGRABILITY OF NONLINEAR PARTIAL DIFFERENCE EQUATIONS AND YANG-BAXTER MAPS

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We give a review of integrability aspects of nonlinear partial difference equations related to soliton partial differential equations. In particular we present the higher dimensional consistency property for integrable equations on the 2-dimensional grid and certain classification results obtained recently. Finally the relation of integrable partial difference equations and coupled Yang-Baxter maps on the chessboard is presented.

RECURSION OPERATORS FOR ORDINARY DIFFERENTIAL EQUATIONS

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For some decades recursion operators have been used to study and construct hierarchies of partial differential equations. Recently Euler et al (J. Nonlin. Math. Phys. to appear) extended the concept to ordinary differential equations with their study of the Riccati and Ermakov-Pinney Hierarchies. There has since been a burst of development on the subject of Differentiable Sequences with applications to the Riccati equation, the Kummer- Schwarz and generalised Kummer-Schwarz equations and the Emden-Fowler equation. It would appear that many other sequences of ordinary differential equations remain to be unearthed. We describe the method of construction of recursion operators for ordinary differential equations and illustrate the process with some simple examples. Differential sequences are notable for their properties in terms of the symmetry and singularity analyses. Some like the patterns of resonances are quite intriguing and promote further investigation into the properties of the equations comprising differentiable sequences. We illustrate these properties with selected examples.

TWO CASES OF CONTINUATION OF PERIODIC ORBITS: THE MAGNETIZATION PROBLEM AND THE COUPLING OF TWO OSCILLATORS

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We study the effect of magnetization due to a time dependent magnetic field and the onset of global chaos due to the overlap of the resonances. This is studied through the continuation of periodic orbits with first and second order perturbation theory and their stability. The second problem is a first step for the study of

the transfer of energy between two coupled oscillators one of which is nonlinear. The portrait of the phase space (the study of the stable and unstable periodic orbits) when the two oscillators are coupled reveals what will happen when a dumping term is added and how the system will behave when we want to transfer energy from one degree of freedom to the other.

TRAVELING WAVES IN 1- AND 2 – DIMENSIONAL LATTICES

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We will start this talk by presenting a review on the existence of travelling waves in 1D lattices. Discrete solitons are ubiquitous structures that arise in numerous physical applications ranging from dislocations or ferroelectric domain walls in solids, nonlinear optics. The bifurcations of travelling wave solutions in the discrete NLS systems will be considered. We study travelling waves on a two–dimensional lattice with linear and nonlinear coupling between nearest particles and a periodic nonlinear substrate potential. We show the existence of both uniform sliding states and periodic travelling waves as well in a two-dimensional lattices equation using topological and variational methods. Time permitting, we will present some recent results on the existence of discrete gap solitons in DNLS with saturable nonlinearities based on critical point theory.

GENOMIC PROTEOMIC AND ELECTRICAL BRAIN SIGNALS INTEGRATION TOWARDS THE MULTISCALE FUNCTIONAL MONITORING AND CNS COMPLEXITY

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Nowadays, researchers have a very good idea of how nerve cells communicate with each other, however, is still a long way from understanding completely how they interact in the nervous system. Diseases of the nervous system constitute an even greater medical problem, as they affect many millions of people of all ages, in all nations, in all walks of life. The recent advances in neuroscience and related technologies are making possible the integration of methods like Genomic, Proteomic and Electrical Brain Signals, towards a better understanding of the normal and pathophysiological processes in the nervous system. It is expected that in the near future patients suffering from neurological disorders like Alzheimer, Parkinson or brain injury will benefit from new therapeutic approaches based on the development of novel and powerful computational tools for the analysis, interpretation and monitoring of complex neural data within and across all levels of organization.

PHASE MODELS OF COUPLED NONLINEAR OSCILLATORS FROM EXPERIMENTAL DATA

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Self-sustained oscillations are encountered in various fields of science and engineering. In my talk, I propose we explore coupled self-sustained oscillators using phase dynamics models. We shall see how phase models can be used for describing and quantifying key features of interaction (e.g., strength, directionality, time delays) among observed oscillator systems. To reconcile theoretical models with observational data, I present a novel approach for reconstructing the phase dynamics equations, which are *invariant* with respect to the chosen observable. The approach opens a new perspective for an *observable independent* characterization of interaction between oscillator systems. We further verify the theory in a version of the classical Huygens' pendulum clocks experiment, using two mechanical metronomes placed on a rigid base.

NONLINEAR DYNAMICS, FLUCTUATIONS, AND NONEQUILIBRIUM STATISTICAL MECHANICS

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Dynamical systems theory is playing a key role to understand fundamental aspects of nonequilibrium statistical mechanics such as the origin of time asymmetry as expressed by the second law of thermodynamics. Our aim is to explain the exciting new developments in this field.

FRACTAL STATISTICS OF NON-EQUILIBRIUM BILLIARDS

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Chaotic billiards are useful models to study the foundations of non-equilibrium statistical mechanics. In their context, relations have been established between macroscopic features characteristic of irreversible phenomena on the one hand, such as entropy production or transport coefficients, and dynamical properties on the other, such as Lyapunov exponents. In this talk, I will offer a short review of several examples of non-equilibrium billiards and discuss the fractality of their statistics, whether transient or stationary.

ERGODIC PROPERTIES OF THE RELAXATION PHASE IN NON-CHAOTIC UNIMODAL MAPS

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The convergence to the mean values of observables is studied for nonlinear dynamical systems in the period-doubling bifurcation regime. The phase space convergence to the mean values is studied numerically and theoretically; it reveals a characteristic behavior induced by several special points in phase space. The convergence to the mean value for these points is exponential as opposed to the power-law convergence of the majority of the phase space. The issue of universality of these results, which characterize the period doubling bifurcation behavior, is discussed.

WHAT’S NEW IN WOLFRAM’S NEW KIND OF SCIENCE?

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Wolfram’s monumental best seller entitled “A New Kind of Science” was based almost entirely on brute – force computer simulations. In sharp contrast, this lecture presents a rigorous analytical theory based on attractors from a nonlinear dynamics perspective.
New results and concepts to be presented include the partitioning (via Felix Klein’s vierergruppe) of all 256 local Boolean rules studied empirically by Wolfram into 88 global equivalence classes, one of which

contains 4 topologically conjugate rules, capable of universal computation and endowed with a 1/f spectrum. Another major result is the rigorous characterization of the time – asymptotic dynamics (attractors) of 112 local rules, via an explicit generalized *Bernoulli shift formula*.

Even more surprising, we have discovered that the attractors of 170 local rules are blessed with the remarkable property of *time – reversality*. For such rules, the past evolution in time can be recovered from the future evolutions of a corresponding "twin" rule. Only 86 local rules exhibit an "arrow of time". One of our most interesting discoveries is a new phenomenon dubbed an "*isle of Eden*", having no counter part in hyperbolic differential equations, which has neither past nor future!

In addition to providing a mathematical formulation for brain-like dynamics, the discoveries cited above provide simple dynamical mechanisms for mimicking many exotic phenomena from brain science, quantum physics, cosmology, etc.

ON THE STABILITY OF THE LAGRANGE POINTS: ANALYTICAL AND NUMERICAL RESULTS

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In the three body problem there is a special configuration, where three celestial bodies may stay in the vertices of an equilateral triangle for all time. The so-called restricted three-body problem is defined as consisting of two massive bodies and a third massless point mass which moves in the gravitational field of the two primary bodies. Close to the former mentioned configuration there exist interesting solutions for stable orbits. We discuss when these 'Lagrange' points are stable, show numerical results of extensive numerical integrations and develop finally a theory of the stability regions with the aid of a 4 dimensional mapping based on the Nekhoreshev theory.

COMPLEXITY IN SKELETONIZATION ON A DISCRETE LATTICE

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A generalized morphological concept is introduced, combining Medial Axis created skeletons with Voronoi sets in an innovative construction. It is based on the Divider concept [1, 2, 3] adapted for use on a discrete lattice [1]. The fundamental definitions, axioms and theorems are presented. Simple examples are studied. The advantages and disadvantages of the new method are discussed in comparison to state of – the – art methods and some applications are suggested.

References

[1] A. Aggarwal, Y. Bakopoulos, Th. Raptis, Y. Doxaras, E. Kotsialos, "The Divider Set: A New Concept in Morphology", COMPUTERS (Special Session 5, Computer Graphics and Rendering, Organized by Prof. Xiaolin Lu, Zhejiang University of Finance & Economics, China, part of the 10th CSCC Multiconference), Vouliagmeni, Athens, Greece, July 13-15, 2006 Available in http://cag.dat.demokritos.gr.
[2] Y. Bakopoulos, Th. Raptis, I. Doxaras, "Geometric definition of a new skeletonization concept", 2006, arxiv:cs.CG/0607145, see: http://cag.dat.demokritos.gr
[3] Y. Bakopoulos, H. Ugail and S. Kotsios, "Description of 3D Morphology using the Concept of Divider Set", manuscript under preparation, 2007.

A NONLINEAR CLASSICAL MODEL FOR THE STUDY OF THE DECAY WIDTHS OF ISOSCALAR GIANT MONOPOLE RESONANCES IN NUCLEI

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The decay of the Isoscalar Giant Monopole Resonances (IGMR) in nuclei is studied by means of a nonlinear classical model consisting of several non-interacting particles (nucleons) moving in a potential well with an oscillating wall (nuclear surface). The motion of the nuclear surface is described by means of a collective variable, which appears explicitly in the Hamiltonian as an additional degree of freedom. The total energy of the system is therefore conserved. Although the particles do not directly interact with each other, their motions are indirectly coupled by means of their interaction with the moving nuclear surface. Free parameters of our model are the degree of collectivity and the fraction of nucleons that participate to the decay of the collective excitation. We have calculated the decay width of the IGMR in several nuclei. Despite its simplicity, our model reproduces the trend of the experimental data, which show that with increasing mass number the decay width decreases. Moreover, with the proper choice of the free parameters mentioned above, the calculated decay widths are in a good agreement with the experimental ones. It seems that this agreement is dictated by the corresponding behavior of the maximum Lyapunov exponent as a function of the system size.

THE COMPLEXITY OF NONLINEAR TIME SERIES ANALYSIS

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The advances in the theory of nonlinear dynamics and chaos brought forth insight on dynamical processes and provided a different perspective (than the classical statistical one) as well as a methodological framework for the analysis of time series, referred to as nonlinear time series analysis. I will review some of the basic concepts and aspects of nonlinear time series analysis, including state space reconstruction, fractal dimension estimation and nonlinear prediction. I will discuss statistical issues regarding this analysis and present a rigorous statistical test for evidence of nonlinear dynamics in the time series, the so-called surrogate data test for nonlinearity. Finally, I will consider strongly oscillating time series and discuss related problems in the standard nonlinear analysis, as well as propositions for new approaches. In particular, I will focus on the prediction of turning points of the oscillating time series.

APPLICATIONS OF RECURRENCE QUANTIFICATION IN NONLINEAR TIME SERIES ANALYSIS

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The methods of recurrence plots (RP's) and recurrence quantification analysis (RQA) have drawn a lot of attention as a tool for time-series analysis in recent years. In the present work we present results of time series analysis at various scales. We examine the application of these methods in three characteristic examples a) temperature time series obtained from molecular dynamics simulation of liquid argon b) temperature time series obtained from laboratory experiments on a horizontal round heated jet and c) an environmental time series concerning the daily variation of the level of the free surface of a river. In each case we extract the characteristics of the system and we relate the results to the system state. Based on the findings of this work we draw conclusions on the usefulness of the RP and RQA in different classes of time series as well as the advantages of these methods compared to more conventional (linear or nonlinear) analysis techniques since they do not demand stationarity of the time-series examined.

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SPATIOTEMPORAL DISTRIBUTED SYSTEMS: SOC OR/ AND CHAOS

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In this study we test nonlinear analysis of experimental time-series obtained from different kinds of distributed physical systems and compare the results with the basic theory of nonlinear spatiotemporal input – output dynamics, especially concerning SOC and Low Dimensional Chaos. Up to now, the Self Organized Criticality (SOC) and Low Dimensional Chaos theories are conflicted when applied for the modelling and physical understanding of random processes with power law scaling and fractal profile as implemented in the case of nonlinear distributed systems. In this work the modern theory of far from equilibrium nonlinear stochastic dynamics and nonlinear data analysis of space plasmas (solar cycle, solar wind, magnetosphere), seismic and eeg epileptic events are used for the unification of the two competitive and antagonistic, until now, theoretical points of view of critical complexity, such as Self Organized Criticality and Low Dimensional Chaos applied in the above systems. Subsequently, we provide further information, about the co-existence of a local and global low dimensional strange attractor in the previously mentioned dynamical distributed systems. Also for the above theoretical unifications and understanding of experimental results we used outcomes of modern chaotic synchronization theory.

QUANTUM CHAOS IN GENERIC SYSTEMS

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Random matrix theory (RMT) has proved to be an excellent model for the statistical properties of energy spectra of classically chaotic Hamiltonian systems, even if the number of degrees of freedom is small, say just two, which is certainly one of the most dramatic manifestations or signatures of classical chaos in bound quantum systems, one of the cornerstones of quantum chaos. It goes back to the original papers by Casati, Valz-Gris and Guarneri in 1980, and independently by Bohigas, Giannoni and Schmit in 1984, where the conjecture was formulated. It has been theoretically supported by the dynamical and semiclassical theory of spectral rigidity by M.V. Berry using the diagonal approximation in the treatments of double sums over periodic orbits.

The next important step beyond this approximation has been achieved by Sieber and Richter, followed by the development of an expanded semiclassical theory by S. Müller et al. Classically integrable quantum systems show Poissonian statistics, as is well known and corroborated by extensive numerical and analytical works, whereas in chaotic systems the spectral fluctuations obey the statistics of the Gaussian orthogonal (GOE) or unitary (GUE) ensembles (depending on whether an antiunitary symmetry exists or not, respectively. Typical (generic) systems in nature are, however, neither integrable nor fully chaotic but somewhere in between, namely there may be a classically regular motion on invariant tori for some initial conditions in the classical phase space, and chaotic motion for the complementary initial conditions. One important class are the nearly integrable systems, i.e. only weakly perturbed integrable systems, described by the KAM-scenario.

One often studied example is the 2D billiard family which is a quadratic conformal map of the unit circle, introduced in 1983 by the author. There are other mixed type systems, not KAM-like, namely e.g. the mushroom billiard introduced by Bunimovich in 2001, and currently a subject of intense theoretical, numerical and experimental studies. In this billiard we have exactly one invariant chaotic and one invariant regular component. The spectral statistics in such mixed type systems rests upon the so-called Principle of Uniform Semiclassical Condensation (PUSC) of Wigner functions of eigenstates and goes back to the notion of regular and irregular eigenstates proposed by Percival, the theoretical foundations by Berry and the theory by Berry and Robnik in 1984.

The author initiated the research on quantum spectra of mixed type systems in 1983/4. A review of these ideas, foundations and results can be found in (Robnik 1998). The best mathematical statistical measure to analyse such systems are the so-called E(k,L) probabilities: E(k,L) is the probability of having exactly k levels in an interval of length L - after unfolding, i.e. with mean level density equal to one. The gap probability E(0,L) is directly related to the level spacing distribution P(S), which is the 2nd derivative of E(0,S). Aurich, Bäcker and Steiner introduced them in the context of quantum chaos. Our theory states that the E(k,L) statistics factorise in the strict semiclassical limit of a sufficiently small effective Planck constant, and for case of level spacings the formulae by Berry and Robnik (1984) should apply. The factorisation property is direct consequence of statistical independence of the sequences of regular and irregular levels. Berry-Robnik (BR) theory has been verified in many different systems in the asymptotic semiclassical regime. If the energy is not sufficiently large and thus the effective Planck constant not sufficiently small one observes deviations from BR behaviour which emerge due to both, the localisation effects, and due to the overlap of and tunnelling between the regular and chaotic regions in the quantum phase space of Wigner functions of eigenstates. The result is a linear behaviour of P(S) at small S, as predicted qualitatively already by Berry and Robnik in 1984. A fractional power law level repulsion was discovered and discussed by Prosen and Robnik in 1993/4, and this regime is observed between the linear level repulsion regime and the BR tail. For a qualitative overall picture see (Robnik and Prosen 1997). The purpose of this lecture is to give a review of the above theory and to present some important very recent results on the random matrix models of generic quantum systems, i.e. systems of the mixed type at small energies or large effective Planck constant, that is the regime beyond the Berry-Robnik asymptotical regime.

References and Literature for Further Reading:

[1] H. J. Stöckmann, *Quantum Chaos: An Introduction*, Cambridge University Press, Cambridge (1999).
[2] M. Robnik, *Nonlinear Phenomena in Complex Systems* (Minsk) 1 (1998) 1-23.
[3] M.V. Berry in *Chaos and Quantum Physics*, eds M-J Giannoni, A Voros and J Zinn-Justin, Amsterdam, North-Holland (1991) 87-199.
[4] M.V. Berry and M. Robnik, J. Phys. A: Math. Gen., 17 (1984) 2413.
[5] O. Bohigas in *Chaos and Quantum Physics*, eds. M-J Giannoni, A Voros and J Zinn-Justin, Amsterdam, North-Holland (1991) 87-199.
[6] G. Casati and B.V. Chirikov in *Quantum Chaos: Between Order and Disorder*, eds. G. Casati and B.V. Chirikov, Cambridge, Cambridge University Press, (1994).
[7] Baowen Li and M. Robnik M., J. Phys. A: Math. Gen. 28 (1995) 2799.
[8] T. Prosen and M. Robnik, J. Phys. A: Math. Gen., 26 (1993) 1105.
[9] T. Prosen and M. Robnik, J. Phys. A: Math. Gen., 27 (1994) 8059.
[10] M. Robnik and T. Prosen, J. Phys. A: Math. Gen., 30 (1997) 8787.
[11] M. Robnik, J. Phys. A: Math. Gen., 17 (1984) 1049.
[12] G. Veble, M. Robnik and V.G. Romanovski, J.Phys.A: Math.Gen., 35 (2002) 4151.
[13] M. Robnik and G. Veble, J.Phys.A: Math.Gen., 31 (1998) 4669.
[14] T. Prosen and M. Robnik , J.Phys.A: Math.Gen., 32 (1999) 1863.
[15] M. Robnik, International Journal of Bifurcation and Chaos16 No.6 (2006) 1849-1853.
[16] S. Grossmann and M. Robnik, J.Phys.A: Math.Theor., 40 (2007) 409-421.

CLASSICAL AND QUANTUM CHAOS IN THE DISSOCIATION OF A DIATOMIC MOLECULE IN A LASER FIELD: THE KEY ROLE OF THE FREQUENCY OF MAXIMUM DISSOCIATION

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This work deals with the problem of quantum-classical correspondence in systems, which can escape to infinity above an energy threshold. In particular, the focus is on the classical and quantum aspects of the multiphoton dissociation of a Morse molecular bond induced by a moderate, low frequency, laser pulse. The photo-dissociation probabilities are calculated and analyzed as a function of the laser frequency, the intensity and the pulse shape. A well established quantum and classical result is that for large laser intensities the dissociation probability presents a maximum at frequency $\omega_{max} \sim 0.80-0.90\ \omega_{01}$, where ω_{01} is the transition frequency from the ground to the first excited state (red shift phenomenon). In this work, we go further and explore the quantum and classical effects of the optimum frequency ω_{01} on the overall excitation and dissociation dynamics. Firstly, it is shown that both quantum and classical results predict that ω_{max} continues to be the optimum frequency for photo-dissociation even at very low intensities. However, the quantum results show a multi-peak structure vs laser frequency, which is attributed to resonant multi-photon transitions, whilst the classical results show a smooth curve with a broad maximum at ω_{max} which is explained by phase space arguments. Secondly, it is found that in both quantum and classical approaches ω_{max} marks a transition in the effects of turn-on time of pulse shape on dissociation probability: for $\omega < \omega_{max}$ the gradual turn-on of the field leads to a noticeable reduction of the photo-dissociation probability, whilst for $\omega > \omega_{max}$ such effect is of minor importance. A classical interpretation of this finding is given which is based on stickiness effects in phase space. Finally, the crucial role of ω_{max} is further demonstrated, concerning the time dependence of the dissociation and ground state probability. The first decreases faster and the latter oscillates weaker for $\omega < \omega_{max}$ rather than for $\omega > \omega_{max}$. This transition is predicted by both quantum and classical dynamics, although there are secondary differences, which are revealed and discussed.

CLASSICAL CHAOS AND QUANTUM INFORMATION

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Quantum Information Theory is the extension of Classical Information Theory when the quantum nature of the physical devices plays a key role. All the information storage and processing systems, to work in the desired quantum mechanical way, must be isolated from environmental perturbations and classical interactions with other systems. This isolation protects entanglement (the fundamental resource of quantum information) from decoherence (the deterioration of quantum coherence). But in order to prepare the initial state of a quantum system, to control its evolution, and measure its final state, we must interact with it with big classical systems and thus induce unavoidable perturbations. This is the main problem for the scalability of all proposed architectures for quantum computers. In the search for design optimizations it has been natural to ask whether the classical properties of quantum systems play any role either helping in the protection of entanglement or inducing specific undesired behavior. Thus the question of the influence of classical chaos or integrability has been posed and studied extensively. While there exit many results based on specific models of quantum systems, the picture is not definite since one can see chaos in some cases to accelerate decoherence but in many cases to help entanglement. In this talk we present two different results. The first is an inequality, which holds, under certain conditions, for general systems. The proof is based on Random Matrix Theory. The second result is an analysis of how the existence of scars influences decoherence and which is the role of bifurcation points. This study is based on the comparison of Classical and Quantum Kicked Tops, the latter used as a model of a system of many qubits.

ABSTRACTS OF POSTERS

(IN ALPHABETICALORDER)

STABILITY OF EQUILIBRIA AND DYNAMICS OF OLIGOPOLY MODELS IN ECONOMICS

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Oligopoly is an intermediate situation between monopoly and perfect competition. The complexity is greater than the two extreme cases and this fact is reflected in the resulting dynamics. We present a review of recent developments in oligopoly theory with a stress on the circumstances under which we find chaotic behaviour. We examine the robustness of the results of the known models by extending them to include different forms of their inverse demand functions, cost functions and formulation of the continuous dynamical system.

THE METHOD OR REGULARIZATION OF COLLISION ORBITS IN THE RESTRICTED 3-BODY PROBLEM

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The aim of this essay is to analyze and describe the method of regularization applied to collision orbits of bodies moving in the gravitational field. The study refers to the 2-dimensional, circular, restricted 3-body problem.
We use Birkhoff's transformation in order to extinguish the singularities of both primary bodies, simultaneously. More precisely, the method is based on the following essential steps: a) a change of coordinates (called Levi-Civita transformation), b) the introduction of a fictitious time and c) the use of the conservation of energy in order to transform the singular differential equations into regular ones, through the introduction of the extended phase space.
Finally, we apply the above method to the "Earth-Moon" system. Moreover, we present trajectories in the regularized, rotating and inertial system of coordinates and form Poincaré sections of the regularized orbit.

LOW-DIMENSIONAL QUASIPERIODIC MOTION IN HAMILTONIAN SYSTEMS

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A new method has been recently introduced for detecting chaos and order in N – degree of freedom Hamiltonian systems: It is called Generalized Alignment Index (GALI) and predicts rapidly and accurately if a certain orbit is chaotic or regular, by computing the volume of k unit deviation vectors as they follow the given orbit in the 2N – dimensional phase space. As is well known, regular orbits of N – degree of freedom Hamiltonian systems lie, in general, on N – dimensional tori. It does happen, however, in many cases of physical interest that these tori have dimensions much lower than N. In this paper, we derive the asymptotic behavior of the $GALI_k$ indices for the case of lower dimensional tori and apply our results to the famous Fermi Pasta Ulam lattice.

DISSOCIATION OF A PERIODICALLY DRIVEN MORSE MOLECULE: EFFECTS OF INITIAL FIELD PHASE

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In this work, we examine the impact of the initial phase of an external field interacting with an open nonlinear (Morse) potential on the escape probability from the potential in the view of the recent advances in nonlinear classical dynamics. The physical system motivating our work is the photo-dissociation of a diatomic molecule and the impact of the initial (or absolute) phase of the external laser field. The main finding is that the dependence on the initial phase is dictated by the energy exchange between the main periodic orbits and the external field through the concomitant modifications in the regular structures surrounding these orbits in phase space. For initial phases, at which a periodic orbit gains energy from the external field the surrounding island of stability widens along the energy axis and narrows down along the angle axis. This modification causes enlargement of the escape probability of a microcanonical ensemble of trajectories with energy close to that of the periodic orbit. Furthermore, it is shown that the energy exchanges of the p.o. with the field and the associated phase space changes depend strongly on the frequency of the field. A systematic study of this dependence in the region around the optimum frequency for escape is performed and possible regularities are extracted and analyzed.

MODELLING SPIKES IN NATURAL AND FINANCIAL PHENOMENA

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Many physical and social phenomena show sudden and unpredictable changes of their dynamical behaviour. In particular, in laser physics, chemical reactions, ion channels, neural and climate systems, and others, we observe a multi-regime dynamics, in which we can distinguish a normal or stable state, governed by a mean-reverting diffusion process accounting for random fluctuations around some long run mean, and a turbulent or unstable state, where the motion experiences jumps and short-lived spikes. In this lecture we propose a general methodology to model spikes using excitable dynamics in a multi-regime switching approach. The switches between regimes are controlled by a Markov process, thus allowing us to model these transitions in a flexible way. The turbulent dynamics is obtained through the well-know FitzHugh-Nagumo (FHN) model. Although in the stochastic version of (FHN)-dynamics the spikes occur stochastically, as in the deterministic case they have the same height and duration. On the contrary, in our model the heights and the duration of the spikes can be modulated by varying the parameters of the Markov transition probability matrix. Finally we exhibit some examples of interest in physics and in finance

FRACTAL ACTIVE SHAPE MODELS

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Active Shape Models often require a considerable number of training samples and landmark points on each sample, in order to be efficient in practice. We will talk about Fractal Active Shape Models, an extension of Active Shape Models using fractal interpolation, in order to surmount these limitations. They require a considerably smaller number of landmark points to be determined and a smaller number of variables for describing a shape, especially for irregular ones. Moreover, they are shown to be efficient when few training samples are available.

POPULATION DYNAMICAL MODELS FOR SPECIES WITH NON-OVERLAPPING GENERATIONS

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The population dynamics of species with non-overlapping generations is modeled by mappings in discrete time. We present some basic definitions from the theory of dynamical systems and the main bifurcations of fixed points of maps. Then we examine some basic mapping models for populations and concentrate on the dynamics of species obeying to the Allee effect. This is expressed as a negative dependence of the rate of increase of the population on its size for small values of the population. We study a chain of identical sites with non-zero dispersal probably to the nearest neighbor and comment on the dynamical description of biological phenomena as the source-sink and the rescue effect. Finally we present a prey-predator system where the prey obeys to the Allee effect while the dynamics of the predator is of the logistic type.

CHAOTIC ANALYSIS OF TIME SERIES CORRESPONDING TO THE BASIC CHARACTERISTICS (TIME, SPACE, MAGNITUDE) OF EARTHQUAKE OCCURRENCE IN HELLENIC REGION

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It is well known that seismicity exhibits scaling properties. In particular, the temporal correlations of earthquakes and the distribution of earthquake size follow a power law. Famous paradigms are the Gutenberg-Richter and Omori's law for aftershocks. Also, the spatial distribution of earthquakes is found to be scale-invariant. For example, fault and fracture breaks have a self-similar scaling and the earthquake populations in different tectonic zones exhibit spatial variability, clustering and intermittency. Furthermore, the nonlinear character of the earthquake dynamics is supported by a series of observational facts, as well as by nonlinear models, which mimic many spatiotemporal characteristics of seismogenesis. On the other hand, chaotic systems are known to exhibit scale invariant (fractal) properties, as well as a strong nonlinear character. Significant experimental evidence for low dimensional chaos has been reported in different regions of earthquake occurrence.

In order to test the hypothesis that the observed phenomenology of earthquakes could be derived from a low dimensional nonlinear underlying process, we applied the nonlinear analysis techniques to five time series concerning the Hellenic region for the time period of 1964-2004. These time series correspond to interevent times, latitude, longitude, depth and to the magnitude of earthquakes greater than 4 Richter and were constructed using the bulletins of the National Observatory of Athens. In particular, we estimated the autocorrelation coefficient, the power spectrum, the slopes of the correlation integrals using the Theiler's criterion, and the maximum Lyapunov exponent. Moreover, we used the method of surrogate data in order to exclude the case of an infinite dimensional stochastic process that can mimic the profile of low dimensional process (null hypothesis). Based on our results, we can conclude that the temporal and spatial correlations observed for earthquakes in Hellenic region could be due to a low dimensional chaotic attractor, while the energy which is released by each earthquake (magnitude) corresponds to a high dimensional stochastic process. These findings could be useful for earthquake prediction of individual earthquakes, since it is known that deterministic chaotic processes are much more predictable from purely stochastic processes.

THIRD-ORDER NONLINEAR OPTICAL RESPONSE OF META NANOPARTICLES

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A lot of macroscopically visible objects in nature, share a symmetry which is called fractal geometry. During the last years fractal nanostructures are extensively studied due to their extremely interesting physical properties. Moreover, their ability to enhance local electromagnetic fields, resulting in very strong enhancement of their nonlinear optical properties (e.g. SERS) makes them very promising candidates for nanophotonic applications.
In this view the nonlinear optical (NLO) response of thin gold nano-island films, prepared by thermal evaporation onto glass substrates, was investigated by means of the Optical Kerr Effect (OKE) and Z-scan techniques, employing laser excitation of 35 ps at 532 nm. The effect of parameters like film thickness, deposition rate, size and morphology of nanoparticles and pre-treatment of the substrate, on the response was investigated.
Then, by the same experimental techniques, solutions of metal nanoparticles (Au, Ag) encapsulated by hybrid block copolymer micelles were studied. The role of the polymeric macromolecules is to make the nanoparticle systems more soluble in several solvents and also to avoid aggregation of the nanoparticles and formation of large macroscopic clusters. The dependence of the NLO response on the polymer/metal ratio, as well as on the concentration of the solutions of these systems was also investigated.
In both cases, large enhancements of the NLO response of the nanoparticles were found compared to bulk metal films. The observed enhancement was attributed to the surface plasmon resonance exhibited by such nanostructures, which depends strongly on the shape and the size of the nanoparticles. Changing of these parameters generally influences the local anisotropy factor (S), as well as the fractal dimension (D). When the films' percolation threshold is exceeded (i.e. for large values of the fractal dimension, see also figure), the SPR vanishes resulting in significant decrease of the NLO response.

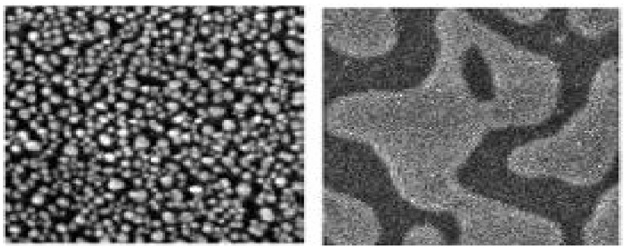

Figure: HR-SEM images of 2.5 nm (left) and 15 nm (right) thick Au

STUDY OF PRESEISMIC ELECTROMAGNETIC EMISSIONS BY MEANS OF NON-EXTENSIVE AND EXTENSIVE STATISTICAL MECHANICS AND FRACTAL WAVELETS SPECTRAL ANALYSIS

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An important question in geophysics is whether earthquakes (EQs) can be anticipated prior to their occurrence. Pre-seismic electromagnetic (EM) emissions seem to provide a promising window through

which the dynamics of EQ preparation can be investigated. Recent studies imply that these signals not only provide insight concerning important characteristics of the preparation of the earthquake process but also yield clues regarding the underlying associated fracture dynamics. However, the existence of precursory features in pre-seismic EM emissions is still debatable: in principle, it is difficult to prove associations between events separated in time, such as EQs and their EM precursors. Our approach is motivated by the need to generate a rigorous measure of the degree of complexity of the preseismic signals during the last stage of global instability. Entropy is a method to quantify the order / disorder of a time series. A time-dependent entropy is used in the quantification of precursory "crust injury" level. Among the different entropy measures, we used non-extensive and extensive ones, namely, Tsallis entropy and Shannon entropy respectively. Both these entropies detected the pattern of piezo-stimulated alterations in the preseismic EM signals and was able to discriminate the different "injury levels" of the focal area.
A fractal spectral analysis by means of wavelets verified the extracted different last stages of the earthquake nucleation. Based on laboratory and field data as well as theoretical arguments we suggest that taken together the emergence of: (i) significant reduction of the complexity and (ii) strong persistent behavior, it might be concluded that the associated EM activity witnesses the fracture of the population of strong and large asperities that sustain the system.

DETECTION OF LOW-DIMENSIONAL CHAOS IN WIND TIME SERIES

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Research on chaos theory in geophysical phenomena, such as rainfall, temperature, river flow, wind velocity etc, has attracted great interest in recent years. In the present work we investigated the existence of low-dimensional deterministic chaos in wind time series. In a first place we used the raw data without any noise filtering. Characteristic times were extracted using the autocorrelation function and average mutual information function. The estimation of invariant measures, such as the correlation dimension and Lyapunov exponents indicate, although not in a clear way, the possible existence of a low–dimensional attractor. In a second place we applied several noise reduction methods and we performed the same test again. The obtained results show in a more clear way the existence of a low-dimensional attractor. In addition, the null hypothesis is tested for the dynamical characteristics of the wind time series by using nonlinear surrogate data and the corresponding results provide significant evidence for the existence of low dimensional chaotic dynamics underlying the wind time series.

NONLINEAR ANALYSIS OF SOLAR CYCLE DATA. EVIDENCE FOR LOW DIMENSIONAL CHAOS

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In this study we apply the modern algorithm of Nonlinear Analysis in Solar Cycle data in order to test the hypothesis of low dimensional chaotic dynamics. In particular, we use daily and monthly data corresponding to sunspot index and estimate the correlation dimension, the singular value spectrum, the Lyapunov exponents spectrum and the mutual information. Moreover, we apply nonlinear predictions methods of the solar cycle and we compute surrogate data in order to exclude the hypothesis of color noise.

EXISTENCE AND STABILITY OF DISCRETE BREATHERS IN A 2D DUSTY PLASMA CRYSTAL

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Recent theoretical and experimental investigations of dust-contaminated plasmas (*dusty plasmas*, DP) [1] have established the existence of *strongly coupled* DP lattices (crystals). These crystalline configurations, consisting of highly charged massive dust grains, are typically formed in the sheath region above a horizontal negatively biased electrode in gas discharge experiments (e.g. [1, 2]). Typical low-frequency oscillations are known to occur [1, 2] in these *mesoscopic* dust grain quasi-lattices in the longitudinal (in-plane, acoustic mode), horizontal transverse (in-plane) and vertical transverse (off-plane, inverse dispersive optic-like mode) directions. A variety of 2D and 3D configurations are possible [1b], although the spontaneous occurrence of successive *hexagonal* 2D layers seems to be the most often encountered possibility. A 1D DP crystal has also been realized experimentally, by using appropriate substrate potentials. Such 1D lattices have been shown to host collective excitations, in the form of solitons, localized envelope wave packets, as well as discrete breather-type excitations (see [8] and Refs. therein). In the present work a hexagonal DP lattice in considered. Transverse motion in this system is described by a Klein-Gordon-like Hamiltonian in the presence of an asymmetric quartic potential. By adopting real values for the potential (nonlinearity) parameters, as provided by experiments [4, 5, 6], and using the results of [6, 7], we shall prove that 2D DP crystals may support single-site as well as multi-site localised oscillations (multibreathers) [9].

[1] P. K. Shukla and A. A. Mamun, *Introduction to Dusty Plasma Physics* (Institute of Physics, Bristol, 2002); G. Morfill, H. M. Thomas, and M. Zuzic, in Advances in Dusty Plasma Physics (Eds. P.K. Shukla, D.A. Mendis, and T. Desai) (World Scientific, Singapore, 1997). [2]. U. Konopka, G. E. Morfill and L. Ratke, Phys. Rev. Lett. 84, 891 (2000).
[3]. A. V. Ivlev, R. Sütterlin, V. Steinberg, M. Zuzic and G. Morfill, Phys. Rev. Lett. 85, 4060 (2000).
[4]. C. Zafiu, A. Melzer and A. Piel, Phys. Rev. E 63, 066403 (2001).
[5] T. Misawa, N. Ohno, K. Asano, M. Sawai, S. Takamura and P. K. Kaw, Phys. Rev. Lett. 86, 1219 (2001).
[6]. V. Koukouloyannis and R.S. MacKay, Journal of Physics A: Math. Gen. 38 (2005) 1021-1030
[7]. V. Koukouloyannis, Physical Review E, 69, 046613 (2004)
[8]. V. Koukouloyannisand I. Kourakis Existence of multibreathers in one-dimensional Debye crystals, PRE 75 (in print)
[9]. V. Koukouloyannisand I. Kourakis Existence of breathers and multibreathers in 2D dusty plasma crystals (in preparation)
[10]. I. Kourakis and P. K. Shukla, Phys. Plasmas, 11, 3665 (2004).

COMPLEX DYNAMICS IN LOW DIMENSIONAL LATTICES: OSCILLATORY BEHAVIOR OF A PREDATOR-PREY MODEL

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A Predator–Prey model is studied using Mean Field (MF) approximation and Kinetic Monte Carlo (KMC) simulations on low dimensional square lattices. A lattice compatible scheme that gives rise to "center"-type oscillations at the MF level is constructed. It involves two reactive species (predator and prey) and empty sites. The amplitude and the period of oscillations depend on the system's parameters. KMC simulations demonstrate locally the evolution of the species' concentrations and the formation of patterns. For homogeneous initial conditions and depending on the reaction rates the model exhibits an oscillatory coexistence state between predator and prey.

ON THE ADAPTIVITY OF NONLINEAR SYSTEMS

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The goal of this reasearch is to find out the properties and processes that make systems adaptive. Adaptation in general is a process through which a system restores, maintains or increases its fitness. It is likely that the properties and processes causing adaptivity in various systems are similar (when described at a suitable level of abstraction), or at least form a small number of different classes. Several notable generalizations have already been made, e.g. the concept of feedback and its importance in system adjustments has been proposed by cybernetics. Also, the ideas of evolution theory have been extended beyond their original biological context. However, as much as I know, there still exists no well-systematized scientific overview of adaptation in different kinds of systems, and of underlying processes of adaptation in specific cases and in general. The creation of such a source would be very helpful for many different disciplines. On the poster I give a general overview of the concept of adaptivity, present some examples, describe my research goals, and call for comments and suggestions, and for scientific cooperation.

NEKHOROSHEV STABILITY IN THE 1:1 RESONANCE OF THE ELLIPTIC RESTRICTED THREE BODY PROBLEM

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All investigations of the Nekhoroshev stability of the Trojan type motion up to now were based on the circular three body problem. This circular model is a great simplification of the real physical system, because it neglects all phenomena due to the ellipticity of Jupiter´s orbit. In the present work we extend rigorous results of Nekhoroshev estimates to this more realistic model based on a symplectic mapping for the system. For this reason we developed the perturbing function up to 4th order in the eccentricities and 8th order in the variations of the semi major axis and derived a precise mapping in 4D, describing the dynamics of a massless body in the equilateral configuration of the three body problem in the plane. The algorithm to construct the Birkhoff normal form of symplectic mappings and also the method to derive the remainder at the optimal order of truncation is presented and applied to the Jupiter´s Trojan case. We show the interplay between the remainder of the normalized mapping and the resulting stability region around the fixed point based on different kinds of determination of the remainder. In addition we compare our results with the proper elements of the known asteroids given in literature. Up to now three asteroids of Trojan type motion can be proven analytically to be Nekhoroshev stable for the lifetime of the Solar System.

CONTINUATION AND STABILITY OF PERIODIC ORBITS IN A PERTURBED SYSTEM OF NONLINEAR COUPLED OSCILLATORS

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This work is part of a more general work concerning the energy transfer and dissipation in nonlinear mechanical oscillators. We intend to study the transfer of oscillations from the main body of the mechanical system to a nonlinear adjunction and their final decrease. The first step is to study the continuation and stability of periodic orbits of the unperturbed integrable Hamiltonian system to the Hamiltonian part of the perturbation. We apply a theorem by Poincare that finds the existence of the saddles and centers of the perturbed system.

APPLICATION OF THE GENERALIZED ALIGNMENT INDEX METHOD TO THE DYNAMICS OF MULTI DIMENSIONAL SYMPLECTIC MAPS

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We study the phase space dynamics of multi-dimensional symplectic maps, using the method of the ***Generalized Alignment Index (GALI)***. In particular, we investigate the behavior of the *GALI for a system of N coupled standard map* and we show that it provides an efficient criterion for rapidly distinguishing chaos from order. We also present examples of its ability to identify the dimensions of tori and predict slow diffusion.

COMPLEXITY, KNOWLEDGE AND CHANGE IN THE 21ST CENTURY: SEEKING THE ARCHETYPES OF THE ORGANIZATIONAL CULTURE

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Our era is characterized by phenomena of increasing complexity, interdependence, fuzziness, and instability; it also features the pursuit of innovation and the shift of attention from tangible assets to intangible, such as knowledge and adaptability. We know from our experience that the enterprises and the organizations are complex but unified systems, which we cannot analyze into components without falling to reductions or omitting substantial interactions. Nowadays, complexity theory seeks and reveals some profound relations, invisible until now, which permit us to see beyond the wheel of opposites, beyond the ephemeral forms and connect the parts of the whole in a global web of coactions.
Organizational conflicts emerge as a result of the complexity of human systems. They are caused by the existence and action of a large number of stakeholders; because of their difference and constant interaction, they produce situational changes and new needs within the system they exist. These different stakeholders, as well as the representatives of groups with different cultures, operate almost exclusively under the influence of their own *patterns* of perception and behavior; thus they find it hard to understand the “other side” and communicate with “them”.
This is why all attempts to impose linear – mechanical solutions in conflict situations, without the *substantial* participation of *all* parts concerned, have developed a negative tradition and predisposition to these parts. To the same end have reached the attempts to plan *global solutions*; they seem to ignore the basic principle of chaos theory: “any change initiative applied to a part of system can influence the whole system, beyond the narrow limits of the application field, on a non-linear, non-predictable way”.
During the last decade, the use of innovative techniques and tools, based on self-organization, attraction and emergence is been adopted by an increasing number of consultants, researchers, and academics. This approach is being proved more *effective* to deal with complex matters in organizations and communities, such as strategy planning, decision making, knowledge transfer, conflict resolution, and organization change.

KINETIC MONTE CARLO SIMULATIONS OF THE OSCILLATORY CO OXIDATION WITH SURFACE OXIDE FORMATION

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The oxidation of CO on metal surfaces exhibits interesting oscillatory behaviour and spatiotemporal patterns under certain conditions. Oscillations arising at high pressures (mbar to atmospheric) are attributed to the "oxide model", in which the slow oxidation / reduction of the surface is coupled to the steps of the CO oxidation mechanism. In the present work a mesoscopic simulation of this system is

carried out using a Kinetic Monte Carlo (KMC) method inspired by the Ziff-Gulari-Barshad (ZGB) model. The ZGB model is extended to take into account the surface oxide formation. Oscillations in this model are obtained when a different reactivity is attibuted to the two phases - metal surface and oxidised surface.

CONTINUATION OF MULTIPEAK BREATHERS IN THE DISCRETE NLS

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We consider the question of continuation of breathers in a parametrically forced discrete NLS appearing in nonlinear optics. We review some results for small amplitude and high frequency parametric forcing. The emphasis will be on extensions to multipeak breathers in one and higher dimensional lattices.

STUDY OF THE BEHAVIOR OF A 4TH ORDER NON-AUTONOMOUS CIRCUIT IN LOW FREQUENCY AREA

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In this paper, the dynamic behavior of a 4th order nonlinear circuit has been studied. The circuit consists of a N-type nonlinear resistor R_N, a negative conductance G_n and a sinusoidal generator $v_s(t)$. Theoretical and experimental phase portraits and spectrums have taken place with the amplitude of the input signal at various values, proving this way the genesis and catastrophe of the Double-Bell strange attractor . Finally,we have observed the Poincare diagrams through which we come to conclusions for the dynamic behavior of the system.

EVALUATION OF MUTUAL INFORMATION ESTIMATORS ON NONLINEAR DYNAMIC SYSTEMS

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Mutual information is a nonlinear measure used in time series analysis in order to measure the global correlations (linear and non-linear) between their terms with time lag τ. The aim of this study is to evaluate some of the most commonly used mutual information estimators, i.e. estimators based on histograms (with fixed or adaptive bin size), k-nearest neighbors and kernels. We assess the estimators by Monte-Carlo simulations on time series from nonlinear dynamical systems of varying complexity. As the true mutual information is generally unknown, we investigate the consistency of the estimators (convergence to a stable value with the increase of time series length), the rate of consistency and the degree of deviation among the estimators.

NONEXTENSIVITY AND TSALLIS STATISTICS IN THE ACTIVATION OF A SINGLE GEOLOGICAL FAULT?

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Solotongo-Costa and Posadas (SCP) [1] have recently introduced a model for earthquake dynamics consisting of two rough profiles interacting via fragments filling the gap. The irregularities of the fault

planes can interact with the fragments between them to develop a mechanism for triggering earthquakes. The fragments size distribution function comes from a nonextensive Tsallis formulation, starting from first principles. An energy distribution function, which gives the Gutenberg-Richter law as a particular case, is analytically deduced:

$$\log(N(>m)) = \log N + \left(\frac{(2-q)}{1-q}\right) \times \log[1 + a(q-1) \times (2-q)^{(1-q)/(q-2)} \times 10^{2m}] \tag{1}$$

where N is the total number of EQs, and $N(>m)$ the number of EQs with magnitude larger than m. α is the constant of proportionality between the EQ energy, ε, and the size of fragment. The equation (1) provides an excellent fit to seismicities generated in large geographic areas usually identified as “seismic regions”, each of them covering many geological faults. Herein, we focus on the activation of *a single fault* by means of precursory EM emissions. In the frame of the above mentioned fragment-asperity interaction model for EQs, a sequence of precursory EM pulses occurs during the fracture of the fragments that fill the space between the irregular fault planes of the activated individual fault. We show that the expression (1) also describes the amplitude distribution of the detected precursory EM pulses in all the detectable range of magnitudes. Importantly, both cases give very similar values for the nonextensive parameter q: the seismicities and the preseismic EM activities are characterized by q-values around 1.6.
More recently, Silva et al., [2] have revised the model introduced by SCP [1] by considering a different definition for mean values in the context of Tsallis nonextensive statistics and introducing a different scale between the earthquake energy and the size of fragment. Their approach also leads to a Gutenberg type law, as following:

$$\log(N(>m)) = \log N + \left(\frac{(2-q)}{1-q}\right) \times \log[1 - \left(\frac{1-q}{2-q}\right)\left(\frac{10^{2m}}{a^{2/3}}\right)] \tag{2}$$

The equation (2) also describes the seismicity for various regions. Interestingly, both two approaches presented in Refs. [1] and [2] provide very similar values for the nonextensive parameter q, while other physical quantities, e.g., energy density, differs considerably. We show that the Eq. (2) allows as to determine the cumulative number of preseismic EM pulses (“EM foreshocks”) as a function of the amplitude. We pay attention to the fact that the associated q-values are similar with both the seismicities and preseismic EM activities also distributed around the value 1.6
It is worth mentioning that the estimated for the q-nonextensive parameters is in full agreement with the upper limit $q < 2$ obtained from several independent studies involving the Tsallis nonextensive framework. Finally we show that temporal evolution of the Tsallis entropy distinguishes the last stage of the earthquake preparation process. The main result of the present distribution is that the activation of a single fault can be described in terms of nonextensivity and Tsallis statistics.

[1] Solotongo-Costa, O., and Posadas, A., Fragment-Asperity Model for Earthquakes, Physical Review Letters 92, 048501-1 / 4, 2004.
[2] Silva, R., Franca, G., Vilar, C., and Alcaniz, J., Nonextensive models for earthquakes, Physical Review E 73, 026102-1/5, 2006

IMAGE COMPRESSION BASED ON FRACTAL PROPERTIES AND OPTIMIZATION METHODS

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This study refers to methods of compressing images through the use of fractal properties. The main idea is the following: given a picture, algorithms will be used to transform it into a fractal (or at least try to approximate the shapes present in the picture, through a fractal). Then, by using instruments like Iterated System Functions, it is possible to compress the fractal-like image. However, this technique demands a great number of calculations and system resources. Hence, the main focus of the problem is to improve the algorithms of compression/decompression in order for them to be applied in a real time application and also optimize the process from the compression quality point of view. Nowadays, there are several methods that try to implement and optimize the compression process. Among them one can find interesting the compression using Kohonen self-organizing neural networks, compression made using quadtree partitioned IFSs and hash like compression. These methods will be studied and characterized in the present paper.

THE DRIPPING FAUCET EXPERIMENT

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A dripping faucet may easily be seen in everyday life. Its rhythm is sometimes regular but sometimes not, which sensitively depends on the flow of water. If the rhythm is irregular, one might blame it on noise due to unseen influences such as small air vibrations. However, it is nowadays well-known that this is an example of a system capable of chaotic transition. The same system can change from a periodic and predictable to an aperiodic, quasi-random pattern of behavior, as a single parameter (in this case, the flow rate) is varied.
The story of drips falling from a faucet goes back, in the early 70's. At the dawn of this decade, it had been generally realized that simple mechanical oscillators can undergo a transition from predictable to unpredictable behavior analogous to the transition from laminar to turbulent flow in a fluid. In 1977 Otto Rössler [1] suggested that an exceptional connection between flow and oscillator dynamics is the example of a dripping faucet.
Robert Shaw was the first who in 1984 experimentally studied this behavior [2], [3] proving Rössler's suggestion true and also establishing the aspect that Chaos is not only a mathematical product but also a phenomenon ubiquitous in the real world. In the years to follow there had been other similar attempts like [4]-[6]. In this work we will review past work on this problem and present our own study of the exciting range of phenomena related with the chaotic attractors exhibited by the model.

References
[1] Rössler O., *Synergetics : A Workshop*, Ed. H. Haken, Springer, (1977)
[2] Shaw R., *The Dripping Faucet as a Chaotic Model System,* Aerial Press, (1984)].
[3] Martien P., S.C. Pope, P.L. Scott, R. S. Shaw, Phys. Lett. A110 399 (1985)
[4] X. Wu and Z.A. Shelly, Physica D 40, 433 (1989)].
[5] Sartorelli J.C., Gonçalves W.M. , Pinto R.D., Phys. Rev. E 49, 3963 (1994)
[6] Innocezo A., Paladini F., Renna L., Phys Rev. E 65, 056208 (2002)

PERIODIC ORBITS AND BIFURCATIONS IN THE SITNIKOV FOUR-BODY PROBLEM

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We study the existence, linear stability and bifurcations of what we call the Sitnikov family of straight line periodic orbits in the case of the restricted four-body problem, where the three equal mass primary bodies are rotating on a circle and the fourth (small body) is moving in the z – direction vertical to the center mass of the other three. Contrary to the restricted three-body Sitnikov problem, where the Sitnikov family always exists as the ``family parameter'' $\dot{z}_0$ (or z_0) tends to infinity, and in which we have infinitely many critical Sitnikov periodic orbits, here this family exists only in **one interval** of $\dot{z}_0$ values and only **twelve three-dimensional families** of symmetric periodic orbits exist, which bifurcate from twelve corresponding critical Sitnikov periodic orbits. We also calculate the evolution and the end of the characteristic curves of these 3D branch-families as well as their stability. In the three-body Sitnikov problem all the bifurcated 3D families end on the plane but in the four-body problem there are 3D families whose periodic orbits never become planar.

STUDY OF THE DYNAMIC BEHAVIOUR OF NONLINEAR DUFFING -VAN DER POL TYPE CIRCUIT

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We have studied the dynamic behavior of a nonlinear Duffing-Van Der Pol type circuit at different values of amplitude of signal inputs and selected values of frequencies. We have examined bifurcation diagrams for selected values of amplitude and frequency, Poincare' maps with strange attractors of special interest and phase portraits. We have observed the appearance of bubbles (primary bubble) as well as the development up to their distributions by the use of elements of circuits as control parameter. Diagrams, which show the phenomenon of antimonotonicity, have been presented. In these diagrams period doubling and reverse period doubling have appeared with chaotic region and period windows between them.

NON-LINEAR ANALYSIS OF EEG SIGNALS AS A USEFUL DIAGNOSTIC INFORMATION TOOL FOR THE LOCALIZATION OF THE EPILEPTIC FOCUS

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Nonlinear time series analysis techniques have been developed to analyze and characterize apparently irregular behavior − a distinctive feature of the EEG. These techniques, apart from classical measures such as power spectral estimates, or auto-correlation function, mainly involve estimates of correlation dimension, entropy related measures, Lyapunov exponents, measures for determinism, similarity, interdependencies, recurrence quantification as well as tests for nonlinearity. Their application to EEG recordings during physiological and pathological conditions was shown to offer new information about complex brain dynamics. In particular, the nonlinear EEG analysis allows characterizing chronic alterations of the epileptic brain providing potentially useful diagnostic information about the localization of the epileptic focus. To characterize complexity we estimate the autocorrelation function, the power spectrum, and the correlation dimension D_2. Furthermore, we use the Singular Value Decomposition Analysis (SVD Analysis) as a noise filter in order to obtain additional information about the underlying dynamics. We analyze intracranial EEG recordings from epileptic patient during the seizure attack from within and from outside the seizure generating area. The apparent random character of the EEG time series is revealed by the abrupt decaying profile of the autocorrelation coefficient. Furthermore, the power spectrum for all the time series is continuum and aperiodic. The values of correlation dimension D_2, calculated from interictal recordings were significantly lower for the epileptic focus ($D_2 \approx 3$) as compared to remote areas of the brain, for which the slopes of the correlation integrals do not reveal saturation profile. These results indicate that the dynamics within the seizure generating area are low dimensional and high dimensional for the remote areas of the brain and are in agreement with the outcomes of the SVD Analysis on EEG time series for both the infocus and outfocus electrodes records during seizure attack. Summarizing these findings we conclude that the nonlinear EEG analysis allows the characterization of the dynamics of different brain regions during seizure attack and this could help in the exact localization of the epileptic focus for successful surgical treatment.

USING FLI TO TRACK BREATHERS IN CHAINS OF COUPLED SYMPLECTIC MAPS

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We study the stability of localized in space and periodic in time oscillations (called breathers) in a system of coupled oscillators (Suris maps in our case). FLI is computed in order to categorize each orbit of the phase space of the central oscillator into chaotic or regular. Hence, we can study non-linear stability. Moreover, we increase the size of chain, i.e. the number of coupled oscillators, from three to five and then to nine and further, observing the changes to the stability of the breathers. We can see that the results given by the linear stability analysis agree with the results of the FLI scans of the phase space. What is more, it is shown that a chain of size 9 is enough to describe the stability properties of the system, since further increase of its size has no significant effect. We also attempt to use the scans of phase space with FLI in order to detect breathers without previous knowledge of their exact position in phase space.

NONLINEAR PROPERTIES OF MIXED CATION GLASSES

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The structural properties of mixed cation glasses were investigated by molecular dynamics simulations in Li- and Na-containing borate glasses with composition $0.3M_2O$-$0.7B_2O_3$ (M=Li,Na). Simulated mixed glasses were prepared either by mixing the cations at 5000 K (melt grown mixed glasses) or by the ion exchange process at final temperatures slightly above the simulated glass transition temperature of each composition (ion exchanged mixed glasses). For ion exchange, binary compositions, with appropriate speciation of ca. 1024 particles, were enclosed in a primitive cubic cell, in contact with adjacent cubic cells in the z-direction filled with $NaNO_3$ or $LiNO_3$, for M=Li or Na, respectively. It was verified that the foreigner ions diffuse in the entire primitive cell whereas at the same time host ions moved towards the adjacent cells. During this simulated ion exchange process, short-range order structural changes occurred and, at the same time the composition of the simulated glass in the primitive cell is conserved, considering both types of cations. For melt grown mixed glasses the structural properties were found to vary in a nonlinear way as a function of mixing. This finding was further attributed to the formation of clusters consisting of dissimilar cations within the glass matrix. The results are correlated with the nonlinear dynamic properties that characterize mixed cation glasses.

STATE SPACE RECONSTRUCTION FOR MULTIVARIATE TIME SERIES PREDICTION

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In the nonlinear prediction of scalar time series, the common practice is to reconstruct the state space using time-delay embedding and apply a local model on neighborhoods of the reconstructed space. The well-known method of false nearest neighbors is often used to estimate the embedding dimension. For prediction purposes, the optimal embedding dimension can also be estimated by some prediction error minimization criterion.
We investigate the proper state space reconstruction for multivariate time series and modify the two above mentioned criteria to search for optimal embedding in the set of the variables and their delays. We pinpoint the problems that can arise in each case and compare the state space reconstructions (suggested by each of the two methods) on the predictive ability of the local model that uses each of them. Our results are obtained from Monte Carlo simulations on known chaotic maps.

EXPERIMENTAL SYNCHRONIZATION OF TWO RESISTIVELY COUPLED DUFFING-TYPE CIRCUITS

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The last decades chaotic synchronization became a very important research field among the scientists, because of its applications in secure communications. This work explores the phenomenon of the chaotic synchronization between two identical nonlinear circuits. The circuits we used are two second order nonlinear electrical circuits, described by the well known Duffing's equation. We coupled the circuits via a linear resistor and we examined the behavior of the system in two different cases of coupling, (bidirectional and unidirectional). In both cases of coupling, we found out, that the system is synchronized for different values of the coupling resistor. Finally, we compared the theoretical results from the simulation, with the experimental results and we saw that the system had the expected dynamical behavior.

CRITERIA FOR LARGE-SCALE CHAOS IN THE PROBLEM OF HOMOGENEOUS MAGNETIZATION

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We consider the one-dimensional non-autonomous Hamiltonian system related to Landau-Lifshitz equation for homogeneous magnetization. By applying the subharmonic Mel'nikov theory we determine the generation of periodic orbits at the main resonances 1/1 and –1/1 with the external magnetic field. Then, by considering time as an additional degree of freedom and using the second-order perturbation theory developed recently by Meletlidou and Stagika (2006), we determine the generation of periodic orbits at the 0/1 resonance. Then, by evaluating the distance of the above resonances in the Poincare section we find an estimate for the resonance overlapping and thus the generation of global stochasticity. Although this is an overestimate due to the existence of higher-order resonances, it is a better one, compared to the estimate obtained by first-order theory.
