CHAOS 2017

Book of Abstracts

10th Chaotic Modeling and Simulation International Conference

Editor

Christos H. Skiadas

30 May – 2 June 2017

Barcelona, Spain

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Preface

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It is our pleasure to welcome the guests, participants and contributors to the 10th International Conference (CHAOS2017) on Chaotic Modeling, Simulation and Applications. We support the study of nonlinear systems and dynamics in an interdisciplinary research field and very interesting applications will be presented. We intend to provide a widely selected forum to exchange ideas, methods, and techniques in the field of Nonlinear Dynamics, Chaos, Fractals and their applications in General Science and in Engineering Sciences.

The principal aim of CHAOS2017 International Conference is to expand the development of the theories of the applied nonlinear field, the methods and the empirical data and computer techniques, and the best theoretical achievements of chaotic theory as well.

Chaotic Modeling and Simulation Conferences continue to grow considerably from year to year thus making a well established platform to present and disseminate new scientific findings and interesting applications. We thank all the contributors to the success of this conference and especially the authors of this *Book of Abstracts* of CHAOS 2017.

Special thanks to the Scientific Committee, the ISAST Committee and Yiannis Dimotikalis, the Conference Secretary Mary Karadima and all the members of the Secretariat.

May 2017
Christos H. Skiadas
Conference Chair

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CHAOS 2017

Chaotic Modeling and Simulation International Conference
Barcelona, Spain, 30 May – 2 June 2017

Honorary Committee and Scientific Advisors

Plenary and Keynote Talks

Chimeras: Do They Exist in the Real World?

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Institute for BioEngineering of Catalonia (IBEC), Spain

Despite having a simple structure, networks of coupled oscillators can show highly complex dynamics. We here focus on a particularly intriguing example, the so-called chimera states, which are characterized by a co-existence of synchronous and asynchronous motion. Such chimera states can be found for example in rings of identical, non-locally coupled phase oscillators. Despite the translational symmetry of the network's structure, its dynamics segregates into two complementary groups. While a group of nodes oscillates coherently, the remaining oscillators perform an erratic motion. There is growing conceptual and experimental evidence that chimera states are relevant for the understanding of real-world networks. I will briefly review these findings including some recent results of our own work. In this work, we pointed to an analogy between the sudden collapse of chimera states to a fully coherent state on the one hand and the onset of epileptic seizures on the other hand. We will furthermore look at different of ways of controlling the dynamics of chimera states proposed by several groups in the past few years. Evidently, taking the step from understanding to controlling chimera states further advances the applicability of this concept. It opens new perspectives in science and engineering.

Keywords: Coupled oscillators, chimera states, synchronization, electroencephalography, epilepsy.

"Power Spectrum Analysis and Missing Level Statistics of Microwave Graphs with Violated and Preserved Time Reversal Invariance"

Michał Ławniczak, Małgorzata Białous, Vitalii Yunko, Szymon Bauch, Barbara Dietz, Leszek Sirko
Polish Academy of Sciences, Poland

In the talk I will discuss experimental and numerical studies of the power spectrum and other fluctuation properties in the spectra of microwave networks simulating chaotic quantum graphs with broken and with preserved time reversal symmetry. In the measurements a few percent of the levels were missing in each realization of a quantum graph.
On the basis of our data sets we demonstrate that the power spectrum in combination with long-range and short-range level correlations provides a powerful tool for the identification of the symmetries and the determination of the fraction of missing levels. It is important to point out that such a procedure is indispensable for the evaluation of the fluctuation properties in the spectra of, e.g., molecules or nuclei, where one has to deal with missing levels.
The subject of my talk extends substantially the results presented in our recent publication [1].

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[1]. M. Białous, V. Yunko, S. Bauch, M. Ławniczak, B. Dietz, and L. Sirko, Phys. Rev. Lett. 117, 144101 (2016).

Acknowledgements: *This work was partially supported by the Ministry of Science and Higher Education grant UMO-2013/09/D/ST2/03727 and the EAgLE project (FP7-REGPOT-2013-1, Project Number: 316014).*

On the Real Jacobian Conjecture

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The real Jacobian conjecture said: If $F = (f, g): \mathbb{R}^2 \to \mathbb{R}^2$ be a polynomial map such that $\det(DF(x))$ is different from zero for all $x \in \mathbb{R}^2$, then F is injective.
This conjecture had a negative answer by Pinchuk in 1994. Now several authors look for adding an additional assumption to the fact that $det(DF(x))$ is different from zero for all $x \in \mathbb{R}^2$, in order that the conjecture holds.
Theorem 1. Let $F = (f, g): \mathbb{R}^2 \to \mathbb{R}^2$ be a polynomial map such that $det(DF(x))$ is different from zero for all $x \in \mathbb{R}^2$. We assume that the degrees of f and g are equal and that the higher homogeneous terms of

the polynomials f and g do not have real linear factors in common, then F is injective.

Theorem 2. Let $F = (f, g): \mathbb{R}^2 \to \mathbb{R}^2$ be a polynomial map such that $det(DF(x))$ is different from zero for all $x \in \mathbb{R}^2$and $F(0,0) = (0,0)$. If the higher homogeneous terms of the polynomials $ff_x + gg_x$ and $ff_y + gg_y$ do not have real linear factors in common, then F is injective.

Theorems 1 and 2 are proved using qualitative theory of the ordinary differential equations in the plane.

Statistics of Neutron Resonance Width and Random Matrix Theory (RMT) (local approach versus semicircle law-based consideration)

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(Dated: 19th July 2016)

For many years, experimentally observed nearest level spacings as well as widths statistics of thw low-energy resonance neutron scattering off heavy nuclei were believed to be in good agreement with predictions of the Random Matrix Theory (RMT). However, relatively recent measurements of the neutron widths distribution [1] display appreciable deviation from the famous Porter-Thomas distribution (PTD): $\frac{dw}{dx} = \frac{e^{-x/2}}{\sqrt{2\pi x}}$, where$x = \Gamma/\langle\Gamma\rangle$,is the resonance width measured ih the units of its mean value. These deviations have been interpreted by the authors as a clear evidence of irrelevance of the RMT approach.

It should be said that the statement is quite misleading. Indeed, the PTD could be valid only if a given resonance would not be exposed to any influence of the other (including remote enough) one. As a rule, this is not the case. In practice, resonances overlap because of their finite Breight-Winger widths and interference effects essentially influence the width distribution. There are known a few examples where the actual widths distributions had been investigated analytically under some additional conditions. In particular, the distribution of the strongly overlapping resonances of a time-reversal invariant system under condition that the number M of the reaction channels is very large and scales with number $\mathrm{N} \to \infty$ of the energy levels has been described in detail in [2]. The most complete and comprehensive description of the width distribution is also from [3] for the systems without time-reversal symmetry. The number M of the channels as well as the degree of resonance overlapping is assumed in the latter study to be arbitrary.

Regrettably, the problem becomes much more complicated and the obtained results, [4], are appreciably more restricted in the case of the $T - invariant\ systems$, such as atomic nuclei. Nevertheless, a complete explicit expression can be derived, [5], for the joint distribution of arbitrary number N of interfering nucleat resonanceswith only one (M=1) open decay channel and that is just the case of the neutron resonance scattering.

In fact, to obtain the desired width didtributrion of a given resonance, two non-trivial calculations still have to be performed. Namely, one has to intergrate over positions of all other resonances within some energy interval as well as over the widths of all of them save the one of our interest. Neither of these calculations are trivial. More than that, the very choise of the energy interval is questionable. Let us explain this in more details.

In accordance with the standard RMT, the energy levels of a (closed) system with chaotic dynamics are distributed along the energy axis in some finite interval $-\alpha < E < \alpha$ with the density given by the so called semicircle law:

$$\varrho(E) = N\frac{2}{\pi\alpha^2}\sqrt{\alpha^2 - E^2}$$

Where N is the number of the system's levels and α stands for the radius of the semicircle. At that, the density vanishes identically outside this interval while the number N of the levels inside it is supposed to be infinitely large. At last, the resonance of our interest is situated in the centre $E = 0$ of the semicircle. Within this framework, the width distribution problem have recently been reconsidered in [6], [7].

A shady aspect of this approach consists in intimate connection with the specific peculiarities of the semicircle distribution that manifests itself, in particular, in the strong influence of all resonances within the semicircle including the remote ones to its very ends, along with the complete obliteration off all the resonances outside the finite-sized semicircle interval $-\alpha < E < \alpha$. As a matter of fact, the semicircle law has nothing in common with the properties of the real energy spectrum of heavy nuclei. In the reality, the density of nuclear levels monotonically increases with the energy as $\exp(\sqrt{E/E_F})$ instead of vanishing outside some semicircle. Leaving this fact in oblivion could hardly be superposed with strong influence of the resonances with the energies $E \lesssim \alpha$.

The aim of the proposed presentation is twofold: to give an overview of the current state of the things and to put forward an alternative approach based on the idea that the main effect originates from the influence with only a few nearest neighboring resonances.

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Recurrence and Diffusion in FPU Chains with Alternating Masses

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The periodic Fermi-Pasta-Ulam problem with alternating masses presents complicated dynamics. In joint work with Roelof Bruggeman we analyze the cases of eight and 2n interacting particles to find periodic solutions and invariant manifolds, but with a dynamics that is strongly affected by the choice of the alternating mass m. Normal form calculations help to identify quasi-trapping regions leading to delay of recurrence.
In the case of 2n particles the use of symmetries generalizes the analysis to three exact periodic solutions and families of invariant manifolds (bushes). The results of accidental resonances and diiffusion suggest that equipartition of energy near stable equilibrium is not probable.

Invited Talks

Modelling the Brain: From Dynamical Complexity to Neural Synchronisation, Chimera-like States and Information Flow Capacity

Chris G. Antonopoulos
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In this talk, I will present a review of my recent work on the study of the brain, aiming to reveal relations between neural synchronisation patterns and information flow capacity, namely the largest amount of information per time unit that can be transmitted between the different parts of the brain networks considered. I will start with the working hypothesis, presented in Ref. [1] and supported by numerical evidence, that brains might evolve based on the principle of the maximisation of their internal information flow capacity. In this regard, we have found that synchronous behaviour and information flow capacity of the evolved networks reproduce well the same behaviours observed in the brain dynamical networks of the Caenorhabditis elegans (C.elegans) soil worm and humans. Then, I will talk about the verification of our hypothesis by showing that Hindmarsh-Rose (HR) neural networks evolved with coupling strengths that maximize the information flow capacity are those with the closest graph distance to the brain networks of C.elegans and humans. Finally, I will present results from a recently published paper [2] on spectacular neural synchronisation phenomenon observed in modular neural networks such as in the C.elegans brain network, called chimera-like states. I will show that, under some assumptions, neurons of different communities of the brain network of the C.elegans soil worm equipped with HR dynamics are able to synchronise with themselves whereas others, belonging to other communities, remain essentially desynchronised, a situation that changes dynamically in time.

Keywords: Brain modelling, Neural synchronisation, Chaotic behaviour, Information flow capacity, C.elegans, Hindmarsh-Rose neural dynamics, Chimera-like states.

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Spectrum and Entropy of Anosov-Kolmogorov C-K Systems. MIXMAX Random Number Generator

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The uniformly hyperbolic Anosov C-systems defined on a torus have very strong instability of their trajectories, as strong as it can be in principle. These systems have exponential instability of all their trajectories and as such have mixing of all orders, nonzero Kolmogorov entropy and a countable set of everywhere dense periodic trajectories. We are studying the properties of their spectrum and of the entropy. For a two-parameter family of C-system operators A (N, s), parameterised by the integers N and s, we found the universal limiting form of the spectrum, the dependence of entropy on N and the period of its trajectories on a rational sublattice. One can deduce from this result that the entropy and the periods are sharply increasing with N. We present a new three-parameter family of C-operators A (N, s, m) and analyse the dependence of its spectrum and of the entropy on the parameter m. We are developing our earlier suggestion to use these tuneable Anosov C-systems for multipurpose Monte-Carlo simulations. The MIXMAX family of random number generators based on Anosov C-systems provide high quality statistical properties, thanks to their large entropy, have the best combination of speed, reasonable size of the state, tuneable parameters and availability for implementing the parallelisation.

Special Sessions Talks & Contributed Talks

Full Disclosure Attack on Ultralightweight Mutual Authentication Protocol: SASI

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RFID is one of the most growing identification schemes in the field of ubiquitous computing. Unique identification and non-line of sight capabilities result in rapid deployment of this technology as compared to other identification schemes. In addition to functional haste, RFID incorporates wireless medium therefore security and privacy are two important concerns of RFID systems. To prevent the system from malicious adversaries in a cost effective manner, several Ultralightweight Mutual Authentication Protocols (UMAPs) havre been proposed. Simple logical operations are being used by these protocols such as XOR, AND, OR etc. and hence prove to be less secure than traditional cryptographic protocols. In this research cryptanalysis of the state of the art UMAP: SASI protocol is performed and revealed its secret ID with 100% success rate. The proposed attack model highlights the weak diffusion properties of the protocol messages and primitives.

Keywords: Index Terms—RFID, UMAP, Tango attack, SASI, cryptanalysis

Lyapunov Exponent Evaluation of the CBC Mode of Operation

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The Cipher Block Chaining (CBC) mode of encryption was invented in 1976, and it is currently one of the most commonly used mode. In our previous research works, we have proven that the CBC mode of operation exhibits, under some conditions, a chaotic behavior. The dynamics of this mode has been deeply investigated later, both qualitatively and quantitatively, using the rigorous mathematical topology field of research. In this article, which is an extension of our previous work, we intend to compute a new important quantitative property concerning our chaotic CBC mode of operation, which is the Lyapunov exponent.

Keywords: Lyapunov coefficient, Cipher block chaining, mode of operation, Topological study.

Cosmological Parameters and Higgs Boson in a Fractal Quantum System

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The stochastic deformation and stress fields inside the fractal quantum system are investigated. It is shown that in the coupled system (dislocation – quantum dots) the presence of fractal quantum dot leads to a curvature of fractal dislocation core. For the fractal model of the Universe the relations of cosmological parameters and the Higgs boson are established. Estimates of the critical density, the expansion and speed-up parameters of the Universe (the Hubble constant and the cosmological redshift); temperature and anisotropy of the cosmic microwave background radiation were performed.

Keywords: Fractal Quantum System, Stochastic Deformation and Stress Fields, Higgs Boson, Cosmological Parameters, Fractal Model of the Universe.

Behavior of Coupled Fractal Structures and Their Attractors in the Model Nanosystem

Olga P. Abramova, Andrii V. Abramov
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The behavior of the deformation field of coupled fractal structures in the multilayer nanosystems is investigated. On the example of coupled fractal surfaces (elliptic and hyperbolic type) it is shown that the behavior of the deformation field is determined by mutual influence of stochastic processes on each other. Features of behavior of attractors (singular points) of the deformation field for these structures is investigated. When changing the governing parameters, there are possible effects of alteration and moving of the fractal structures relative to each other.

Keywords: Fractal Bulk Structures, Coupled Systems, Attractors, Deformation Field, Multilayer Nanosystem.

Critical Exponents of Directed Percolation: Three-Loop Approximation

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Directed bond percolation problem is an important model in statistical physics. It provides a paramount example of non-equilibrium phase transitions. Up to now its universal properties are known only to the second-order of the perturbation theory. Here, our aim is to put forward a numerical technique with critical exponents of directed percolation universality class can be calculated to the higher orders of perturbation theory. It is based on the perturbative renormalization scheme in ε, where ε = 4-d is a deviation from the upper critical dimension. The universal quantities are expressed in terms of irreducible renormalized Feynman diagrams and there is no need for calcuation of renormalization constants. Numerical evaluation of integrals has been done using Vegas algorithm from CUBA library. In the framework of this procedure, dynamical exponent z and critical exponent η are computed up to three-loop order in ε.

Keywords: Directed bond percolation, renormalization group, non-equilibrium phase transition, multidimensional numerical integration

Mobile Robot with Chaotic Displacement and Obstacle Avoidance for Surveillance and Exploration Tasks Using a Bounded Control Law

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The effectiveness of robots in exploration and surveillance tasks is related basically to the coverage achieved in the workspace and to the unpredictability of its route or trajectory. This paper presents a control proposal for this kind of tasks through the tracking of chaotic trajectories in an omnidirectional mobile robot. The proposal achieves a complete sweep of the patrolled or explored area and a difficult prediction of the robot movements thanks to the topological transitivity and the sensitivity to initial conditions that the chaotic systems have. It is emphasized that this control law is continuous with a procedure for fixed obstacle avoidance and that it keeps the robot speed bounded; this last issue is very important for an adequate implementation. The fulfillment of the

control objective of chaotic trajectory tracking is demonstrated by means of the Lyapunov stability theory. Finally, to validate the proposed control scheme, simulations with satisfactory results are showed.

Keywords: Chaos, tracking, obstacle avoidance, mobile robot, bounded control law.

Modeling of Summarization Process According to Basic Concepts of Text Invariants

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The study and description of complex systems behavior, such as natural language and its mechanisms of use in written and oral form, can be expressed in the most comprehensive and volume way within the theory of chaos from a position of the system general behavior. In this paper, we propose a model of a text semantic analysis in summarization process according to the basic concepts of text invariants, which help to analyze the text at the level of the deep semantics, gradually improving referencing model on the semantic level. Text databases are used as basic invariants, which are semantic core of a text, semantic inverse images of s and texts conceptual invariants. It is proposed to use text databases as a basis for constructing situational models and invariant representations of situations, which underlie in understanding of text meaning by a person. A model of building semantic inverse images of s for the synthesis of sentences in automatic summarization was developed.

Keywords: complex systems, the language structure, comprehension strategies, text conceptual invariant, text database, semantic text analysis, modeling, automatic summarization.

Compact Finite Differences Method for Burger-Huxley Equation

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A numerical solution for the Burgers-Huxley equation is presented by using compact finite differences method. In the solution of the problem, finite differences discretization along the time, and fifth-order compact finite differences scheme along the spatial coordinate have been applied. The result shows that the applied method in this study is an applicable technique and approximates the exact solution very well.

Influence of Aspect Ratio on Roads to Chaos in Cavity Containing Nanofluid

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We studied numerically the transient laminar natural convection in two cavities for A=1 and A=2. The fluid is water and the nanofluid is copper oxide (CuO). The horizontal walls are adiabatic and the vertical walls are composed of the two regions of the same size maintained at different temperatures. Transfer equations are resolved using the (stream function -vorticity formulation). We analyzed the effect of Rayleigh number on heat transfer and on the roads to chaos borrowed by the system for the two cavities. The first Hopf bifurcation was observed and our systems are determinist. As the Rayleigh increased multiplicity solutions are represented by attractors in spaces of phases. We compared results obtained between the two cavities.

Keywords: Natural convection, Bifurcation, Critical Rayleigh number, Limit point, Limit cycle, Attractor, Nanofluid.

Correlation and Spectral Properties of Chaotic Signals Generated by Tent-Like Maps

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Complete spectral characterization of chaotic signals is of fundamental importance when it comes to Engineering applications of these signals, in particular to chaos-based communication systems. As the available spectrum is limited, it is necessary to control the spectral characteristics of the transmitted signals.
In this context, we recently deduced the autocorrelation sequence and the power spectral density of chaotic signals generated by a family of piecewise linear maps with an arbitrary number of segments, all of them with positive slope [1].
In this work, we extend this result for segments with positive or negative slopes. This way, this new results englobes our previous and also skew tent maps besides a number of other maps presented in the literature [2,3,4].
Numerical simulations are presented to confirm the theoretical results.

Keywords: Chaos, Chaos-based Communication, Autocorrelation Sequence, Spectral Analysis, Piecewise Linear Maps.

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Anomalous Diffusion by the Fractional Fokker-Planck Equation and Levy Stable Processes

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Understanding anomalous transport in magnetically confined plasmas is an outstanding issue in controlled fusion research. A satisfactorily understanding of the non-local features as well as the non-Gaussian probability distribution functions (PDFs) found in experimental measurements of particle and heat fluxes is still lacking. In particular, experimental observations of the edge turbulence in the fusion devices show that in the scrape of layer (SOL), the plasma fluctuations are characterized by non-Gaussian PDFs. It has been recognized that the nature of the cross-field transport through the SOL is dominated by turbulence with a significant ballistic or non-local component where a diffusive description is improper. It has been shown that the chaotic dynamics can be described by using the Fokker-Planck equation (FPE) with coordinate fractional derivatives as a possible tool for the description of anomalous diffusion. We present a study of anomalous transport in terms of the Fractional FPE in relation to the Langevin equation with Levy white noise. The goal of this work is to give an overview and new insights into the recent development in the statistics of charged particle motion in the presence of a-stable Levy fluctuations in an external magnetic field and linear friction using Monte Carlo numerical simulations and a theoretical framework for the FFPE. The Levy noise is introduced to model the effect of non-Gaussian, intermittent electrostatic fluctuations. The statistical properties of the velocity moments and energy for various values of the Levy index a are investigated as well as the role of Levy fluctuations in the statistics of the particles' Larmor radii in order to examine potential limitations of gyro-averaging. In addition, to this we elucidate on the nonextensive properties of the velocity space statistics and characterization of the fractal process in terms of Tsallis statistics. Two limiting cases of the forced FFPE were studied using an expansion in the fractionality parameter a close to two. However, due to

the intractability of these models, a minimal model for the FFPE is thus constructed retaining mainly the effects of the fractional operator in order to understand the properties of the FFPE. Furthermore, we corroborate the analytical work with numerical solutions to the Langevin system with Levy distributed noise which show qualitatively similar results.

Keywords: Non-local theory, Levy noise, Tsallis entropy, Fractional Fokker-Plank Equation.

New Method for Constructing Solutions of Nonlinear Partial Differential Equations

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A new method for reducing nonlinear partial differential equations to the equivalent systems of ordinary differential equations on the definite function class is proposed. The method is based on the corollary of the Kolmagorov's theorem (about representation of functions of several variables in the form of a superposition of one-variable functions products) and bilinear functional equations theory. This method allows to obtain a number of new (including soliton) solutions of nonlinear equation of mathematical physics.

Keywords: Nonlinear partial differential equations, Bilinear functional equations, Soliton solutions, Separation of variables.

Applying Nonlinear Analysis to Brain Signals: From Claims of Chaos to Clinical Applications

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In my talk I will review the mutually beneficial interaction between the development of nonlinear signal analysis techniques on the one hand and applications of these techniques to signals from the brain on the other hand.
The framework of nonlinear time series analysis was initially introduced using signals from low-dimensional dynamical systems. It was shown that for example a non-integer value of the correlation dimension or a positive Lyapunov exponent are indicative of a chaotic dynamics. Shortly after, numerous applications to experimental real-world data were published and reported evidence for low-dimensional chaos in recordings from the brain, climate data and many more. These reports

provoked a controversial discussion about the conclusiveness of indicators for chaos when extracted from experimental data. It became clear that while it was straightforward to interpret the correlation dimension or Lyapunov exponents for low-dimensional mathematical model systems, their interpretation for experimental data is more involved.
Fortunately, this initial controversy quickly took a positive twist. Problems encountered in the application of nonlinear signal analysis to real-world signals permanently led to the improvement of the underlying methods. This holds in particular for signals from neuronal dynamics. Existing techniques were improved, for example by correcting for the influence of temporal correlations. New techniques were developed for data modalities which are specific for neuroscience experiments, such as multiple recordings of stimulus triggered activity. Furthermore, completely new analysis frameworks, such as the concept of surrogate time series, were introduced. It was specifically this progress which in turn was the key for a successful characterization of neuronal recordings.
After reviewing this evolution outlined above, I will show some own results in this context obtained in close collaboration with clinical partner institutions. I will show studies of continuous electroencephalographic (EEG) recordings from patients with epilepsy. For example, we compared different types of time series analysis measures with regard to the localization of the epileptic seizure-generating brain area from recordings of the seizure-free interval. We found that nonlinear time series analysis measures show a very high performance in this task, if and only if they are combined with surrogate time series. If they are applied without using surrogate time series, they hardly outperform classical linear measures such as estimates of the linear correlation. Apart from the theoretical appeal of such findings, the prospect to reliably localize the epileptic focus without the necessity of observing actual seizure activity, is of clear clinical relevance.

Keywords: Nonlinear time series analysis, surrogate signals, neuronal data, electroencephalography, epilepsy.

Passive Advection of a Vector Field: Effect of Strong Compressibility

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The field theoretic renormalization group and the operator product expansion are applied to the stochastic model of passively advected vector field with the general form of the nonlinear term. The advecting velocity field is generated by the stochastic Navier-Stokes equation with compressibility taken into account. The model is considered in the vicinity of space dimension $d = 4$ and the perturbation theory is constructed within double expansion scheme in y and $epsilon=4-d$. Here y describes scaling behavior of the random force that enters a stochastic equation for the velocity field. We show that the correlation functions of the passive vector field in the inertial range exhibit anomalous scaling behavior. The critical dimensions of tensor composite fields of passive vector field are calculated in the leading order.

Keywords: anomalous scaling, passive vector advection, field-theoretic renormalization group

A New Chaos-based Stream Cipher for Real-time Multimedia Encryption using FPGA Platform

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Embedded systems are today, progressively present in many applications. The connectivity of all these devices to different telecommunication networks, and ultimately to the Internet, has become the norm or is in the process of becoming so. However, transmitted critical data between these systems can be easily attacked by an intruder. Therefore, the security of multimedia information is today a great challenge of embedded communicating systems to be taken into account during the initial stages of the development of an embedded system and it must be considered simultaneously with current constraints (consumption, surface, etc.). This paper presents the development and hardware implementation using FPGA of a new chaos-based stream-cipher dedicated to real-time multimedia encryption for embedded applications. Our solution is based on a VHDL description of a new stream chaos-based key generator including feedback chaotic synchronization. The proposed architecture is particularly attractive since it provides a high security and a good trade-off between performance and hardware resources.

Keywords: Chaotic encryption, embedded system, stream cipher, chaotic synchronization, Hardware FPGA, VHDL, multimedia.

Regional Control and Synchronization of Cellular Automata

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Spatially extended systems mainly cellular automata (CA), may exhibit unpredictable behavior. In the context of regional control problems, we are interested in this paper in forcing the system by exerting appropriate actions in order to make it behave in a desired way only on a subregion of the domain. It aims at synchronizing two systems (master/slave) by means of agents that make measurements on an experimental system and transmit this information to the controlled one. We investigate the case of agents fixed on the boundary of the region, in one dimension CA. The problem will be extended to the case of agents performing different types of random walks, either "blind" or targeted.

Keywords: Spatially extended systems, control theory, synchronization

Analysis of Exchange Rate Variation in Small Economies of Southern Caucasian Countries

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In this report we represent results of our analysis on the complexity measure calculation of currency exchange variation for two small economies of former USSR countries Armenia and Georgia. According to Index of Economic Freedom (IEF) Armenia and Georgia fell in different groups; Georgia is listed as 22st among countries with mostly free economics (overall score 72.6, for 15 January of 2014) while Armenia is listed as 41st with economy regarded as moderately free (with overall score 68.9, for 15 January of 2014). The analyzed in this research data represent daily exchange rates of Armenian and Georgian national currencies with respect to the United States Dollar. Data sets of daily exchange rate, from 2001 to 2013, have been acquired from the official electronic sites of the Central Bank of Armenia and National Bank of Georgia. For analysis of currency exchange data, we used the Lempel and Ziv complexity (LZC) data analysis method. In order to be focused on the daily variability features of currency exchange process we have calculated LZC values of the increment series of mentioned above original exchange rate data sets. It was shown, that for the entire considered 13 year time, period daily increment sequences of Armenian Dram reveal larger extent of complexity (LZC=0.90) comparing to Georgian Lary (LZC=0.73).

It is important that LZ complexity values of both used data sets changed for different parts of considered time periods. Exactly in the first, second and third parts of analyzed time period, measured LZC values of Armenian Dram daily increment series were 0.97, 0.88 and 0.91 accordingly. For daily increments of Georgian Lary consequently we calculated following LZC values of 0.81, 0.66 and 0.71. Moreover, when we looked at variation of complexity measure for smaller, one year, windows we observed that for both currencies this characteristic evolves almost in parallel, always being larger for Armenian dram. It should be stressed that for both analysed currencies exchange rate daily increment time series reveal maximum for about 2002-2003. At the same time minimal values of calculated LZC have been detected prior starting of financial crisis in about 2007-2008. LZC value for increment data sets of Georgian Lary exchange rate decreased to 0.5-0.6 in this time period. Thus we see that increment series of exchange rate data sets of Georgian Lary always reveal lesser value of Lempel and Ziv complexity measure comparing to Armenian dram. This means that variation of daily increments of Georgian currency exchange rate is more regular comparing to Armenian currency exchange rate which is closer to randomness. This situation holds for whole analysed period as well as for certain parts of whole considered time period.

Keywords: Economics, exchange rate, complex dynamics, time series analysis. Chaotic modeling.

Stochastic-Resonance-like Phenomena in a Class of Biologically Inspired Generic Models

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A novel case of probabilistic coupling for hybrid stochastic systems with chaotic components via Markovian switching is presented. We study its stability in the norm, in the sense of Lyapunov and present a quantitative scheme for detection of stochastic stability in the mean.

In particular we examine the stability of chaotic dynamical systems in which a representative parameter undergoes a Markovian switching between two values corresponding to two qualitatively different attractors. To this end we employ, as case studies, the behaviour of two representative chaotic systems (the classic Roessler and the Thomas-Roessler models) under the influence of a probabilistic switch which modifies stochastically their parameters. A quantitative measure, based on a Lyapunov function, is proposed which detects regular or irregular motion and regimes of stability.

In connection to biologically inspired models (Thomas-Roessler models), where strong fluctuations represent qualitative structural changes, we observe the appearance of stochastic resonance-like phenomena i.e. transitions that lead to orderly behaviour when the noise increases. These are attributed to the nonlinear response of the system.

Keywords: Stochastic Resonance, Biological Circuits, Thomas-Roessler class of models, Lyapunov Stability.

Multifractal Analysis of a DNA Based Molecular Transistor

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The programmability, flexibility as well as low cost of synthesis, has made DNA a widely used material for creating the molecular structures and molecular electronics structures such as DNA nanowires, diode or transistor. However, self-assembled DNA-based template nanostructures have been considered as a potential method to create complex three-dimensional electronic circuitry on scales that are not accessible by conventional Silicon based materials. Designing of any functional electronic device from DNA will require a basic theoretical understanding of how carrier transport actually works in this complex biomolecule. In this work, we have tried to study the transport properties of a molecular transistor based on DNA molecules. We have considered an N-base-pairs double-stranded DNA as central molecule and two metal leads with k-sites connected to each strand of DNA. In the complex quantum systems such as mentioned system, one could see critical behaviors such as localization–delocalization transition. The statistical properties of such Hamiltonians coincide with random matrix theory (RMT) emerged from the need to characterize complex quantum systems in which the knowledge of Hamiltonian is minimal. Localization–delocalization transitions of noninteracting electrons are disorder-induced continuous phase transitions. The strong multifractality of wave-function amplitudes of this critical transition is a characteristic feature of transition. The obtained result could be confirmed via the multifractal analysis (MFA) of different sequences. In recent decades, MFA of electronic wave function at localization–delocalization transition has been a hot topic for study. We remember that at the metal–insulator transition (MIT) the multifractal spectrum is a convex function of scaling index with a maximum. Multifractal spectrum would be broader as much as the system goes toward the insulator behavior.
We have considered MFA for different DNA sequences. It is clear that all of them show concave behavior. This behavior confirms a metal–insulator transition as mentioned previously. But, if we consider the wider

interval for α parameter, it could be seen that the diagrams are smooth and they behave closer to conductivity state. Whatever AT-content of the sequence is increased, the spectrum is flatter, and then the system approaches to the insulator like behavior. Therefore, one could obtain the appropriate sequence for using in DNA transistor.

Keywords: DNA based molecular transistor, localization-delocalization transisition, Quantum Chaos, Multifractal.

Instability in Third-Harmonics Generation

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Large optical nonlinearities are critical to photonic technologies, and generation of harmonics is a convenient way of producing new wavelengths of light. In particular, third-harmonic generation from infrared sources is often used as a source of ultraviolet light. In this paper, we study the stability of the dynamics of the process of intracavity generation of third harmonic. We show that owing to a rather general phenomenon analogous to Anderson transition, a stability-instability transition due to the combined action of driving field and nonlinearity coupling is seen. It is shown that the dynamics of the system strongly depends on the external electric field of the fundamental mode and on the coupling coefficient of the interacting modes.

Absolute Negative Mobility in Ratchets: Symmetry, Chaos and Noise

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Ratchet effect refers to the possibility of transporting particles in noisy system even if the mean force is zero (zero bias). Moreover, if the transport is in the opposite direction to the bias, this transport is called Absolute Negative Mobility (ANM). In the framework of a particle in a micro-pump device, we showed that the existence of ANM is related to a parity symmetry-breaking and to a crisis of the deterministic problem. Then, adding Gaussian noise to the problem, it is generically possible to find a parameter range where ANM occurs. However, in the literature ANM may appear with different scenarios. It ensues the open questions of the roles of the parity-symmetry, the crisis transition and more generally the role of chaotic dynamics in the ANM phenomenon? This study provides answering elements to these questions.

Keywords: Ratchet, Absolute Negative Mobility, Chaotic dynamics, Symmetry-breaking, Noise, Particle transport, Synchronization.

Correct Graph of Lyapunov Exponent

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According to professional publications, (for example [1]) the graph of Lyapunov exponent in the bifurcation parameter function r has the same form as in Fig.1. The graph refers to the logistic dependence: $y_{k+1} = r y_k (1 - y_k)$. Detailed numerical tests indicate that the graph is definitely incomplete, as it turns out that in the range of variability of parameter *r,* where chaos is generated, there is an infinite number of both positive and negative values of the exponent (Fig.2). Accordingly, in the chaotic domain the graph of Lyapunov exponent has a fractal character (Fig.3). It should also be added that in practical calculations the positive values prevail. Theoretically however, there is an infinite number of both positive and negative values, but the relation of the number of positive numbers to the negative ones is also infinite. This situation is analogical to the relation between irrational and rational numbers.

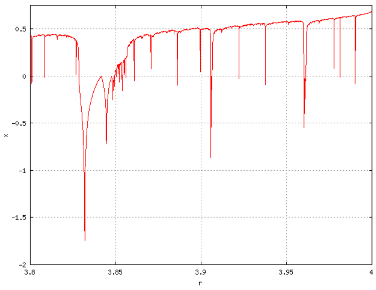

Fig.1.

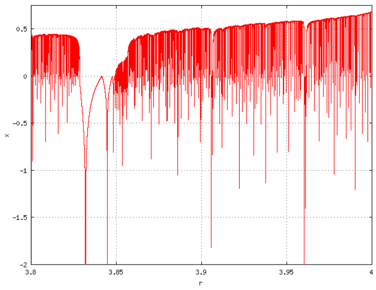

Fig.2.

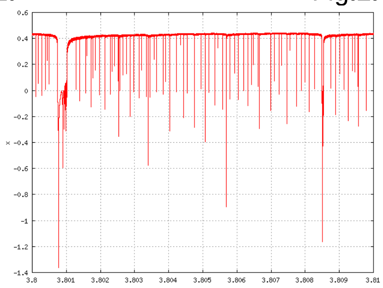

Fig.3.

Keywords: Chaos, Lyapunov exponent, logistic model, fractal.

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Is the Occurrence of an Attractor in a Multi-Scale Ndt Computer Based Data Analysis a Good Indicator of Chaos Data Modelling?

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Inverse problems approach in material testing quality assurance puts some challenges in its composition items discrete and continuous which include as well heuristics from both the norms and the human factor qualifications. Further matter features, properties, ageing, its several loading forces and engineering properties that are highly nonlinear functions are added complexity to solve.
In the case of ultrasound material diagnosis the task is more difficult to decipher since it requires analysis of continuous data originating from numerical signals obtained from each bounds of the tested material. Data carried in the output signals are usually corrupted by many structure noises, their analysis needs understanding of the matter pattern components, its engineering properties and the many human factors items or interfaces from material welding or joining and its control. Computational methods are useful signal processing tools allowing various filtering methods known to be powerful processing kernels. However many of them are suitable when noise is smooth and expressed as a zero-mean Gaussian in linear model ; but when it has indiscriminate source compilation from material's reflectors scattering as grain boundaries and other micro structures, classical tools and kernels are not very helpful means. However the complexity of the model order estimation carries on complicated modeling. Wavelet based auto regressive parametric model is a successful processing technique for natural signals, able to withdraw the non stable characteristics of data. In this study non linear numerical methods are addressed under an inverse problem approach for discriminating back-scattered ultrasonic waves and their micro structural features. A steel welded matter was used as experimental sample. Wavelet multi-scale analysis was investigated with a predictive approach, as a powerful computational tool for noise discrimination and data extraction. The analysis based correlations, residuals and interpolations calculations have able matter scales discrimination, as well detection of the material phase’s scale; and indicates a linear signal energy distribution at micro structural levels. Which could point to potential outcome of ultrasonic wave signature of

micro-structures at different energy scales related to matter phases. Multi-polynomial interpolations reveal an attractor involving data modeling through chaos theory for a predictive purpose of material behavior.

Keywords: Modeling, Simulation, Linear and nonlinear systems, Chaos in Ndt, Signal processing, Signal filtering.

Percolation Process in the Presence of Velocity Fluctuations: Two-loop Approximation

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Critical behaviour of directed bond percolation is studied in presence of an advective velocity field. The velocity field is assumed to be incompressible and generated by stochastic Navier-Stokes equation. The model is studied by means of field-theoretic approach. Renormalization group (RG) method is used in order to analyse asymptotic large-scale behaviour of the model near its critical point and to calculate perturbatively all fixed RG points and critical exponents in the framework of double-expansion scheme [1]. We classified possible asymptotic regimes corresponding to infrared stable fixed points of the RG equations which have been calculated up to the two-loop approximation.

Keywords: Directed bond percolation process, stochastic Navier-Stokes equation, perturbative renormalization group.

References:

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Wave Manifestations of Classical Chaos in Microwave Spherical Resonator with Centred Dielectric Sphere

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Cavity microwave resonators, being physical application of billiard dynamical system, can show integrable, chaotic and intermediate behavior depending of its geometry and filling. In this paper, the eigen frequencies of cavity microwave resonator with centered dielectric sphere was obtained and processed with Random Matrix Theory to

determine the presence of chaotic regions. The result of analysis of cavity microwave resonator spectral properties demonstrates an emergence of chaotic region with increase of perturbations in the form of centered dielectric sphere. It could be concluded, that changes in behavior of cavity microwave resonator with increase of perturbation coincides with theoretical predictions of small-disturbances method for classical case.

Keywords: Small-disturbances method, Random Matrix Theory, Eigenvalues, Clasterisation, Spectral rigidity, Simulation, Chaotic behavior.

Chaotification of an Underactuted System

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Chaotification can be useful in many applications: robotics, communication, optimization, chemistry… In this paper, we design a command allowing the chaotification of an underactuated mechanical system, which is the pendulum on the cart system. After feedback linearization of the operated part of the system and the application of nonlinear feedback state control, the overall system has been set in the form of two-coupled oscillator of Duffing. Matlab simulations have permitted the validation of the chaotification of the system. Finally, an experimental validation was performed using real time hardware in the loop (HIL).

Keywords: chaotification, nonlinear analysis, underactuated systems, Dufffing oscillator, MATLAB, hardware in the loop.

Operative Scheme of the Short-Range Complex Weather Forecasting and Its Applications to Prediction in Medicine and in Electric Power Industry

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Dynamics of Earth atmosphere can be described by sophisticated non-linear systems of partial differential equations. The computational technology for weather forecasting includes a finite-difference approximation as well as a parameterization of some physical processes (e.g. phase transformations of water, interaction with soil and ocean, and

chemical reactions). Errors of such computational technologies increase with lead-time. We obtain a computational technology, which uses results of several hydrodynamic forecasting schemes and forms a new weather forecast with better (respect to original schemes) accuracy.
There are various kinds of human activity, which are connected with weather, and if we want to optimize our logistics, we should take into account weather forecasting with maximal precision. We forecast the number of Ambulance trips (per day or per night) in 2009-2013 in Moscow, and we develop an operative technology of forecasting for 1 – 3 days the amount of trips.
Other kind of human activity is hourly power consumption in regions of Russian Federation. Prediction of consumption may influence tactics of both - consumers and producers of electricity and the strategy of the electricity power market regulator. We evaluate parameters of our algorithm according to information from archives, which describes power consumption and air temperature. Average MAPE error obtained in our forecast (if lead-time =1 day) for the regions is 3.2% while for prediction without using weather it is equal to 3.7%. The impact of our weather forecast into the error decreasing is equivalent to the reduction of the forecast lead-time of 1 day.
We will deliver the estimations of our forecasts' errors.

Keywords: Weather forecasting, Lead-time, Correlation function, Ambulance trips, Hourly power consumption, MAPE error.

Transitive Dendrite Map with Zero Entropy

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Hoehn and Mouron [Ergod. Th. & Dynam. Sys. (2014) {34}, 1897-1913] constructed a map on the universal dendrite that is topologically weakly mixing but not mixing. We modify the Hoehn-Mouron example to show that there exists a transitive (even weakly mixing) dendrite map with zero topological entropy. This answers the question of Baldwin [Topology (2001) {40}, 551--569].

Keywords: entropy, mixing, transitive dendrite map.

Replay of Spatio-Temporal Patterns and Critical Behaviour Near a First-Order Transition in a Model of Spiking Neurons

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Recently [Minati et al. Chaos (2016) 073103] it has been shown that a simple network of glow lamps (nonlinear devices that share some similarity with LIF neurons) shows critical behaviour (including avalanches power laws with 1.5 exponent in size) observed near the edges of the metastable region in a first-order (discontinuous) phase transition.

Critical phenomena and avalanches indeed emerge not only in second order transition, but also in first-order phase transitions as one enters the metastability region and approaches the spinodal curve therefore our goal is to understand if this may be the case in neural cortical experiments.

Here we study a simple neural model, with structured connections among LIF neurons, and we observe that there is a parameter region with first order transition and hysteresis, where critical precurors are observed as one approaches the spinodal curve.

The transition is between a quite uncorrelated state with low spiking rate, and a high-activity dynamical state with high spatiotemporal order.

Metastability and hysteresis are ubiquitous in the brain, they are related to the ability of the brain to show stimulus-selective persistent activity.

The brain rapidly switches from one state to another in response to a stimulus, and it may remain in the same state for a long time after the end of the stimulus. This behavior suggests the existence of a repertoire of metastable states. On the other hand, to respond quickly to the external stimulus, the brain have to be near the edge of instability.

This is consistent with the observation of critical scale-free phenomena in the brain activity.

We study a simple Leaky Integrate and Firing neuron model with structured connectivity whose topology is the result of learning multiple phase-coded patterns.

The result of learning spatiotemporal patterns (each with quenched randomly-chosen phase ordering) gives rise to quenched disorder in the network connections structure.

As studied before [Scarpetta et al. J. Comp. Neuro. (2013) 34, 319], the network is able to replay one of the stored pattern when a partial cue (a short stimulus similar to the pattern) is presented. When a partial cue is presented, the dynamics abruptly falls in the basin of attraction of the pattern, and a persistent replay is observed.

Even in absence of cue stimulation, the noise can induce the replay of a pattern randomly chosen between the encoded ones. This happens when the strength of the connections is higher than a certain critical value.

At the transition the rate shows a discontinuity, hinting at a first order transition.

For a low amplitude of the noise, we also observe hysteresis in the behaviour of the network, as is expected for a first order transition.

This means that, ramping up the strength of the connections at a finite rate, the system falls in the "replay state" at some rate dependent strenght, while ramping it down it goes back to the "low activity state" at a lower connections strength.
Near the "spinodal", that marks the switching from the metastable down state to the up state, and viceversa, we observe precursor phenomena with critical scaling invariance and large fluctuations, and power laws in the size and duration of the avalanches.
Critical scaling invariance of avalanches and hysteresis are two important phenomena that has been observed in the brain, but this is the first time that it has been shown how a single simple spiking model can show both phenomena.
It is notable that we find avalanches with power-law statistics nearby a discontinuous phase transition in this spiking model, as it was observed also in a previous paper on lamps network. This is a possible alternative hypothesis to explain the experimental observations of avalanches in cortical cultures, rather than the more common hypothesis about a continuous phase transition.
Moreover this model captures some additional features of neuronal avalanches that are not captured usually in other models, such as the stable recurrence of particular spatiotemporal patterns, and the conditions under which these precise and diverse patterns can be retrieved.
Indeed, experimentally neuronal avalanches are highly repeatable [Beggs et al. J. Neurosci. (2016) 24, 5216] and can be clustered into statistically significant families of activity patterns that satisfy several requirements of a memory substrate.
Many in vitro and in vivo studies have demonstrated that cortical spontaneous activity occurs in precise spatiotemporal patterns which often reflect the activity produced by external or sensory inputs. The temporally structured replay of spatiotemporal patterns has been observed to occur, both in the cortex and hippocampus, during sleep and in the awake state, and it has been hypothesized that this replay may subserve memory consolidation.
Previous studies have separately addressed the topics of phase-coded memory storage and neuronal avalanches, and few are the works which show how these ideas converge in a single cortical model.
We find that critical features such as scale-invariant spatio-temporal avalanches, occur in spontaneous dynamics of our associative memory model, when the excitability of the model is tuned to be near the spinodal point of a discontinuous hysteretic first-order transition, between the successful persistent replay and non-replay of encoded spatiotemporal patterns.

Identification of Chaotic Systems with Application to Heart Rate Variability

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Chaotic dynamical systems present complex dynamics which are hard to identify in practice. There are many systems that exhibit windows of chaotic dynamics such as weather, biological population growth models, electronic oscillators or semiconductor lasers to mention only a very few. In this work we are going to treat the following problem: given a chaotic signal, what is the chaotic dynamical system that generates it? For this we focus on the issue of determining the dynamical system that model the human heart from the measurement of the electro-cardiogram (ECG) signal. In the same token we are going to deduce heart rate variability (HRV) on the experimental data obtained from professional athletes. This works addresses the scientific debate with regards to HRV and the complex dynamics displayed: Are they chaotic or stochastic? It is claimed that HRV is chaotic, nonetheless proof is still lacking. Claims for chaos in HRV are typically based on applying computer data analysis algorithms to cardiac data. Besides, these conventional techniques for nonlinear time series analysis generally lack sensitivity and robustness to discriminate chaotic dynamics from noise. The suggested alternative methodology for identification is based on the recently shown fact that a low order chaotic system can be decomposed into a harmonic oscillator controlled by a nonlinear feedback. In this respect, a Fast Fourier Transform is first applied to the time series to obtain the fundamental –or dominant- frequency. This permits to obtain the harmonic dynamics. Then, some tentative nonlinear feedback is proposed to model the nonlinear part of the system. Least square methods are used to obtain the underlying parameters of the system. This study intends to provide an alternative method to classify HRV in the context of deterministic chaos with clear applications in healthcare and wellbeing.

Keywords: Chaotic time series, heart rate variability, parameter identification, decomposition method.

A Simple Mathematical Model for HIV Infection with Delayed Immune Response

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We propose a simple model for the dynamics of HIV infection with a delay between the antigenic stimulation and the generation of CTL. Numerical simulations show that as the delay is increased, it is observed the generation of periodic oscillations in the model. These oscillations may describe viral blips, seen in HIV patients, and the necessary CTL response to control the infection. More work is needed in order to better understand the role of the delay in this type of model.

A Cobweb Model for Multiphase Markets

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We present and discuss a generalization of the cobweb model, in order to describe multiphase markets, namely those markets characterized by demand/supply functions which cyclically oscillate over time. The real world prototypical example we have in mind is represented by energy (electricity) markets. The model is based on a periodically perturbed discrete difference equation and results in a non-autonomous equation. All the elements of a single-phase cobweb model are affected by the explicit, recurrent dependence on time of the demand/supply functions. In particular, a new expectation formation mechanism must be introduced, in order to obtain a model which is consistent with the multiphase market assumption. In the present contribution, starting from classical adaptive expectations, this is obtained by introducing multiphase adaptive expectations. Such expectation mechanism essentially depends on two parameters, the expectation weight, as in the classical adaptive expectations, and phase weights, which describe the relevance given to in-phase expectation errors with respect to out-of-phase ones. After presenting the non-autonomous difference equation, we show how it can be rewritten in autonomous form. Dealing with local stability analysis, we show how equilibrium stability is affected by the periodic perturbation, highlighting differences with the unperturbed model. We analytically prove how independent, different dynamics of two single-phase cobweb models synchronize on qualitatively similar dynamical behaviors, depending on the coupling degree of phases. Moreover, we prove the occurrence of both quasi-periodic and/or chaotic, unstable dynamics, which underline a much more ambiguous

role of the expectation weight then in a single phase cobweb model. Finally, we turn our attention to global stability. We show the occurrence of multistability, with complex attractors coexisting with the stable equilibrium, which are absent in the unperturbed model. Through numerical simulations, we investigate the structure of the basins of attraction and the evolution of each attractor.

Keywords: Cobweb model, multiphase Markets, chaotic and quasi-periodic dynamics, bifurcation analysis, multistability.

Heat Activated Blur of Surface of Antiphase Boundaries in BCC Alloys

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This paper examines the effects of smearing antiphase boundaries in the alloys CuZn and NiAl with superstructure B2 depending on the temperature. Computer simulations were performed using the Monte Carlo method, as in [1-3]. Interatomic interaction specified by using Morse pair potentials [4]. Mechanism of migration, applied in this investigation was diffusion of the atoms for vacancies. We used periodic boundary conditions.
Were considered the influence of antiphase boundaries in <100> and <110> directions on the structural and energy characteristics of CuZn and NiAl during the phase transition of the order-disorder. Were shown structural changes of the alloy near the antiphase boundaries with increasing temperature, leading to their smearing and faceting. It is shown that the BCC-alloys with antiphase boundaries in <110> direction is more stable on low temperature.

Keywords: Monte-Carlo, phase transformations, order, disorder, superstructure, B2, BCC-alloys, crystal.

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Vibrational Resonance in Energy Harvesting Systems

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In this talk, we present our work on energy harvesting systems, which transform environmental energy into electrical energy. A reliable and widespread environmental energy is vibrational kinetic energy, which is a suitable energy source to exploit. To maximize the energy harvested, our study aims to enhance the oscillations, i.e., the vibrational energy, of a dynamical system through the phenomenon of the resonance. In particular, when a system is driven by a low frequency and a high frequency forcing, it has been shown to give birth to the Vibrational Resonance (VR) phenomenon [1, 2, 3]. It appears when the two forcing amplitudes resonate and a maximum in amplitude is reached. We study the appearance of this phenomenon in two different bi-stable oscillators [4, 5]. The first system is a Duffing oscillator, chosen as a paradigmatic nonlinear system. The second system is an existing model of energy harvesting that shows a potential with one or two wells depending to a mechanical parameter. Besides studying the second system, we analyze the effect of the VR phenomenon on the system output, to optimize the electrical power harvested. We provide in both cases numerical simulations which are in complete agreement with the previous experimental data.

Keywords: vibrational resonance, energy harvesting, nonlinear dynamics.

A Computational Approach to Locate Crossing/Sliding Regions and their Basins of Attraction of Discontinuous Dynamical Systems

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Several models in the applied sciences are characterized by instantaneous changes in the solutions or discontinuities in the vector field (discontinuous Filippov systems). Knowledge of the geometry of interaction of the flow with the discontinuities can give valuable insights in the behaviour of such systems. Here, we focus on the class of the piecewise smooth systems, and describe some numerical techniques to

locate the crossing and sliding regions on a discontinuity surface, to compute the sets of orbits converging to one or the other region, and to describe the separatrices of such sets as numerically computed implicit functions. Some numerical tests will illustrate our approach.

Keywords: Discontinuous Filippov systems, crossing/sliding regions, continuation methods, basins of attraction of crossing/sliding regions, reconstruction of separatices of regions.

Dynamics of Stochastic Hamiltonian Systems and Wild Arnold Diffusion

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We study the dynamics of stochastic Hamiltonian systems in particular stochastic perturbation of integrable Hamiltonian systems. We give a new derivation of variational integrator for these systems allowing us to make a numerical exploration of some examples. In particular, we focus on the role of the stochastic perturbation with respect to the speed of drift of the action variables. Evidence for a wild form of Arnold diffusion is given and discussed.

Keywords: Hamiltonian systems, stochastic Hamiltonian systems, variational integrators, Arnold diffusion, chaotic dynamics.

Emergent Semantic Logic to Explain Emergence in Complex Systems and Particularly in Brain

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Can semantic logic of the brain explain the emergence of the complex systems? Beyond the quantitative aspect that information is endowed with, which is present in the information theory of Shannon and Weaver, from a psychological viewpoint it is its qualitative component that is important. This qualitative component is given by its significance. That is why semiology and semiotics, meaning and semantics, are notions which today are revisited from another perspective, not only the philological one. The semantic aspects of information become very important for psychologists, too, because the structure of the nervous system, as well as the way in which it works, necessitates this approach. Nervous structures, from the margins to the brain cortex, contain multiple-layered nervous nuclei, of an increasing complexity, from the spine to the bulb and the brain stem, then to the diencephalon and to the

subcortical centers. Practically speaking, what we see at the level of nervous structures represents a general principle at the matter level. That is why we call this information semantically-emergent information, whereas the corresponding logic based on which the information is structured, a semantically-emergent logics, which is different from the bivalent logics, but different also from the multivalent logics or fuzzy logics, because the values which can be true cannot be probabilistically assessed, they are conditioned by their semantic value. In complex systems (like brain), emergence is achieved by relating the informational contents from the less complex levels to the most complex levels, thus achieving unity from an informational viewpoint between digital and analog, discreet and continuous, fragmented and holistic. The teleological sense is keeping the systems' coherence in physical reality.

Keywords: Emergent semantic logic, Brain's semantic system, Complex system, Information.

Renormalization Group Analysis of the Phase Transition in the Superfluid Helium: Effect of Compressibility

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Critical dynamics constitutes a fascinating subject both from experimental and theoretical perspective. One of the most studied models is a model E, which describes critical behavior in superfluids. Here we consider it in the presence of additional velocity fluctuations and our main aim is to analyze possible effect of compressible modes. To this end we introduce well-known Kraichnan rapid-change model in order to generate compressible velocity field. Resulting stochastic differential equations are then recast in the form of field-theoretic action using De Dominicis-Janssen approach. By direct power counting and analysis of ultraviolet divergences it is shown that the model is multiplicatively renormalizable. The renormalization group equations are derived in the standard fashion and calculations of universal quantities are performed to the leading order of perturbation theory in the double expansion (ε, δ) scheme. Here ε is the deviation from upper critical dimension 4 and δ is the deviation from the Kolmogorov scaling regime. The fixed points of the renormalization group are given and possible infrared stable regimes are discussed in detail.

Keywords: Renormalization group, superfluid helium, compressibility, stochastic dynamics.

Analysis of a Discrete Model of Prey-Predator System with Prey Refuge

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A refuge model of prey-predator system with Holling type-II functional response is proposed. The existence of fixed points is established and their stability conditions are derived. Neimark-Sacker bifurcation result is obtained. Numerical simulations suggest that the system exhibits chaotic behavior under certain situations along with Fold and Flip bifurcation.

Keywords: Prey-predator system, Refuge, Neimark-Sacker bifurcation, White noise.

On a Simple and Effective Scheme for Suppressing Chaos Based on Regular Proportional Feedback Control

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A simple method for suppressing chaos in a discrete dynamical system has been proposed by Guemez and Mathias and consists in applying regular proportional feedbacks in the system variables only. The success of the scheme seems to depend critically on the strength and the period of the feedback. Unfortunately, the paucity of the reported results prevents the interested reader to appreciate the effectiveness of the technique. The present paper intends to fill this gap by providing an important number of numerical proofs that demonstrate without any doubt the method is able to stabilize an impressive number of ordered orbits, of different periods, often only with a small intervention in the system variables. Some additional aspects, including the mechanisms of transition from chaos to order and vice-versa, the distance between two successive interventions or the influence of the system degree of chaoticity on the percentages of success in stabilizing a periodic orbit, are also investigated. The numerical simulations have been performed on the logistic map but similar results can be obtained on other unidimensional maps.

Keywords: Chaos control, Proportional feedback, Numerical simulation, Logistic map.

An Algorithm to Find the Smallest Disks Enclosing Graph-Directed Fractals

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Iterated function system (IFS) theory is a fruitful branch of fractal geometry which has many applications such as signal modelling, image compression, electronic antennas etc. It is important to find the smallest disk enclosing the attractor of an IFS to calculate the fractal dimension more precisely and there are several algorithms to find the smallest disk bounding the attractor of the IFS including [2], [5], [6]. There is a generalization of classical iterated function systems which extends the horizons of the self-similarity notion, called graph-directed iterated function systems (GIFS). In this work, we consider graph-directed iterated function systems and give an algorithm to find the smallest enclosing disks of the attractors of the GIFS.

Keywords: Fractals, Graph-directed iterated function systems, smallest enclosing disk.

Non Linear Continuity of Optics to Meteorological Precipitators. Quantum Parameters

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The sunrays light and the stars is weakened as it penetrates the earth's atmosphere. We can study of this effect, as a function of the wavelength. The distribution of light in the daylight sky as scattering light and the astronomical extinction, consist wavelength functions too. Both cases, extinction and scattering, may be repeated with artificial light sources. We can study for investigating dense media such as fog, dew, water drops, rain, atmospheric haze. All them, we can consider as a nonlinear deterministic dynamical system governed by a small number of differential (or difference) equations can give rise to apparent randomness. This apparent randomness is associated with the existence of a fractal attractor in the system's state space. An attractor is a set of points to which state-space trajectories of the underlying dynamical equations are attracted. The fact that the set is fractal means that it has fine scale structure which persists under repeated magnification of the set. Such fractal structure is said to be self-similar. The photons those are operated on Meteorological Precipitators create the presuppositions run to quantum physics.

Keywords: meteorological precipitators, dynamical system. Astronomical extinction, light scattering.

Statistical Investigation and Thermal Properties for a 1-D Impact System with Dissipation

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The behavior of the average velocity, its deviation and average squared velocity are characterized using three techniques for a 1-D dissipative impact system. The system – a particle, or an ensemble of non-interacting particles, moving in a constant gravitation field and colliding with a varying platform – is described by a nonlinear mapping. The average squared velocity allows to describe the temperature for an ensemble of particles as a function of the parameters using: (i) straightforward numerical simulations; (ii) analytically from the dynamical equations; (iii) using the probability distribution function. Comparing analytical and numerical results for the three techniques, one can check the robustness of the developed formalism, where we are able to estimate numerical values for the statistical variables, without doing extensive numerical simulations. Also, extension to other dynamical systems is immediate, including time dependent billiards.

Keywords: Chaos, Scaling law, Critical exponents, Thermodynamics.

Nonlinear Dynamics of Reactive EEG Patterns under Cerebrovascular and Cardiovascular Distortion

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We examine the task of estimation the differences in the human brain lability involving its opportunity to reproduce the external rhythm under cerebrovascular and cardiovascular distortions. For solving the task the electroencephalographic (EEG) patterns before, during and after intermittent photic stimulation are evaluated by the continuous wavelet transform and the wavelet-transform modulus maxima methods as well as the recurrence quantification analysis. The degree of the human brain lability is estimated on the basis of changes in multifractal, wavelet and recurrence features of the EEG patterns taking place under the photic stimulation. The coefficients of photic driving and holding and the energy increase times calculated by the wavelet spectra of the EEG patterns of patients with cerebrovascular and cardiovascular distortions differ significantly from the parameters determined for the healthy subjects. For the patients with two types of cardiovascular pathology (persistent and paroxysmal atrial fibrillations) the degree of the wavelet coherence of the light time series and the reactive EEG series is also distinguished.

The study demonstrates the opportunity of nonlinear dynamics methods to estimate quantitatively the human brain lability of light stimulus perception for various groups of patients having cerebrovascular and cardiovascular distortions.

Keywords: EEG patterns, Wavelet transform, External rhythm, Multifractality, Cerebrovascular and Cardiovascular Pathologies.

Theoretical Modeling of the Interaction between Two Complex Space Charge Structures in Low-Temperature Plasma – Self-Modulated Oscillations

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By introducing the scale resolution in the expression of the physical variables and the dynamics equations, a theoretical model was developed in the frame of Scale Relativity Theory in order to describe the interaction between two complex space charge structures coupled by an electron beam, in low-temperature plasma. The complexity of the interactions in the plasma volume is replaced by non-differentiability (fractality), the constrained motions on continuous and differentiable curves in the Euclidian space of the plasma discharge particles being replaced with the free motions, without any constraints, on continuous but non-differentiable curves in a fractal space of the same plasma discharge particles. The dynamics of the electrons is described by using a forced damped oscillating system and the response of the global discharge current to different changes in the resolution scale, oscillating frequency and damping coefficient was analyzed. The proposed model reveals the presence of self-modulated oscillations of the discharge current, which are also experimentally evidenced in a low-temperature plasma diode with a special geometry of the cathode.

Keywords: Scale Relativity Theory, Self-modulated oscillations, Fractality, Complex space charge structures.

Theoretical and Experimental Analysis of Low-Frequency Instabilities in Low-Temperature Magnetized Plasma

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Assuming that the magnetized plasma particles are moving on continuous and non-differentiable curves (fractal curves), a theoretical model was developed in the frame of the Scale Relativity Theory, able to explain some characteristics of the potential relaxation instability and electrostatic ion-cyclotron instability, as well as the interaction between these two instabilities which leads to the amplitude and frequency modulation of the second instability by the first one. The non-differentiability of the movement trajectories in the fractal space of the plasma particles generates chaoticity either through turbulence (in the fractal hydrodynamics approach) or through stochasticity (in the Schrödinger approach). Experimental results are shown, which are in agreement with the theoretical model predictions.

Keywords: Scale Relativity Theory, Instability, Fractality, Chaos.

Entropy of Online Ratings Data: A Simulation Study

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Entropy used as a measure of data complexity and disorder. Multinomial distribution describes statistically the observed frequencies of online ratings. In this paper using simulated datasets of multinomial distribution and real rating datasets of Amazon, Google Play and TripAdvisor, we compare the entropy of data with the entropy of the specific cases of multinomial distribution best fitted to data. Simple Binomial distribution and Binomial Mixtures performance examined.

Keywords: Binomial Distribution, Entropy, Online Rating, Amazon, Google Play, TripAdvisor, Multinomial Data Simulation.

Geometry of Quantum Riemannian Hamiltonian Evolution

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This work concerns a study of the quantum mechanical extension of the work of Horwitz et al. on the stability of classical Hamiltonian systems by geometrical methods. Simulations are carried out for several important examples; these show that the quantum mechanical extension of the classical method, for which trajectories are plotted as expectation values of the corresponding quantum operators, appears to work well, providing results consistent with the corresponding classical problems. The results appear to provide a new contribution to the subject of quantum chaos.

On Quasi-Periodic Solutions Associated with the Extended Nonlinear Feedback Loop in the Five-Dimensional Non-Dissipative Lorenz Model

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A recent study suggested that the nonlinear feedback loop of the three-dimensional non-dissipative Lorenz model (3D-NLM) serves as a nonlinear restoring force by producing nonlinear oscillatory solutions as well as linear periodic solutions near a non-trivial critical point.
In this study, using a five-dimensional non-dissipative Lorenz model (5D-NLM), we discuss the role of the extension of the nonlinear feedback loop in producing quasi-periodic trajectories. By solving a locally linear 5D-NLM for an analytical solution, we illustrate that the extension of the nonlinear feedback loop in the 5D-NLM can produce two incommensurate frequencies whose ratio is irrational, yielding a quasi-periodic solution. The quasi-periodic solution trajectory moves endlessly on a torus but never intersects itself.
While the nonlinear feedback loop of the 3D-NLM consists of a pair of downscaling and upscaling processes, the extended feedback loop within the 5D-NLM additionally introduces two pairs of downscaling and upscaling processes that are enabled by two high wavenumber modes. The second pair of downscaling and upscaling processes provides a two-way interaction between the original (primary) Fourier modes of the 3D-NLM and the newly-added (secondary) Fourier modes of the 5D-NLM. The third pair of downscaling and upscaling processes involves interactions amongst the secondary modes. By comparing the numerical simulations using one- and two-way interactions, we illustrate that the system with a one-way interaction always produces periodic solutions

with two commensurate frequencies. We also indicate that the two-way interaction is crucial for producing the quasi-periodic solution. Based on the current study using the 5D-NLM, and a recent study using a 7D non-dissipative LM, the statement “weather never repeats itself” is supported by the appearance of a quasi-periodic motion that results from the extension of nonlinear feedback loop, which is capable of producing two or more incommensurate frequencies, and may appear throughout the spatial mode-mode interactions rooted in the nonlinear temperature advection.

Keywords: quasi-periodicity, Lorenz model, nonlinear feedback loop.

Well Posedness for the Fractional KGS System Modeling Electron-Ion Plasma Waves

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In this work we study the global well posedness and long time dynamics for the KGS system involving fractional Laplacian. We will establish the global existence of the weak solution using the Galerkin method and compactness argument. We will give some criterion for the uniqueness and address the existence of local and global strong solutions in the appropriate space.

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Dynamics and Estimates of Star-Shaped Reachable Sets of Nonlinear Control Systems

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We consider the problem of estimating reachable sets of nonlinear dynamical control systems with uncertainty in initial states when we assume that we know only the bounding set for initial system positions and any additional statistical information is not available. We study the case when the system nonlinearity is generated by bilinear terms in the right-hand parts of differential equations. In particular, bilinearity may be caused by uncertainty in the matrix elements included in the state velocities of dynamical system. We deal with star-shaped reachability sets and use for its description the Minkowski gauge functions. Using results of the theory of trajectory tubes of control systems and techniques of differential inclusions theory and also results of ellipsoidal

calculus [1-3] we find set-valued estimates of related reachable sets of such nonlinear uncertain control system.

Keywords: Nonlinear control systems, Bilinear nonlinearity, Estimation problem, Set-membership uncertainty, Ellipsoidal calculus, Funnel equations, Trajectory tubes, Simulations for uncertain systems.

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Non-Autonomous Dynamical Systems: "Strong" Normal Forms and Integrability

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The aim is to discuss some recent results about the integrability and the existence of a convergent “strong” normal form in the case of a system of ODEs with non-autonomous non-linearity, in a neighbourhood of an equilibrium. No assumptions are made on the time dependence (i.e. the time dependence is aperiodic).

The proof is based on a perturbative approach for a suitable class of non-autonomous Hamiltonian systems and relies on some ad-hoc techniques developed by the same authors to treat more specific aperiodic time-dependent problems.

From a joint work with S. Wiggins.

Keywords: Aperiodic time dependence, Perturbation theory, Normal forms.

A New Quantum Mechanical Formalism Based on the Probability Representation of Quantum States

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A new quantum mechanical formalism based on the probability representation of quantum states is proposed. This book in particular deals with the special case of the measurement problem, known as Schrödinger's cat paradox. We pointed out that Schrödinger's cat demands to reconcile Born's rule. Using new quantum mechanical formalism we find the collapsed state of the Schrödinger's cat always shows definite and predictable outcomes even if cat also consists of a superposition

$$|cat\rangle - c_1|live\ cat\rangle + c_2|death\ cat\rangle,\ |c_1|^2 + |c_2|^2 - 1.$$

Using new quantum mechanical formalism the EPRB-paradox is considered successfully. We find that the EPRB-paradox can be resolved by non principal and convenient relaxing of the Einstein's locality principle. The effective method of testing of chaotic dynamics for dynamic systems with infinite number of variance, classical and quantum ones is proposed. Initial results are formulated in [1].

Keywords: Quantum states, Probability theory, Schrödinger's cat, EPR-paradox, EPRB-paradox, Einstein's locality principle, Quantum chaos.

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Complexity of the Snapshot Attractors considering Chaotic Dynamics

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The complexity C that reasons a given time series of measurement, plays important role of the statistical physics information theory mathematics. We consider a chaotic time sequence of measurements, it is described by statistical complexity C(H, D), which depends on the entropy H and the disequilibrium D on a finite N-system. The characterization of the dynamical properties can be understood by the spectrum of complexity C(H, D) considering the concept of information theory. Although the Kolmogorov-Sinai entropy provides the tendency of the flow, but the complexity C allows to determine the localisation of the strange attractor, the transition states and periodic motion on the parameter space. The snapshot attractors can be applied to study the model of global atmospheric circulation using a driving system. We researched the chaoticity of this model by numerical approximation to analyse the statistical complexity of the time dependent attractor.

Keywords: Chaotic modeling, Statistical complexity, Kolmogorov-Sinai entropy, Snapshot attractor, Numerical simulation.

Bifurcation based Mechanical Diodes: Quasiperiodic Solutions as Energy Transfer Carriers

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In the last decade there has been a significant interest in the modeling and design of micro electronic mechanical systems (MEMS) for energy harvesting, biomedical applications and structure monitoring. In this talk we will analyze the dynamical behavior of an acoustic diode [1]. The nonlinear vibrations have a preferred direction of transmission and the presence of an abrupt change (jump) in the energy transfer could be used as a switching mechanism.

We will see that resonances, bifurcations, periodic orbits, tori and chaotic states are essential to understand the dynamical behaviour. Numerical continuation of the solutions [2] as some of the parameters are varied will shed some light into the complex underlying mechanism.

Keywords: acoustic diode, nonlinear vibrations, Hertz contact model, numerical continuation and bifurcations.

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Global Bifurcations and Chaos in Low-Dimensional Polynomial Dynamical Systems

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The global qualitative analysis of low-dimensional polynomial dynamical systems is carried out. First, using new bifurcational and topological methods, we solve Hilbert's Sixteenth Problem on the maximum number of limit cycles and their distribution for the 2D Liénard polynomial, Holling quartic, and Kukles cubic dynamical systems. Then, applying a similar approach, we study 3D polynomial systems and complete the chaos transition scenario for the classical Lorenz system connecting globally the homoclinic, period-doubling, Andronov-Shilnikov, and period-halving bifurcations of its limit cycles which is related to Smale's Fourteenth Problem.

Keywords: Polynomial dynamical system, Bifurcation, Limit cycle, Chaos.

Experimental Evidence of Wave Chaos Signature in a Microwave Cavity Cylinder Resonator with Fractures of Side Surface

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The billiards microwave (microwave cavity resonators) in which the boundary has a surface fractures and contains both dispersing and focusing portions, there may be signs of chaos in its frequency spectrum. The common feature of such billiard's border is its small smooth surface (at least in the absence of the second derivative). Since the billiard system breaks the side surface is non-integrable, its chaotic properties have been studied experimentally. We use the spectral approach, when signs of wave chaos are shown in the properties of the inter-frequency intervals distribution system spectrum. With this approach, in the absence of surface fractures the spectral lines of the resonator are independent, and the distribution of inter-frequency intervals is a Poisson distribution. In the case of existence of surface fractures, the spectral lines are correlated and inter-frequency intervals in spectrum allocation approaches the Wigner distribution.

Keywords: Wave chaos, Cavity microwave resonator, Small smooth surface, Probability distribution of inter-frequency intervals, Wigner distribution.

Wave Chaos Signature in a Microwave Cavity with a Singular Perturbation

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Wave chaos signature in cavity quasi-optical cylindrical resonator under the influence of a singular perturbation has been studied theoretically and experimentally. Such perturbation in the resonator cavity was created by inserting into it a thin metal rod. It was found that disturbances cause great changes in the statistical properties of the wave spectrum of the resonator. Empty resonator wave spectrum has a Poisson distribution of the probability of inter-frequency interval distribution, but under the influence of the singular perturbation the wave resonator tends to Wigner distribution, i.e. it appears the signature of wave chaos. We have studied the main spectral properties of the cavity resonator with this singular perturbation: the probability distribution of inter-frequency intervals, the spectral rigidity, the correlation coefficient between the spectral lines in the resonator spectrum.

Keywords: Chaos signature, quasi-optical cylindrical resonator, singular perturbation, wave spectrum, spectral rigidity, inter-frequency interval, correlation coefficient.

Relativistic Magnetohydrodynamic Turbulence in the Early Universe

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The purpose of this work is to understand the dynamics of a relativistic plasma field so that we can better understand the early universe. In this talk, I will discuss what we have learned by numerically studying simulated relativistic magnetogydrodynamic turbulence under conditions similar to those found in the early universe. After introducing our numerical code, we will discuss our studies of invariants, energy cascades and magnetic field generation (Magnetogenesis).

Keywords: Magnetohydrodynamic Turbulence, Cosmology, Magnetogenesis.

Optical Spin Turbulence in Half-Light Half-Matter Bose Systems

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Recent advances in nanophotonics have brought about coherent light sources with chaotic circular polarization [1], which promises applications in the field of information encoding and transmission. Today, however, only a low-dimensional chaotic evolution of optical spin is achieved. Here we report a new physical mechanism that could give rise to light with spatiotemporal spin chaos (so that a light wave resembles a two-component turbulent fluid) [2]. We have found that light with such properties can be emitted by the system of exciton polaritons, half-light half-matter quasi-particles in semiconductor microcavities. Since excitons are strongly coupled to externally driven cavity photons, they share a unified quantum state rather than just constitute a nonlinear medium for propagating light and thus represent a qualitatively new system compared to conventional laser devices. The polariton system is described by the Gross-Pitaevskii equations and as such is more similar to Bose-Einstein condensates or macroscopically coherent states in superconductors, except that it is highly nonequilibrium. From the physical viewpoint, the considered chaotic mechanism originates in the interplay between spin symmetry breakdown and scattering into pairs of Bogolyubov excitations [3]. As a practical matter, it opens up the way for controllable regular or chaotic spin modulation of light on the scale of picoseconds and micrometers.

Keywords: nonlinear optics, spatiotemporal chaos, self-organization, polariton, spin, Bose-Einstein condensate, turbulence.

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A Mathematical-Physical Model for the Mirror Neurons Paradigm

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Considering that any biological structure can be assimilated to a fractal (both structurally and functionally), a mathematical-physical model is proposed in order to explain the mirror neurons paradigm. Extending de Broglie's idea concerning the wave-corpuscle duality by means of the

information (in its implicit and explicit) form, we are lead to assume the existence of a fractal medium, which can store and transmit information in the form of a natural field (that will be called ‘’a fractal field’’). In such conjecture, Cooper type pairs structures can be generated by means of the spontaneous symmetry breaking of such field. In consequence, the mirror neurons transmitting mechanism can be explained by this spontaneous symmetry breaking, in which the specific neuronal network and specific logics appear.

Keywords: Mirror neurons paradigm, Fractal field, Information, Wave-corpuscle duality, Coherence, Neuronal network, Spectral network, Spontaneous symmetry breaking.

On the Takens-Argémi-Benoît’s Transformation

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We show that the Jacobian matrix of the “normalized slow dynamics” can be directly deduced from the three-dimensional singularly perturbed system to which it is associated while using a transformation we call “Takens-Argémi-Benoît’s transformation” which is thus expressed as a linear function of the Jacobian matrix of the original singularly perturbed system and of the Hessian of its slow invariant manifold. Then, we prove, while using well-known results concerning the determinant of the sum, that the determinant of the Jacobian matrix of the projection of the “normalized slow dynamics” on the tangent bundle to the slow manifold leads to the same condition for existence of canards solutions as that provided by Benoît in the beginning of the eighties.

Keywords: singularly perturbed systems, canards solutions, Jacobian, Hessian, determinant of the sum.

Pseudohyperbolic Attractors and their Examples in Three-Dimensional Maps

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We present some elements of modern theory of strange attractors. We divide all attractors into two classes: quasiattractors and wild (pseudo)hyper-bo-lic attractors. In particular, pseudohyperbolic attractors (or, another term, volume hyperbolic attractors) include hyperbolic and Lorenz attractors but can contain homoclinic tangencies and, hence, Newhouse wild hyperbolic sets. However, bifurcations of these

homoclinic tangencies do not lead to the birth of periodic sinks (quasiattractors, conversely, allow the birth of periodic sinks, by definition). The theory of wild pseudohyperbolic attractors was laid by Turaev and Shilnikov [1,2] and we discuss some elements of this theory and give several examples of such attractors for three-dimensional H'enon-like maps, for more details see e.g. [3].

Keywords: strange attractor, pseudohyperbolicity, bifurcation, discrete Lorenz-like attracor, fenomenological scenaria.

References:

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Symmetry Breaking in the Formation of Two Clusters with the nonlinear Kuramoto mean field model

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The Kuramoto model is universally applicable to many weakly interacting systems, such as Josephson junctions. However, in many cases couplings which include higher harmonics are needed, such as those relating to electro-chemical oscillators and phi-Josephson junctions. In this study, we consider a global mean field synchronization model, called the nonlinear mean field Kuramoto model, where a finite number of phase oscillators are coupled via a global mean field which is a nonlinear function of the Kuramoto mean field. As observed first by Komarov and Pikovsky [1], identical oscillators with initial phase drawn randomly from a uniform distribution form two asymmetrical clusters under such a model. The distribution obeys a scaling law of N^1/2, showing that such a symmetry breaking is related to initial fluctuations. We attempt to find the source in the asymmetry through analytical method as well as numerical method. Analytically, we conducted linear stability analysis, and reformulated the Watanabe-Strogatz dynamical equations in the complex plane. The singularity in the Moebius transformation is analytically located, which provides a candidate for the singularity of the dynamics that we seek. The numerical simulation confirms the location predicted by theory, but it also confirms that statistical tools can't be applied to study the location of the singularity based on only the initial condtions, because the singularity cannot be obtained without integration. During the investigation, further properties of Watanabe-Strogatz variables and of the nonlinear mean field Kuramoto model were

discovered to indicate several future paths to take for uncovering this process of symmetry breaking.

Studying Network Mechanisms of Ictogenesis Reveals Quantitative Prognostic Markers for Epilepsy Surgery

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Although large-scale brain networks are recognised as important in the generation of seizures (ictogenesis), the network paradigm introduces unfamiliar challenges and new opportunities to understand epilepsy. We cannot rely on purely local or global perspectives for ictogenesis; rather we need new tools to study and classify the local versus global mechanisms of ictogenesis in networks. Herein we introduce a measure of the contribution of each node within a network to emergent ictogenesis, which is defined by the effect on network ictogenicity of a perturbation to that node. We use exemplar networks to study how the apparent ictogenicity of nodes can vary according to network structure and the effect of abnormal intrinsic “excitability”.
We apply this approach to study functional networks derived from patients with pharmacologically intractable epilepsy, and demonstrate that the model can yield predictions for which nodes could be most crucial for ictogenesis. We argue that such an approach provides an insightful and principled way to interpret and describe generalised or focal seizure dynamics and can aid advances in pre-surgical planning and the provision of quantitative prognoses.

Keywords: networks, electroencephalography, epilepsy, epileptic seizures.

NANOCHAOS in raising a machine reliability and the creation of "eternal" STRUCTURES

"... Two dangers do not stop threaten the world: order and disorder ..." Paul Valéry

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A synergetic model of construction destruction was built firstly from the point of modern physics and the theory of phase transitions "disorder - order" (at the atomic and nanostructured level). The principal different role of a chaos on the structural at various levels of construction under the temperature-load power - from positive to atomic level and nanoscale to negative at the meso level and sorely-negative on a macro level was shown. It was received a theoretical approach underlying parameter

equation Zhurkov $\tau = \tau_0 \exp \frac{U_0 - \gamma\sigma}{kT}$ - activation energy destruction Uo from this synergetic model of a destruction. Approximation of Professor Grabar $U_0 \cong kT_s \ln \frac{[1]}{\tau_0}$ for all bcc and fcc metals and their alloys gives the error not more than ± 1,6%, where τ - time to fracture; T - temperature test (operation activity); Ts - the melting point of the metal or alloy; τ_0 ~10^{-13} sekonds - during the thermal vibrations of atoms; k - Boltzmann constant; γ - activation volume.

On the basis of this synergetic model was proposed a number of approximations to quantify the characteristics of durability and reliability of a wide class of metallic structural materials and formulation of innovative applications. This concept allows us to offer a strategy of "eternal" designs by periodic restoration of chaos in nanostructured level design of a construction. The ways of this "nano Chaos" were proposed.

Keywords: Chaos, Order, Nanostructures, "Eternal" structures, Physics of strength.

Chaos and a Quantitative Modeling of the Kinetics of Phase Transitions on the Final Measure Areas

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The analysis of chaos role in the modeling the phase transition kinetics (percolation model, Ising's model, a model of melting nanoparticles) was shown.

It was discovered and quantitatively described the role of scale in these phase transitions. On an example of the stochastic simulation algorithm of percolation it was shown that the final measure models is a number of features that define the region's large-scale constant L. Thus, with decreasing L:

• percolation threshold P * increases;
• region scattering (band phase transition) increases;
• fractal dimension of nano-object is reduced.

The quantitative relationships of these parameters on a large-scale field constant L were established. It is shown that the probability of connecting cluster well described by Fermi-Dirac-Grabar distribution:

W (L) = 1 / (1 + exp ((P*-P) / L)).

A functional dependence of threshold a percolation P * from the fractal dimension of the space D (Cartesian approach prof. Grabar) was realised:

P * = 1 - ln ((D + 1) / 2)

Keywords: Chaos, Phase transitions, Percolation, Percolation threshold, Fractal dimension, The clipping cluster.

Scaling Investigation for the Chaotic Dynamics for an Ensemble of Particles Moving in a Periodically Time-Dependent Potential Well

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The dynamics of a classical particle confined in a box of infinite potential at the edges and containing a potential well where the bottom is periodically moving in time isstudied. The dynamics is described by a two dimensional, nonlinear and area preserving map. The phase space is mixed and composed by a large chaotic sea surrounding periodic islands and limited by invariant spanning curves. In the model, if an initial condition is given in the chaotic sea it never visits a stability region hence not entering an island nor crossing an invariant spanning curve. We study the statistical and transport properties of a set of initial conditions given in the chaotic sea. Our findings confirm the curve for the average square energy grows to start with and bends towards a regime of saturation after a typical crossover time. The main goal is to investigate the statistical properties by solving the diffusion equation along the chaotic sea.

Keywords: Chaos, nonlinear dynamics, scaling law.

Spectral Analysis and Invariant Measure in the Study of a Nonlinear Dynamics of the Metabolic Process in a Krebs Cycle

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In the frame of a mathematical model, we proceed the investigation of the metabolic process in a Krebs cycle. For the first time, the metabolic process is studied by using the expansion of the autooscillatory kinetics in a Fourier series and by the construction of histograms of the invariant measures of chaotic attractors. We analyze the found scenario of adaptation of the metabolic process at a change in the dissipation of the kinetic membrane potential. We consider the sequence of modes of self-organization and deterministic chaos, correspondence of the spectral mapping to the attractors of given modes, and structural-functional connections of the metabolic process in a Krebs cycle as a single dissipative structure.

Keywords: self-organization, deterministic chaos, metabolic process, Krebs cycle, Fourier series, strange attractor, invariant measure, bifurcation.

A Nonparametric Bootstrap to Test for Chaoticity in Time Series

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The goal of this paper is to introduce a procedure to test whether the largest Lyapunov Exponent (LLE) of a system is significantly greater than zero. Our procedure amounts to implementing a nonparametric bootstrap in order to approximate the empirical cumulative distribution of the LLE, computed according to Rosenstein et al. (1993). Then, a bootstrap p-value is calculated allowing to test for the null of non-chaoticity. Using Monte-Carlo, we show that our procedure has good size and power. For chaotic systems contamined with noise, our procedure is appealing since it does not require neither the knowledge of the law of the perturbations, nor the moment of the distribution. We also show that for stochastic non-chaotic systems, the Rosenstein procedure performs quite well.

Approximately Conserved Quantities in the Matinyan Yang Mills Higgs System

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The Matinyan Yang Mills Higgs System (abbreviated MYMH) is a classical Hamiltonian system given by:

$$H = \frac{P_x^2 + P_y^2}{2} + \frac{1}{2}x^2y^2 + \frac{1}{2}g^2(x^2 + y^2) - \frac{1}{2}y^2 + \frac{1}{8}x^4 + \frac{1}{4}py^4$$

It is a generalization of the truncations of the Toda Lattice involving the quadratic cubic and quartic terms. It is well known that the Toda lattice is

while its truncations are not integrable. Approximate integrals for the Toda system have been constructed. The present Hamiltonian has similar algebraic terms with somewhat different coefficients than the Toda truncations.

The MYMH system has been used for modelling the suppression of chaotic behavior in the classical Yang Mills system. This has become necessary in light of our recent understanding on the stability of the universe and the mechanism for the onset of instability. In recent work, this analysis was done by numerical simulation. In this study, we present results for analyzing the possible candidates for approximately conserved quantities (approximate invariants) in light of our work on the Toda truncations. One possible approach is to start from the basic second order invariants, the energy and the angular momentum component which cease to be invariant in the higher orders. The other approach would be to construct higher order invariants by selecting suitable combinations constructed from the truncated expressions which will have a higher order Poisson bracket than the truncation order.

Keywords: MYMH systems, Toda systems, Yang Mills models, truncations.

Chaos in the Transient Current Through As_2Te_3 (In) and Mackey-Glass Simulation of Hysteresis Effect on Glass Substrates

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As_2Te_3 *(In)* is a glass substrate (chalcogenide) that can be used in optoelectronic devices such as computer memory arrays, display devices, optical mass memories because of its sensitivity of current transition. This glass substrate can show chaotic behavior. In this study, we observed that by calculating of maximal Lyapunov exponents with non-linear time series analysis techniques. We observe slow transient effects causing hysteresis in the current-voltage characterization. We find that the current-voltage (IV) measurement delay time. Furthermore, As_2Te_3 *(In)* shows hysteresis effect. A delay differential equation such as Mackey-Glass which has both periodic and aperiodic solutions can be a useful simulation tool for I-V characterization of glass substrate, which indicated chaos or non-periodicity in time series, is claimed to constitute a suitable model.

Keywords: Hysteresis Effect, Mackey-Glass equation, chalcogenides, Lyapunov Exponents, Correlation and delay time, Time Series Analysis.

Gröbner Basis Method in Bifurcation Analysis

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Many natural processes (including biological, chemical or physical) can be described by dynamical systems with polynomial or rational right-hand sides in both state variables and parameters.
The problem of finding bifurcation manifolds of a discrete or a continuous system leads to a system of generally non-linear equations. This work describes a method how to find bifurcation manifolds, using algebraic approach based on Gröbner basis. Method is useful for systems of both differential and difference equations of any dimension where right-hand sides are polynomial or rational functions. The same method can be used also for any nonlinear system with polynomial approximations for example if local analysis is needed.
The biggest advantage of this approach is that the exact formula for a bifurcation manifold is obtained. Gröbner basis method is presented on some well-known dynamical systems, such as Selkov model, Spuce Burworm model, Rozenzweig-MacArthur model or Hénon map.
These systems are usually analyzed numerically using continuation methods implemented in special toolboxes such as Matlab toolboxes Matcont and MatcontM or XPP-Aut software. The result of such continuation is usually a one-dimensional curve in two parameter section of the parametric space, but using the exact formula it is possible to examine dynamical systems in higher dimensions since bifurcation manifolds are obtained as implicit functions in full parameter space.

Keywords: Gröbner basis, bifurcation manifolds, Selkov model, Spuce Burworm model, Rozenzweig-MacArthur model, Hénon map, polynomial system.

Forecasting Chaotic Business Cycles Perturbed by Noise

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The failure of the Federal Reserve to timely raise the federal funds rate to its ``normal'' expectation causes chaos. By applying a Sprott nonlinear dynamical system, it becomes possible to forecast aperiodic business cycles. when the short-term interest rate is prudently targeted, the economy mean-reverts, like a Langevin equation perturbed by noise. Then business cycles no longer exist.

Keywords: Monetary Policy, Chaotic and Random Uncertainty, Sprott System Application, Langevin Equation.

Weighted Recurrence Networks from Chaotic Time Series

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The complex network approach to nonlinear time series analysis has now developed into an important area of research. The most popular method to transform a chaotic time series to complex network is by utilizing the basic property of all dynamical systems, namely, the recurrence. The complex networks generated by this method are called recurrence networks, which are unweighted and undirected networks. By analyzing the statistical measures derived from recurrence networks, one is able to get information regarding the structural properties of chaotic attractors. Here we introduce for the first time the concept of weighted recurrence networks and show that they are more effective in the analysis of chaotic time series. Specifically, by using the weighted degree distribution, we illustrate how the structure of the standard Lorenz attractor is different from that of the standard Rossler attractor.

Keywords: Recurrence Networks, Nonlinear Time Series Analysis, Chaotic Attractors.

Intermittent Theory: An investigation of Scaling Law in the Logistic Map

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The characteristic behaviour of the intermittency is a signal that is regular - periodic or quasi - periodic over a certain period of time and evolves to produce a chaotic "overflow" for a brief instant, the system then returns its regular behaviour and process resumes with the appearance of other "bursts" of non-periodic oscillation. The global chaotic behaviour is then given by the "bursts," but above all by the random distribution of the behaviour of the regular periods. This intermittent transition to the turbulent originates when a tangent bifurcation occurs.

As we have already done for other types of bifurcation, we use the scale formalism where the critical exponents are determined, as well as a scale law for the map in question. We study the behaviour of the convergence for the fixed point at a tangent bifurcation and immediately after the bifurcation using either numerical simulation as well as an analytic approach.

Keywords: scaling laws, tangent bifurcation, critical exponents.

Calculation of the Turbulent Prandtl Number in Generalized Stochastic MHD Model

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Generalized helical stochachastic magnetohydrodynamics (MHD) with adjustable intensity of interaction between the velocity and magnetic field fluctuations, as controled by the coupling constant A, is analyzed by means of renormalization group approach. Dependence of the effective turbulent Prandl number on the parameter A and the parameter of spatial parity violation rho is determined analytically based on the two-loop approximation of the linear response functions of the velocity and the magnetic fields. Presence of helicity is shown to induce a stabilizing effect onto the possible stationary regimes of the system.

Keywords: stochastic systems, random fluctuations of the fields, renormalization group.

Critical Behaviour and Turbulent Transfer: Nonperturbative Renormalization Group Approach

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Motivated by the influence of turbulent velocity flows in real systems on them critical behaviour, the model A of classical nonequilibrium phenomena has been investigated by means of Nonperturbative Renormalization Group (NPRG) techniques. The compressibility of a medium advected by the Gaussian velocity field, the Kraichnan model, were emphasized. Having obtained infra red stable asymptotic regimes, we have derived possible scaling lows and found how compressibility affect quantitative parameters and qualitative behaviour pattern. We

compared the obtained NPRG outcomes with the results of one-loop perturbative RG calculations.

Keywords: exact renormalization, turbulent transfer, critical behaviour.

Renormalization Schemes and the Double Expansion in the Field Theory of Forced Turbulence

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In the field theory of forced turbulence in arbitrary space dimension the correlation and response functions of the velocity field contain divergences at two dimensions in addition to those brought about by the power-law correlation function of the random force at the critical value of its exponent. Renormalization of the model with an account of both sets of divergences gives rise to a double expansion of critical exponents and amplitudes. Contrary to the usual ε expansion, important quantities in the model are not analytic functions in the double expansion. The structure of renormalization-group equations as well as numerical results heavily depend on the renormalization scheme adopted. Consequences of this ambiguity are analyzed on the basis of results of calculations available in several different renormalization schemes.

Keywords: fully developed turbulence, renormalization group, double expansion.

Critical Behavior of Direct Percolation Process in the Presence of Compressible Velocity Field

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Various systems exhibit universal behaviour at the critical point. A prominent example of the non-equilibrium critical behaviour is the directed bond percolation in which transition from an active phase to an absorbing one takes place. Almost every physical process inevitably occurs in some external environment, which can in principle affect its critical behaviour. In many cases such environment can be modeled via advective velocity fluctuations. Then an interesting question arises whether and how advective velocity field influence percolation process. In this work we assume that the velocity fluctuations are generated by the compressible Navier-Stokes equation where the compressibility is taken into account by an additional field related to the density fluctuations. Using field-theoretic approach and perturbative

renormalization group large-scale and long-time behaviour of the system is analysed and possible macroscopic regimes are reviewed.

Keywords: Fully developed turbulence, directed percolation process, continuous phase transitions, field-theoretic renormalization group, anomalous scaling.

Mechanism of Abnormalities and Curiosities in Rhythmic Precipitation

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Liesegang banding is the display of parallel strata of precipitate in a gel, as two co-precipitate ions interdiffuse in the medium. This is often referred to as *periodic* or *rhythmic* precipitation. Although this phenomenon has reached a certain level of universality, some experiments involving a diversity of salt systems and run under exactly the same conditions, fail to give Liesegang bands, or yield a reversal of some well-known trends. We aim at unraveling the mechanisms that lead to such abnormal behavior.

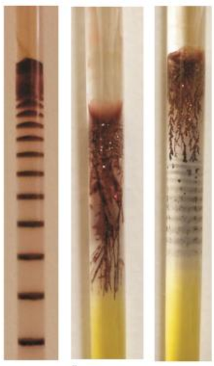

Figure 1: Bands (a), crystallites (b) and mixed pattern (c).

Ag+ and Cr2O72– produce Ag2Cr2O7 Liesegang bands (Figure 1.a) when the experiment is carried out in gelatin. However in agarose, the system fails to produce bands, but instead yields random crystallites (Figure 1.b). In a carefully dosed mixture of gelatin and agarose, a mixture of the two patterns coexisting together is obtained (I. Lagzi and D. Uweyama (2009), Chem. Phys. Lett., 468, 188-192). We attempt to unravel the mechanism of this curious behavior based on IR, viscosity, pH measurements and the gel texture.

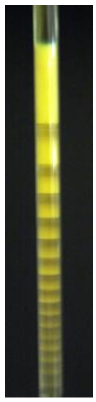

Figure 2: Revert spacing

$PbCrO_4$ patterns in agarose display a revert spacing trend, wherein the spacing decreases with increasing distance from the outer electrolyte-gel junction (Figure 2). A former study (T. Karam, H. El-Rassy and R. Sultan, *J. Phys. Chem. A* (2011)**,** 115(14), 2994-2998) attributed this phenomenon in $PbCrO_4$ to adsorption effects. We revisit this mechanism and delve more deeply into structural effects and gel-ion interactions.

Dynamical Characteristics of Myocardial Contractile Function in patients with Hypertension

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For last decade significant attention has been paid to the investigation of dynamical changes in heart function under different cardiac disfunctions. It has been established that a high degree of variability is a common feature of young healthy hearts, and that decrease in regularity may take place in aging and diseases. At the same time despite a number of important findings, many aspects of dynamical behavior of different physiological charatcteristics should be carefully investigated by means of modern nonlinear time series analysis methods. In present study investigated dynamics of several indexes of myocardial contractile function. Namely, velocity of myocardial fibers circular contraction (MVCC), index of myocardial contractility (IMC), end diastolic pressure (EDP) and ejection fraction (EF) time series for patients with different form of arterial hypertension have been investigated. We have used Lempel and Ziv approach (LZC) of algorithmic complexity measure calculation. LZC a nonparametric, simple – to compute measure of complexity in a one dimensional time series. In order to evaluate long range correlations in changes of heart dynamics in different blood pressure categories of patients with arterial hypertension we have used detrended fluctuation analysis – DFA conceived as a method for detrending local variability in a time series, providing insight into its long-term variation features. This technique provides a quantitative parameter (DFA scaling exponent) that gives information about the correlation properties of the time series. We have analysed time series of sequence of myocardial left ventricle contractile function indexes. These indexes have been calculated from apex cardiograph records. In total 120 adult male persons were inquired, including: 30 healthy subjects, 30 patients with hypertension of different severity (according to guidelines). It was shown, that LZC measure of variability of heart contrac! til! e indexes, manifest clear dependence with the severity of hypertension in different blood pressure categories. Namely, complexity measure of myocardial contractile function time series decrease comparing to healthy group indicating increase in regularity. DFA analysis indicated that in higher hypertensive categories, in myocardial contractile function characteristics occur the shift to clearly persistent behavior, comparing to closer to random-like behavior in healthy persons and patients in transitional blood pressure categories.

Keywords: Nonlinear time series analysis, dynamics, cardiology, hypertension, myocardial contractile function time series.

Inertial Manifold of the Nonlinear Dynamical System Governing a Thermosyphon Model

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Thermosyphons, in the engineering literature, is a device composed of a closed loop containing a fluid whos motion is driven by several actions such as gravity and natural convection. Their dynamics are governing for a coupled differential nonlinear systems. In several previous work we show chaos in the fluid, even with a viscoelastic fluid. We study the asymptotic behavior depending on the relevant parameters and it is obtained through an inertial manifold.

Keywords: Thermosyphon, Asymptotic behaviour, Inertial Manifold.

Combining Nonlinear Noise Reduction with in-Painting in the Analysis of Variable Star Light Curves

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With the advent of TESS (the Transiting Exoplanet Survey Satellite) the next-generation exoplanet-hunting space telescope, targets will be observed for shorter times than with the Kepler Space Telescope. Therefore, noise reduction in data analyses is expected to be important. In the analysis of Kepler Space Telescope data to date we have used nonlinear projective noise reduction on continuous one-month light curves. We present our initial results of nonlinear noise reduction on continuous light curves that have been obtained by in-painting. We also touch on the methodology of M Small as used on the in-painted data.

Keywords: Nonlinear noise reduction, in-painting, variable-star light curves, delay windows.

Effective Computation of the Dynamics Near a Periodic Orbit

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In this talk we will focus on the use of the so-called jet transport technique to study the dynamics near periodic orbits of ordinary differential equations (ODEs). More concretely, we will discuss the computation of normal forms and invariant manifolds (of any dimension) around the periodic orbit.

Jet transport is a technique to compute high order differentials of a given numerical algorithm, with respect to initial data and/or parameters. Combining this method with a numerical integrator for ODEs allows to compute Taylor expansions of Poincare maps at a given fixed point. From this power expansion it is not difficult to compute normal forms and high order approximation to invariant manifolds at this point. We note that this approach can be used in situations that are far from integrable.

Keywords: jet transport, periodic orbit, ODE, normal forms, invariant manifolds, Taylor expansion, Poincare map.

Anomalous Scaling in the Compressible Kazantsev-Kraichnan Model with Spatial Parity Violation

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The field theoretic renormalization group and the operator product expansion are used for the investigation of the inertial-range anomalous scaling behavior of the single-time correlation functions of the weak magnetic field in the framework of the compressible Kazantsev-Kraichnan rapid change model with spatial parity violation of the corresponding conductive turbulent environment. Two-loop expressions for the critical dimensions of the leading composite operators in the operator product expansion, which drives the anomalous scaling of the two-point single-time correlationfunctions of the magnetic field in the presence of the large-scale anisotropy, are found as functions of the compressibility and helicity parameters. The influence of the compressibility and the helicity of the turbulent system on the hierarchy of the anisotropic contributions to the anomalous dimensions is discussed and it is shown that the crucial role is played by the composite operator near the isotropic shell in agreement with the Kolmogorov isotropy restoration hypothesis. It is shown that the presence of the helicity as well as of the compressibility of the electrically conductive turbulent environment can have a nontrivial significant impact on the scaling properties of the correlation functions of the passive magnetic field, namely, to make the anomalous scaling more pronounced than in the incompressible and non-helical case. In addition, it is also shown that the persistence of the anisotropy deep inside the inertial interval is more visible especially when the spatial parity violation is present in the system.

Keywords: anomalous scaling, kinematic MHD turbulence, compressibility, helicity.

Turbulent Prandtl Number in the A Model of Passive Vector Admixture

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One of the most important characteristics of diffusion processes in fluids is the Prandtl number as a ratio of the coefficient of kinematic viscosity to the coefficient of the corresponding diffusivity. The numerical values of various Prandtl numbers, in general, depend on the microscopic structure of the fluids at low Reynolds numbers. The situation changes when the Reynolds numbers obtain very high values, i.e., in the so-called fully developed turbulence regime. Here, the Prandtl numbers obtain universal values which are known as ``effective'' or “turbulent'' Prandtl numbers. Recently, the turbulent Prandtl numbers were studied in various models of passive admixtures (scalar or vector) in fully developed turbulence given by the stochastic Navier-Stokes equation using the field theoretic renormalization group technique in the second order of the perturbative expansion (two-loop approximation) [1,2, 3,4].
In the present work the behavior of the turbulent vector Prandtl number is investigated as the function of the spatial dimension $d > 2$ in the framework of the general A model of passively advected vector field, where three important and physically interesting cases, namely, kinematic MHD ($A = 1$), linearized Navier-Stokes equation ($A = -1$) and admixture of a vector impurity by the N-S turbulent flow ($A = 0$), are included. The behavior of the turbulent Prandtl number is studied in the model with the Navier-Stokes fully developed turbulence. Using the field theoretic renormalization group approach in the two-loop approximation we analyzed the dependence of the turbulent vector Prandtl number on the parameter A as well as on the spatial dimension d. For detailed analysis and results see [5].

Keywords: Navier-Stokes equation, Renormalization Group, Turbulence, Prandtl number, Two-loop approximation, A model, Vector admixture.

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Turbulence of Optical Dissipative Solitons

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Optical representation of turbulence phenomena opens the door to the statistical and thermodynamic theory of dissipative coherent and partially coherent structures in a whole, which can be attributed to "one of the central problems of theoretical physics." Our extensive numerical simulations of the generalized cubic-quintic nonlinear Ginzburg-Landau equation, which models inter alia the dynamics of mode-locked lasers, demonstrate a close analogy between the properties of dissipative solitons and the general properties of turbulence. In particular, we show a scenario of transition to turbulence related to "spectral condensation – temporal thermalization" duality and disintegration of dissipative soliton into a non-coherent (or partially coherent) multisoliton complex. Thus, the dissipative soliton can be interpreted as a complex of nonlinearly coupled coherent "internal modes". This allows developing a kinetic and thermodynamic theory of non-equilibrious dissipative phenomena. Also, we demonstrate an improvement of dissipative soliton integrity and, as a result, turbulence suppression due to non-instantaneous nonlinearity caused by the stimulated Raman scattering. This effect leads to an appearance of a new coherent structure – a dissipative Raman soliton.

Keywords: Optical turbulence, Dissipative solitons, Chaos in nonlinear optical systems, Generalized cubic-quintic nonlinear Ginzburg-Landau equation.

Is Possible Quantum Correction for Newton's Law of Motion?

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Contemporary physics, both Classical and Quantum, requires a notion of inertial reference frames. However, how to find a physical inertial frame in reality where there always exist random weak forces? We suggest a description of the motion in non-inertial frames by means of inclusion of higher time derivatives. They may play a role of non-local hidden variables in a more general description complementing both classical and quantum mechanics. https://arxiv.org/abs/1612.06712

Detecting Lyapunov Exponents and Correlation Dimension with Chaotic Time Series Analyzing of 222Rn

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Chaotic time series analyses methods are usually detecting of nonlinear dynamic system behavior. Hence most common a technique nonlinear analysis methods in literature. Lyapunov Exponents and Correlation Dimension analyses are strongest among chaos markers in nonlinear dynamic systems. Lyapunov exponent give information about a dynamical system chaotic behavior. Correlation dimension calculation is a widely-used method for detection of the chaotic behaviors. The nonlinear analysis of time series with various tools is a powerful tool to understand the chaotic dynamics in complex systems. The conclusion of chaotic time series analyses shows the reflection of the chaotic behavior of the complex dynamic systems.

Keywords: Chaos, Nonlinear behavior, 222Rn, Lyapunov exponent.

Mode Analysis of the 2-Adic Tree-Like Complex Networks of Nonlinear Oscillators

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In this work the mode analysis technique of 2-adic tree-like complex networks of nonlinear self-oscillatory systems with nonidentical and nonisochrony parameters is developed. We construct adjacency matrices of different type of tree-like networks and calculate the normal modes. We demonstrate the fractal structure of the normal modes spectrum, which looks like devils staircase fractal. After spectrum calculation using generalized quasi-Hamiltonian approach we shift to the truncated equations for slowly varying amplitudes and phases in the normal coordinates. Finally, the stability analysis of the normal modes is presented.

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The FitzHugh-Nagumo Model and 2-D Solvable Chaos Maps

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It is shown firstly that the forced Van der Pol oscillator and the forced Duffing oscillator are transformed into two-dimensional (2-D) models by a commonly used transformation and/or the Liénard transformation, and the 2-D models are compared with the FitzHugh-Nagumo (FHN) model, which explains neural phenomena. Then, the related 2-D solvable chaos maps to the FHN model are derived from the 2-D chaos solutions, and the solutions corresponding to the orbit of neural cells are numerically calculated with the algorithm and a MATLAB program. Finally, wave-like and particle-like properties of the orbit, mean free time and dynamic stability region of neural cells are briefly discussed on the basis of the numerical result.

Keywords: Van der Pol oscillator, Duffing oscillator, Liénard transformation, FitzHugh-Nagumo model, 2-D solvable chaos map, Wave-like property, Particle-like property, Mean free time, Dynamic stability region.

Variants of Permutation Entropy

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Entropies are playing an increasing role in data analysis. Here various concepts and methods are utilized, with strong or less strong theoretical background. We address structural aspects of Permutation entropy and recent variants of it and demonstrate performance of them in the analysis of large and complex data as EEG data, in particular in the detection of change points and in data classification. Finally, perspectives and challenges of using Permutation entropies and variants are discussed.

Keywords: ordinal patterns, Permutation entropy, Conditional entropy of ordinal patterns, Kolmogorov-Sinai entropy.

Control of Irregular Cardiac Rhythm

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Among the important applications of chaos theory is the understanding and characterization of cardiac pathologies. In this work, we focus on the non-linear dynamics of the heart rhythm with useful results in the prevention of arrhythmias. From a dynamic point of view, the different states of the heart rhythm are qualified by points of equilibrium, periodicity and chaos [1]. Many studies are devoted to the suppression of abnormal rhythm and spatio-temporal chaos in the heart tissue [2-3]. Control methods using external electrical stimulation are applied to alternations and irregular heart rhythms in order to regain a normal rhythm [4]. Mathematically, the control is performed with small perturbations at the system parameter to conduct the periodic and chaotic behavior at the equilibrium point. In cardiac dynamics, the most accessible system parameters available for perturbation are usually the interval between successive stimuli or the next excitation moment, which may be advanced or (in some situations) delayed through low-magnitude current stimulation[5]. In the present work, a non-linear control method (OGY) is used to stabilize unstable equilibrium points at time-1. It is shown that this approach allows control of chaotic behavior or pathological rhythms such as arrhythmia. The results obtained are illustrated in the case of the duration of the action potential of the 1D-map (APD) which models the duration of the cardiac action potential as a function of the previous one [6].

Keywords: Action Potential Duration (APD), chaos, OGY method, equilibrium point, irregular heart rhythm.

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A new Route for Chaos in Tapping Mode Atomic Force Microscopy

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The Tapping Mode Atomic Force Microscopy (TM- AFM) has evolved into a versatile method for nanoscale imaging of surfaces in biological and material sciences. It includes a resonating microcantilever with a sharp nanoscale tip that repetitively touches the sample surface and a controller that keeps the tip amplitude constant using an active feedback loop. One of the most prominent features of tapping mode AFM is the insurgence of highly nonlinear tip-sample interaction forces. As a result, the microcantilever often vibrates in unprecedented chaotic manners that impose a strict tradeoff between stability and operation speed. Particularly, it is known that in contradiction with its existing conceptual models, the AFM can never operate faster than a certain limit.

This paper explores a new route to chaos by developing a model that accounts for coupled dynamics of the cantilever and the controller for the first time. The model considers the modulated dynamics of the micro-cantilever following a periodic averaging method. It shows that although the individual components are globally asymptotically stable, they demonstrate a chaotic response when they are coupled in the architecture of AFM.

The presence of newly identified route to chaos has also been experimentally observed and confirmed by plotting the Poincare sections, Bifurcation diagrams and calculating the Lyapunov exponents.

Keywords: Chaos, Atomic Force Microscopy, Modulated Dynamics, Periodic averaging method, Lyapunov exponents.

Multi Switching Combination Anti Synchronization of Chaotic Systems

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In this paper multi switching combination anti synchronization is achieved between three different chaotic systems. The concept of multi switching combined with combination synchronization scheme strengthens the security of information transmission. Sufficient conditions are obtained for achieving the desired synchronization using Lyapunov stability theory. The effectiveness of the proposed method is validated by performing numerical analysis.

Dual Combination Combination Multi Switching Anti Synchronization of Chaotic Systems

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This paper presents the dual combination-combination multi switching anti synchronization between two pairs of drive chaotic systems and two pairs of response chaotic systems. The multiple combination of chaotic systems and multi switching results in a complex dynamic behaviour, which is interesting to study. Using Lyapunov stability theory, sufficient conditions are achieved and suitable controllers are designed to realize the desired synchronization among eight chaotic systems. Corresponding theoretical analysis is presented and numerical simulations performed to demonstrate the effectiveness of the proposed scheme.

Keywords: Chaos Synchronization, dual synchronization, multi switching synchronization, combination combination synchronization, nonlinear control.

Structure of Manifolds for Parametric Autoresonance in Phase Space

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We will discuss manifolds of trajectories for nonlinear oscillator which are captured into parametric autoresonance. The measure and asymptotic behaviours of such manifolds will be studied in detail by using asymptotical and numerical methods.

Keywords: Nonlinear oscillator, resonance, phase space, asymptotic behavior.

Essential Spectra of Non-Invertible Weighted Composition Operators

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We describe essential spectra of weighted compositions generated by finite hyperbolic Blaschke products in the space of continuous functions on the unit circle and also on disk-algebra.

Nonlinearity and Chaos in Decision Making

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Simple models of complex processes may be helpful in understanding of physiological as well as of psychological mechanisms. In this paper I explore simple models of decision making. If each subject in a group makes decisions independently from the others but is influenced by external propaganda or commercials then simple exponential strengthening/weakening of the decision is observed. But if in the process of decision making the subjects interact then much more complex, even chaotic dynamics may be observed. Even if it seems to be very logical, decision making is mainly an emotional process. I demonstrate that the difference between an emotion and a logical thought may result from the difference in characteristic times – logical thinking is much slower and even may be blocked by emotions.

Keywords: Chaos, Decision making, Neuropsychology, Emotion, Propaganda.

Parameter Estimations for the Modified Izhikevich Neuron Model with Optimization Methods

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Biological neuron models define the dynamical behaviors of the real neurons mathematically in the body. They can be implemented with various hardware and their hardware realizations are used some applications, which require the real time signals. The implementation simplicity and to be able to obtain the different dynamical behaviors of the neuron by setting the least possible number of the parameters in the model are proffered specialties. The Izhikevich neuron model has almost all of these features, but it has a parabolic nonlinear function. In the literature, this parabolic function is transformed to the second, third and fourth orders piecewise linear (PWL) functions for implementation easiness and some coefficients were used in the PWL functions for this conversion. These coefficients were identified by classical step size method, but this method is not reliable enough, because the values of the parameters depend on the sensitivity of the step size, relatively. The aim of our study is to specify these parameters in the second, third and fourth order PWL functions by using the stochastic optimization methods. The parameters in the modified Izhikevich neuron model are estimated by using Genetic and Artificial Bee Colony Algorithms for twenty different dynamical behaviors of the neuron. In accordance with this purpose, these algorithms are run thirty times for each of twenty behaviors of a neuron, and the standard deviation results of these runs are given in the tables to see performance of GA and ABC algorithms. The all results,

which include the values of the coefficients and the total errors of the estimation methods namely classical step size, GA and ABC, are presented in the tables. Additionally, the study is supported by the numerical simulation results.

Keywords: Izhikevich Neuron Models, Genetic Algorithm, Artificial Bee Colony Algorithms, parameter estimation, optimization methods.

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Nonlinear Forecasting of Red Blood Cells Time Series Dynamics

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On healthy individuals as well as on disease patients, their Red Blood Cells (RBCs) are forced to travel along capillaries of the microcirculation with in some cases diameters smaller than the cells themselves. An optical system called Erythrocyte Rheometer has been developed and constructed in our laboratory, in order to evaluate the erythrocytes viscoelastic properties. Ektacytometry quantifies erythrocyte deformability by measuring the elongation of suspended RBCs subjected to shear stress. Raw shear stress elongation plots are difficult to understand. Moreover, most research papers apply data reduction methods characterizing the relationship between curves fitting formulas, bringing pour results. On the other hand our approach works with the naturally generated photometrically recorded time series of the diffraction pattern of several million of RBCs subjected to well controlled shear stress. The development of new quantitative nonlinear methods capable to analyze at the same time biological and mechanical aspects of the cells in flow, not only for healthy controls samples but also for disease patients samples to compare their dynamics, are crucial for restricting the subjectivity in the study of the cells behavior.

To analyze the cells dynamics we used the technique of Time Delay Coordinates, False Nearest Neighbors, Embedding Dimension, the forecasting procedure proposed by Sugihara and May and finally Scaling Exponents. In order to improve the results we studied shuffle surrogates time series, dividing the original photometrically recorded series and concatenating them at random ten times each.

The forecasting technique discussed here is phenomenological in the sense that it attempts to evaluate the qualitative character of a system’s dynamics and to make short range predictions based on ordinary Brownian motion and fractional Brownian motion attempting to provide an understanding of the biological and physical mechanisms that govern the behavior of the system.

The results obtained suggest that through this random walk analysis, apparent noise associated with deterministic chaos can be used not only to distinguish but also to characterize the different RBCs population analyzed in flow. Moreover, obtaining the Scaling Exponents, we were able to find out the evident manifestation of a random process on RBCs samples of healthy individuals and its sharp reduction of randomness on analyzing disease RBCs samples. We can conclude that this is an active work, using chaos quantifiers to analyze and characterize biological cells real data.

Keywords: Chaotic modeling, Time Delay Coordinates, False Nearest Neighbours, Embedding Dimension, Scaling Exponents, RBCs deformability.

Turbulent Advection of Active Scalar Field Near Two Dimensions

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The Renormalization Group approach is applied to the model of the active scalar field advection by an incompressible fluid. The behaviour of the fluid is defined by the Navier-Stokes ensemble with external random thermal-like stirring. It turns out that the model becomes the logarithmic one in the case of the space dimension $d = 2$. Thus, the perturbation theory is built as series in $\varepsilon = d - 2$. The coordinates of the fixed points and the critical dimensions are obtained in the leading one-loop result.

Keywords: field-theoretic Renormalization Group, active scalar field.

About the Fractal Compression of Three-Dimensional Image Based on Quaternion Algebra

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Fractal image compression is lossy compression algorithm based on the representation of the image in a more compact form using iterated systems PIFS – Partitioned Iterated Function System, which often are affine transformations. Fractal compression techniques are quite effective, although not so widespread. As the reality increasingly faced with the need to store and transmit not only two-dimensional images, but also three-dimensional models, the author suggested the possibility of a 3D model compression method of fractal compression. The major drawbacks of compression algorithm of three-dimensional objects are

the same as of the two-dimensional compression: time-consuming compression and the inability to guarantee a certain degree of loss, since the quality of the decoded image depends on the self-similarity compressible. Advantages include a higher compression ratio, faster decoding process, the independence of the reconstructed image resolution (stored image structure). Main attention is paid to the second stage of the algorithm: applying transformations for each pair of blast-rank unit, all the conversion for each pair produced using quaternion algebra that will allow at least use units with less computationally.

Keywords: Fractals, Fractal Compression, Quarenions, 3D Image.

Chaos in Interaction of a Shaker and an Oscillator

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The coupling effect between an excitation machine and vibrational loads was found by Sommerfeld [4,5], is a universal phenomenon and a manifestation of the law of conservation of energy. A rather complete study of the Sommerfeld effect has been given in the works of Kononenko [3], so that we call these phenomena as Sommerfeld-Kononenko effect [1,2]. As shown by Kononenko for a linear oscillator with limited excitation the characteristics of a nonlinear oscillator arise, such as the occurrence of instability regions. In view of this, in the present study, the existence of new possible characteristics is investigated for an oscillator with damping and an electrodynamical shaker. Steady-state regimes of the constructed model are investigated by methods of the theory of dynamical systems. Regular (periodic and quasi-periodic) and chaotic regimes, for the first time, are found and studied.

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An Explanation of Stability of Extrasolar Systems Based on the Universal Stellar Law

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This work investigates the stability of exoplanetary systems based on the statistical theory of gravitating spheroidal bodies. The statistical theory for a cosmogonical body forming (so-called spheroidal body) has been proposed in our previous works. Starting the conception for forming a spheroidal body inside a gas-dust protoplanetary nebula, this theory solves the problem of gravitational condensation of a gas-dust protoplanetary cloud with a view to planetary formation in its own gravitational field. This work derives the equation of state of an ideal stellar substance based on conception of gravitating spheroidal body. Taking into account this equation we obtain the universal stellar law (USL) for the exoplanetary systems connecting temperature, size and mass of a star (in particular, the Sun).

This work also shows that knowledge of some orbital characteristics for multi-planet extrasolar systems refines own parameters of stars based on the combined Kepler 3rd law with universal stellar law (3KL–USL). The proposed 3KL–USL predicts statistical oscillations of circular motion of planets around stars. Really, this combined law connects the mechanical values (the angular velocity and the major semi-axis of a planetary orbit) and the statistical (thermodynamic) values (the parameter of gravitational condensation and the temperature). It means that a stability of the mechanical values (entering in the left part) depends on a statistical regularity of the right part of the 3KL–USL equation. Thus, we conclude about a possibility of presence of statistical oscillations of orbital motion, i.e. the oscillations of the major semi-axis and the orbital angular velocity of rotation of planets and bodies around stars. Indeed, this conclusion is completely confirmed by existing the radial and the axial orbital oscillations of bodies for the first time described by Alfvén and Arrhenius.

This work shows that the stability of parameters of planetary orbits is determined by a constancy of the specific entropy in conformity with the principles of self-organization in complex systems. Therefore, the proposed 3KL–USL explains the stability of planetary orbits in the extrasolar systems.

Keywords: Gas-dust protoplanetary nebula, Spheroidal bodies, Gravitational condensation, Exoplanetary systems, Alfven–Arrhenius' oscillating forces, Stability of planetary orbits, Specific entropy.

An Efficient Estimator of Fractal Dimension of Self-Avoiding Curves

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We study the problem of estimating of fractal dimension of self-avoiding curves embedded in the space R^2, which commonly represent roughened interfaces. Usual graphical and statistical estimators of fractal dimension of roughened self-avoiding.

Common Source as a Possible Explanation of Hyper-Synchronous Seizure State

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During epileptic seizure, the electroencephalogram (EEG) typically shows similar strong oscillations at many channels indicating a hyper-synchronous state. The underlying mechanism for this is investigated in the current empirical study. The starting point is the contradicting findings of different works in the literature, some suggesting increase and others decrease of coupling during epileptic seizure. We have observed both patterns depending on the measure of coupling (interpreted as inter-dependence, information flow and Granger causality) we have applied to longer epileptic seizures and short electrographic seizures (epileptiform discharges, ED). In this work, we attempt to give an explanation of the underlying mechanism to the hyper-synchronous seizure state in terms of direct information flow between brain areas measured by scalp EEG, in conjunction with instantaneous causality, a type of cross-correlation between the brain areas. Our tool for this is the measure of partial mutual information from mixed embedding, modified to quantify both the direct information flow and the instantaneous causality. We first present a proof-of-concept study on known coupled systems of many coupled subsystems (one observed variable from each subsystem), where we also examine the limitations in identifying common driving from a hidden source. Based on the deductions from the simulation study we interpret the results on direct information flow and instantaneous causality in epileptic episodes. It turns out that a possible explanation of the hyper-synchronous epileptic state is the common driving from a hidden source rather than the strong interaction (coupling) among the observed brain areas.

Keywords: Complex systems, complex networks, time series analysis, information flow, brain connectivity, hidden source, epilepsy, electroencephalograms (EEG), epileptiform discharge.

Research of the Pseudo-Chaotic Number Sequences in Secure Communication Systems

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Recently increasing interest in the use of pseudo-chaotic sequence instead of pseudo-random sequences in info-communication systems. This is because the properties of deterministic chaos make it possible to widely use it to encrypt information in both analog and digital communications. The paper discussed several algorithms of pseudo-chaotic sequences based on one-dimensional chaotic maps and studies their statistical properties. The results indicate the possibility of using pseudo-chaotic sequences as true random sequences in the structure of the secure information system. Also need to enter some new definitions relating to the parameters of pseudo-chaotic sequences and distinguish them from classical pseudo-random number sequences.

Keywords: Deterministic chaos, Pseudo-chaotic sequence, Logistic chaotic map, Secure information system.

Dynamics of the Multi-Pendulum Systems with Side Stops

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The main aim of the paper is to analyze the dynamic properties of a multi-pendulum system with side stops where collisions occur. This research is motivated by a real problem of friction-vibration interactions of nuclear fuel rods. The system has several degrees of freedom. Its movement is governed by a set of nonlinear ordinary differential equations. As the main result it is shown that the system exhibits regular, irregular and chaotic pattern for suitable choice of parameters.

Keywords: Meachanical system, bifurcation, regular motion, chaos.

Electronic Valve Instabilities and Modes Jumps

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This article reviews the invention of the electronic valve (lightbulb1, diode2 audion3, triode4 and magnetron5) and their modern counterpart (diode sputter ion pump6 and the diode parallel-plate RIE reactor7), in the period from the 1870's to the 2016. Emphasis is given to the human nature of discovery, invention and patent filing and litigation, along with the fundamental physics and electrical engineering concepts applied within the inventions. The malfunction (mode jumps and instabilities) of the electronic valves are examined using an electrical engineering approach. In the absent of such an approach for the diode sputter ion pump "Argon instability", coupled ordinary differential equations have been used to the mimic the dynamics of the heterogeneous gas burial / release process. Lastly, heterogeneous chemical mode jumps in the metal-organic reactive etch process of GaAs semiconductor material has also been considered.

Keywords: Space-charge, electronic valves, sputter ion pump, RIE reactor, modes, instabilities.

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Experimental Investigation of the Elastic Enhancement Factor in a Transient Region between Regular and Chaotic Dynamics

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We present results of an experimental study of the elastic enhancement factor W for a microwave rectangular cavity simulating a two-dimensional quantum billiard in a transient region between regular and chaotic dynamics [1].
The experimental results for the rectangular cavity are compared with those obtained for a microwave rough cavity simulating a chaotic quantum billiard.
We show that the elastic enhancement factor of the two-port scattering matrix $\hat{S}$ for the rectangular cavity lies below the theoretical value *3* predicted for integrable systems, and is significantly higher than that obtained for the rough cavity. The results obtained for the microwave rough cavity are in good agreement with the results obtained within the framework of random matrix theory.

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Network reconstruction via rank statistics measures

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The study of complex networks is a key tool to understand real-world systems. Inferring the exact structure of how the individual entities are connected is decisive to understand the collective behavior of the network. However, the topology of the system is not always available. This calls for methods that allow one to infer the connectivity of a given system from measured signals. Here, we use a rank-based nonlinear interdependence measure developed for pairs of signals in [1]. It is known that pairwise approaches are prone to mistake indirect connections as real links. Therefore, we refine the method to analyze multivariate signals from networks. We compare the results of the pairwise approach with the ones using this refinement.

Keywords: Complex Networks, Connectivity, Inference.

References:

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Attractors of Sequences of Function Systems and their Relation to Non-Stationary Subdivision

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Iterated Function Systems (IFSs) have been at the heart of fractal geometry almost from its origin, and several generalizations for the notion of IFS have been suggested. Subdivision schemes are widely used in computer graphics and attempts have been made to link fractals generated by IFSs to limits generated by subdivision schemes. With an eye towards establishing connection between non-stationary subdivision schemes and fractals, this paper introduces the notion of “trajectories of maps defined by function systems” which may be considered as a new generalization of the traditional IFS. The significance and the convergence properties of ‘forward’ and ‘backward’ trajectories are studied. In contrast to the ordinary fractals which are self-similar at different scales, the attractors of these trajectories may have different structures at different scales.

Keywords: Subdivision, Fractals, Attractors.

A Study of the Run Length Distribution of the Group Runs Xbar Chart

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Nowadays, quality is essential in every field. Producing quality products or services can help to increase the competitiveness, reputation and customer loyalty of a company as this ensures that the products or services meet customers’ expectations. However, for a product or service to have a satisfactory quality level, the underlying process manufacturing the product or providing the service should be in statistical control. The Group Runs (GR) Xbar chart is proposed as an improvement over the synthetic Xbar chart for the detection of process mean shifts. The GR Xbar chart integrates the Shewhart Xbar sub-chart and an extended version of the conforming run length (CRL) sub-chart. To have a better understanding of the behavior of the GR chart, in this paper, we study the percentage points (or percentiles) of the run length distribution of the GR chart, instead of depending entirely on the average run length (ARL) criterion. Before computing the percentiles of the GR Xbar chart, we need to obtain the optimal parameters of the GR Xbar chart. This can be achieved by writing a computer program to search for a set of optimal K and L values that minimize the out-of-control ARL, while maintaining the in-control ARL at a desired value. Then, the percentiles of the run length distribution of the GR Xbar chart can be investigated using this set of K and L values.

Keywords: Group Runs chart, synthetic chart, Shewhart Xbar chart, conforming run length (CRL) chart.

A Perturbed Nonlinear Model of an articulated Vehicle System with Driver Control

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A tractor-semitrailer vehicle is modeled by a multi-body system to study its planar motion for tracking maneuvers. In this modeling work, the driver steering control is also considered in the driver/vehicle closed system. The inherent parameters of the driver model are determined by an optimization algorithm. The resulting system is a 6-dimensional nonlinear time-delayed differential equations. The linear stability boundaries are computed by a numerical root-finding algorithm to locate the right-most eigenvalues in the complex plane. Different nonlinear motions are found in the system in the vicinity of the bifurcation points using numerical simulations. When a periodic perturbation to the steering angle is considered, chaotic motions are observed. The influences of system parameters such as the vehicle forward speed, the driver's time delay, the perturbation frequency and amplitude are studied with! respect to the system behaviors.

Keywords: Chaotic motion, Tractor-semitrailer vehicle, Driver model, Time delay, Optimal control, Eigenvalues, Bifurcation, Simulation.

Normal and Super Diffusion in a One-Dimensional Impact System

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In this study we seek to aim and understand the role of the accelerator modes (AM) in a transition from normal to super diffusion in the dynamics of a bouncing ball model. Recent studies have considered the nature and focused on the localization (range of the control parameter) of the AM (ballistic modes), roughly described as featured resonances in the phase space. So, in this work we focus in the description of the transport analysis and in the probability of an orbit to reach an AM, giving emphasis in the transition from normal to super diffusion. Through the analysis of the dispersion of the root mean square velocity, we were able to characterize a diffusive transition in a range were a period-1 AM is active. Considering transport properties, such as the survival probability and escape rates for different velocity ranges, a description of the super diffusive scenario for the AM was achieved. The results obtained in this work and the numerical procedures can be extended to other similar dynamical that may present AM or supper diffusion in their dynamics.

Keywords: Chaos, diffusion, accelerator modes, bouncing ball.

Global Phase Portraits of Differential Quadratic Systems having a Singular Cubic Curve

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Planar quadratic differential systems are the simplest nonlinear differential systems. However, global properties of such systems are difficult to handle. Quadratic differential systems appears in biology, dynamic population, physics, chemistry, cosmology, etc. There is an extensively literature about Hilbert's sixteen problem, ciclicity, integrability and quadratic systems. In particular, in the work of J. Llibre, J.S. Pérez del Río and J.A. Rodríguez appears a classification of all real quadratic systems having one real invariant algebraic curve of degree 3 which satisfy some generic conditions. Singular curves are not considering in this work. Here, we complete this study of quadratic systems with an invariant algebraic curve of degree 3 that is irreducible and singular. First we present the normal forms of such systems. Then we provide global phase portraits in the Poincare disk and the corresponding bifurcation diagrams. We also check the topological equivalence between the phase portraits.

Keywords: Quadratic differential systems, global phase portraits, singular curves, invariant curves.

Frequency Analysis of the Laser Driven Nonlinear Dynamics of HCN

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One topic of much interest in this branch of chemical dynamics is the active control of molecular nonlinear dynamical systems and chemical reactivity, typically using lasers. In this work we study the vibrational dynamics of a model for the HCN molecule in the presence of a monochromatic laser field. The variation of the structural behavior of the system as a function of the laser frequency is analyzed in detail using the smaller alignment index, frequency maps, and diffusion coefficients. It is observed that the ergodicity of the system depends on the frequency of the excitation field, especially in its transitions from and into chaos. This provides a roadmap for the possibility of bond excitation and dissociation in this molecule. In this way, we can be more precise in predicting which laser frequencies are best in order to promote dissociation.

Keywords: Nonlinear dynamics, Chaos, Frequency analysis, Control.

Qualitative Results for a Mixture of Green-Lindsay Thermoelastic Solids

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We study qualitative properties of the solutions of the system of partial differential equations modeling thermomechanical deformations for mixtures of thermoelastic solids when the theory of Green and Lindsay for the heat conduction is considered. Three dissipation mechanisms are proposed in the system: thermal dissipation, viscosity effects on one constituent of the mixture and damping in the relative velocity of the two displacements of both constituents. First, we prove the existence and uniqueness of the solutions. Later we prove the exponential stability of

the solutions over the time. We use the semigroup arguments to establish our results.

Keywords: Thermoelastic mixtures, existence, uniqueness, exponential decay, Green-Lindsay heat conduction.

Highway Traffic Speed Data Entropy

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This paper is focused on quantifying nonlinear dynamics of the highway traffic speed data, which are real world discrete time series-data. It is known the highway traffic data are exhibiting chaotic behavior, therefore dynamical invariant measures such as approximate entropy or recurrence matrix will be used to determine predictability of the time-series. These methods based on the state-space reconstruction are well established tools in the area of nonlinear dynamical systems analysis. Approximate entropy is used to quantify the amount of regularity and unpredictability of the time-series data, which are not possible to detect by measures such as mean or variance. Recurrence matrix is visual method used to study higher dimensional state space trajectories. In addition to that, it is possible to quantify several measures from recurrence matrix giving information about system dynamics, stability and predictability. The main result of this paper will be dynamical properties and predictability of the highway traffic speed data.

Keywords: dynamical system, chaos, approximate entropy, recurrence matrix, predictability, road traffic.

Multivariate Analysis of Variation of Annual Number of Warmer and Colder Days Derived from Data Sets of Daily Maximum Air Temperatures

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We investigated changes in local climate system using variability features of number of colder and warmer days from two distant locations in Europe (from 1915 to 2013). Sequences of warmer and colder days were derived from time series of anomalies of max daily air temperatures data sets in Tbilisi (Georgia) and Maastricht (Netherlands). Together with traditional monovariate methods of data analysis, in the present research we used multivariate approach to assess changes, occurred in the climate system. These changes have been assessed from the point of view of the variability of annual number of both warmer and colder days. We show that for the most part of considered observation period the yearly number of warm days rarely reveal increasing trend. At the same time at the end of the analyzed 99-years period the increasing trends are significant for selected locations. The multivariate analysis shows that assessed by variability of annual number of warmer and colder days, dynamical features of local climate system significantly changed in time and also strongly depend on the location. Such changes in Tbilisi occurred almost gradually during the period of observation. In Maastricht stronger differences were found in the middle of observation period. At the same time for both analyzed locations significant, though not always strongest, changes occurred at the end of analyzed time period since 80th of the last century. According to our results, in some time windows of the entire 99-years period, climate system were influenced by factors of the presently unknown dynamical origin, causing essential changes in the temporal correlations of variability of annual number of warmer and colder days. Apparently these influences are not necessarily related just with changes, occurred in the last decades and took place in the past too.

Keywords: Climate change, daily air temperature variation, dynamical structure, long range correlations, multivariate analysis.

Kleptoparasitism and Complexity in a Multi-Trophic Web

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In this work the effects of kleptoparitism in a multi-trophic food-web, in which an omnivorous species scavenges the kills of a top predator, are investigated. Scavengers are assumed to be able to steal predators' kills by direct interference and aggression. The amount of prey shared depends on the relative competitive abilities of omnivores and predators and on their abundances. To make the proposed model consistent, scavenging is accompanied by other features. First, the predator can prey only on the juvenile life stage of scavengers (i.e. not on adult individuals) as well as on a different species of herbivores.
Hence, an age structure is enforced within scavengers, so that they belong to the guild of preys when they are young and vulnerable. Second, predators can switch between prey species selecting the most abundant one. This condition grants the competitive exclusion of the two vegetation eaters, allowing them to co-exist: the omnivore and the herbivore compete for the same vegetation pool but pure herbivores are indeed assumed to be more efficient in its exploitation. The omnivorous species is not able to kill the herbivores, but nonetheless it may exploit their carcasses after they have been killed by predators. Finally, the

juvenile/adult ratio of omnivores varies depending on the available resources and predators' amount. In such a scenario it is shown that kleptoparasitism can modify to a large extent the stability of the system, leading either to a regularization or to chaos, depending both on the scavenger's and the predator's functional response. Moreover, an excess of kleptoparasitism is shown to compromise the whole trophic web, making extinct both predators and scavengers. As far as the authors are aware of, this paper is the first one to explicitly introduce kleptoparasitism in trophic web models.

Keywords: Population dynamics, Trophic webs, Bifurcation analysis, Scavenging.

Development of an Analogue to Digital Converter through a Novel Approach to Estimate the Parameter and the Initial Condition from the Symbolic Sequence Generated by a Tent Map

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This paper proposes a method to determine the accurate absolute digital value of an electrical signal as a form of a tent map (TM) based analogue to digital converter (ADC). Previous works have proposed an iterative electronic implementation of a TM based systems to yield a symbolic digital sequence, however this generally relied on a perfect TM parameter value of 2. Due to variations in the electronic component values and electrical noise, the parameter becomes non-ideal leading to a loss in correspondence between actual input signal and the generated symbolic output signature. However, this work has firstly developed, a novel method to determine the non-ideal parameter value, directly from sequence of symbolic output signatures. The second part of this work utilises the calculated non-ideal parameter to determine a difference measure given the output symbolic signature to determine the actual input signal amplitude. Sampling the symbolic sequence using a field programmable gate array (FPGA) has enabled the parameter accuracy to be constantly reviewed and the difference measures updated yielding the potential for a high speed, low power 12 bit ADC architecture.

Keywords: step size, analogue to digital converter, absolute difference, parameter estimation, initial condition estimation, symbolic dynamics, fractal patterns.

Bifurcations of Hamiltonian Resonances

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In this talk, we will present a summary on the Hamiltonian resonance specifically for three degrees freedom. We will talk about normal forms. Then we will review some our results.

Further Investigation of Chaotic Instabilities in a Mining Dragline

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The occurrence of chaotic instabilities is further investigated in the swing motion of an inclined Furuta pendulum. The analysis is motivated and applied to predicting the nonlinear bucket swing behaviour of a dragline. A dragline is a large, powerful, inclined Furuta pendulum utilized in the mining industry for removal of overburden. A more detailed analysis of the dynamical system with energy dissipation is performed with an extended stability analysis of the pertinent equilibrium states. In addition new physical insight into the effects of inclination angle on the equilibrium behaviour are identified. Subsequently, new analytical predictive criteria for the onset of chaotic instability under more realistic unsteady slewing conditions are obtained in terms of critical system parameters based on Melnikov's method. Numerical simulations under field measured conditions show that the sufficient analytical crite! ria are useful predictors of the onset of chaotic instability. Conditions under which chaotic instability is more likely to occur such as pendulum mass/bucket positions are identified and discussed. The results are important for maximising mining productivity and minimising fatigue damage by avoiding undesirable chaotic dynamics in the dragline operation.

Dynamics of the Hassell Map to the Fixed Point Using Scaling Law

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Convergence to asymptotic steady state in Hassell mapping is characterized by considering a phenomenological description suported by numerical simulations and confirmed by a theoretical description. When the control parameter is varied bifurcations points appear. We analyze the dynamic of the map at the bifurcation point, called transcritical bifurcation where the convergence for the stationary point can be done using scaling law and then using a homogeneous function with three critical exponents. Near the bifurcation the decay to the fixed point is exponential with the relaxation time given by a power law whose slope is independent of the nonlinearity. The formalism is general and can be extended to other dissipative mappings.

Keywords: Hassell mapping, critical exponents, scalling invariance.

Reference: Hans M.J. de Mendon_ca, Edson D. Leonel, and Juliano A. de Oliveira. An investigation of the convergence to the stationary state in the hassell mapping. Physica A: Statistical Mechanics and its Applications, 466:537 - 543, 2017.

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Anomalous Scaling in Compressible Kazantsev-Kraichnan Model with Spatial Parity Violation

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The field theoretic renormalization group and the operator product expansion are used for the investigation of the inertial-range anomalous scaling behavior of the single-time correlation functions of the weak magnetic field within the framework of the compressible Kazantsev-Kraichnan rapid change model with spatial parity violation of the corresponding conductive turbulent environment. Two-loop expressions for the critical dimensions of the leading composite operators in the operator product expansion, which drives the anomalous scaling of the two-point single-time correlation functions of the magnetic field in the presence of the large-scale anisotropy, are found as functions of the compressibility and helicity parameters. The influence of the compressibility and the helicity of the turbulent system on the hierarchy of the anisotropic contributions to the anomalous dimensions is discussed and it is shown that the crucial role is played by the composite operator near the isotropic shell in agreement with the Kolmogorov isotropy restoration hypothesis. It is shown that the presence of the helicity as well as of the compressibility of the electrically conductive turbulent environment can have a nontrivial significant impact on the scaling properties of the correlation functions of the passive magnetic field, namely, to make the anomalous scaling more pronounced than in the incompressible and non-helical case. In addition, it is also shown that the persistence of the anisotropy deep inside the inertial interval is more visible especially when the spatial parity violation is present in the system.

Keywords: Kazentez-Kraichnan Model, Turbulence, Anomalous Scaling, Helicity.

Chaos and Chaos-Like Properties in Semiflows with the most General Acting Topological Monoids

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A semiflow is a triple consisting of a Hausdorff topological space X, a commutative topological monoid T and a continuous monoid action of T on X. We will talk about chaos-related properties on the products of semiflows, chaos and indecomposability of semiflows, syndetic sensitivity, and other properties of semiflows. The main novelty of our research is the generality of the statements. Of course, the statements could not hold for all acting monoids, but we have found large classes of monoids for which they do. They include even monoids for which we cannot say that they are neither discrete nor continuous, but a mix of both (for example T=0,2,3 U [4, □) with the operation and topology induced from real numbers). In that way we can, for example, analyze the dynamical systems whose states are first recorded at some discrete moments and which are then observed continuously, after the initial discrete observation qualifies them as ``interesting.'' That partly exp! lains the motivation for the level of generality which is pursued in our research. We introduce the psp monoids, which include all but ``pathological'' monoids and most of our statements hold for them, which is quite amazing.

Keywords: semiflows, chaos, product spaces, indecomposability, syndetic sensitivity, psp monoids.

Chimeralike States in a Network of Oscillators under Attractive and under Repulsive Global Coupling

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We report chimeralike states in an ensemble of oscillators using a global coupling scheme consisting of both attractive and repulsive mean-field feedback. We identify the existence of two types of chimeralike states in a bistable Li´enard system network. In one type, both the coherent and the incoherent oscillators are in chaotic states (which we refer to as chaos-chaos chimeralike states) and, the other is conventional type, where the incoherent population remains in periodic state while the coherent population has irregular small oscillation. We also find a metastable state in a small parameter regime.

Keywords: Network of oscillator, Chimera states, Chaotic simulation.

Symbolic Dynamics from Higher-Dimensional Chaotic Scattering Data

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From the nonlinear dynamics perspective, understanding atomic and molecular systems involves developing a deep understanding of the phase space structures that regulate transport in Hamiltonian phase space. Though a rich theory has been developed for one- and two-degree-of-freedom systems, many challenges remain for higher-dimensional systems. We present a new topological approach to higher-dimensional chaotic scattering. The input to this approach is the delay time as a function of impact parameters. The output is a rigorous symbolic representation of the dynamics within the scattering region. The method itself develops and utilizes an efficient topological representation of the codimension-one stable and unstable manifolds attached to normally hyperbolic invariant manifolds. We apply this technique to numerical data from a spherical fluid vortex, whose dynamics reduce to a volume-preserving three-dimensional map. This system is a stepping stone to full three-degree-of-freedom Hamiltonian systems, whose feasibility we assess.

Keywords: nonlinear dynamics, phase space structures, transport, Hamiltonian systems, chaotic scattering, symbolic representation, normally hyperbolic invariant manifolds, spherical fluid vortex, map, three degrees of freedom.

Left Invertibility of Chaotic Systems

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When chaotic systems is used as support for secure data transmission, singularity of observability and left invertibility is an important problem. In this paper, data secure transmission is analyzed with respect to the observability and left invertibility concept. Moreover, in order to overcome observability and left invertibility singularities, a immersion technique is proposed. The use of high order sliding mode observer on a well known Qi circuit, allows to highlight the well founded of the proposed analysis and method.

Keywords: Chaotic systems, secure data transmission, Observability, Singularity, left invertibility, Immersion.

Detecting Structural Changes on Time Series

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Entropy has been revealed as a measure of the complexity to detect the structural changes applied to describe the dynamics. We consider different entropy-like measures to detect structural changes in a time series. We analyze the results of different of these measures to previously known generated time series to compare the normalized results and determine what measure fits better. An application to a real seismic data series is shown.

Keywords: Entropy, Time Series, Structural Change.

Robust Chaos in Two-Dimensional Discontinuous Maps with Two Switching Manifolds

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The study of chaotic dynamics has found many applications in various disciplines in science and engineering. Extensive research has been carried out to identify and analyze the dynamical behaviour of chaos. In this study, we propose a 2D piecewise linear discontinuous normal form map with two switching manifolds and three linear branches. This map has application to a simple financial market model. We discuss our normal form map, under the assumption that the outer branches are the same, and present a systematic analysis of bifurcations leading to robust chaos. We develop analytical procedures to identify the underlying generating mechanism of robust chaos in the vicinity of each of the switching manifolds and determine associated parameter space regimes. We also illustrate conditions under which robust chaos occurs near both the switching manifolds simultaneously. We investigate the observed phenomenon that two boundary crises may collide as the discontinuity

parameter changes. Such a collision represents a new type of double crisis, and we calculate the values at which it occurs for different regions of the parameter space.

Keywords: Dynamical systems, piecewise smooth maps, robust chaos, border collision bifurcations, boundary crisis, basin boundaries.

Fractal Approximants on the Circle

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A methodology based on fractal interpolation functions is used in this work to define new real maps on the circle generalizing the classical ones. The power of fractal methodology allows us to generalize any other interpolant, both smooth and non-smooth, but the important fact is that this technique provides one of the few methods of non-differentiable interpolation. In this way, it constitutes a functional model for chaotic processes. In this article we study a generalization of some approximation formulae proposed by Dunham Jackson both in classical and fractal cases.

Keywords: Fractal Interpolation, Trigonometric Approximation, Trigonometric Interpolation, Smoothing, Curve Fitting.

Application of Extended OGY Control Method in a Multi-Chaotic Complex Biological System

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The developed chaos control strategies have been applied to many practical systems, including biological systems. The human body is a complex chaotic system as studied in many articles. Since the interactions between sub-biological systems are unavoidable, the extended OGY (EOGY) control method is a useful strategy for this kind of complexity. The EOGY methodology is introduced to deal with the control of coupled chaotic maps or multichaotic systems. This extension allows one to overcome some limitations of original approach and is applicable to a wide variety of multi-input multi-output dynamical systems. Using key physiological parameters such as blood pressure, hormone levels, and immunological responses are amenable to be used as manipulated control parameters in EOGY control method. The proposed EOGY approach feasibility is illustrated in a well-established multi chaotic biological system.

Keywords: Biological complex systems, Extended OGY method, Multi-chaotic, Chaos control.

Representation of N-soliton of Korteweg-de Vries equation as a superposition of N soliton solutions of the Korteweg-de Vries equation

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Many phenomena of modern physics are described by nonlinear equations. However, now it is not known the general principle of superposition of solutions of nonlinear differential equations. It is well known that the Korteweg-de Vries has an N-soliton solution. This paper shows that the N-soliton solution of the Korteweg-de Vries equation can be represented as a function of N-soliton solutions, which in this case can be interpreted as a generalization of the principle of superposition. In addition, the possibility of presenting N-soliton solutions as a function of N-soliton solutions shows that the N-soliton can be interpreted as interaction of N single solitons. This fact contributes to the understanding of the processes of evolution and self-organization of N-soliton.

Keywords: N-soliton, Generalization of the principle of superposition, Nonlinear differential equations, The self-organization.

Decay for Period One Fixed Point in the Maynard Smith and Slatkin Map

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Decay for period one fixed point in the Maynard Smith and Slatkin mapping is characterized by considering a phenomenological description supported by numerical simulations and confirmed by a theoretical description. We built the diagram bifurcation and verified in the transcritical bifurcation that the decay for the period one fixed point is characterized via a homogeneous function with three critical exponents. Near the bifurcation the decay to the fixed point is exponential with a relaxation time given by a power law whose slope is independent of the

nonlinearity. The formalism is general and can be extended to other dissipative mappings.

Keywords: Maynard Smith and Slatkin, one dimensional map, bifurcation diagram, fixed point, scaling law.

Reference:

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Chaotic Motion of the Hydrogen Atom in a Circularly Polarized Microwave Field

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We consider the problem of the hydrogen atom interacting with a circularly microwave field, modeled as a perturbed Kepler problem. We are particularly focused on the to and from motion, i.e. orbits that make several excursions going far from the nucleus and coming back in an apparently random way. We describe the mechanisms that explain such behaviour. It is interesting to remark how the ejection-collision orbits from/to the nucleus are the skeleton of the to and fro motion. Finally we show how the motion becomes chaotic when varying the energy of the Hamiltonian system.

Keywords: Ejection-collision orbits, periodic orbits, invariant manifolds.

On the Stability and Ultimate Boundedness of Solutions of Certain Third-Order Nonlinear Non-Autonomous Delay Differential Equations

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In this paper, sufficient conditions for the asymptotic stability and uniform ultimate boundedness of all solutions of certain third-order nonlinear non-autonomous delay differential equations are established. Using the basic tools of a complete Lyapunov function, earlier known results are improved and extended.

Keywords: Stability, Boundedness, Lyapunov function, Non-autonomous differential equations, Delay differential equations, Third-order differential equations.

New Aspects Regarding to Some Stochastic Concepts Needful in the Study of the Systems

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It is known that results on almost sure convergence of stochastic approximation processes are often proved by a separation of deterministic and stochastic considerations. The basic idea is to show that a "distance" between estimate and solution itself has the tendency to become smaller. The so-called *first Lyapunov method of investigation* does not use knowledge of a solution. Thus, in deterministic numerical analysis gradient of Newton procedures for minimizing or maximizing F by a recursive sequence X_n are investigated by a Taylor expansion of $F(X_{n+1})$ around X_n - a device which has been used in stochastic approximation for the first time by J.R. Blum, H.J. Kushner, Z. Schuss, M.T. Wasan, M.B. Nevel'son & R.S. Hasminskij.
At the same time, many researchers were fascinated by the great beauty of the theory of Brownian motion and many results have been obtained in the last decades.
In this paper, we shall refer shortly to new aspects regarding to the generalized Markov processes, the Brownian motion in several dimensions and some related problems in a vision of K. Itô. We also emphasize the usefulness of such results in the study of the systems.

Keywords: stochastic calculus, Markov processes, Markov property, Brownian motion, convergence.

A Pseudo Random Number Generator Based on Chaos and Irreducible Polynomial

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Random numbers are critical topic in the information security. For example, private and public key cryptographic systems require random number in the encryption processes. But generation of random numbers are difficult task. Because it is not always possible to show that the desired security requirements have been achieved. This paper proposes a method generating pseudo random numbers. The unique aspect of proposed method is random numbers have been generated using strong cryptographic primitives. This property meets the desired security requirements. Another unique aspect of study is that the seed value of the generator has been determined using one dimensional chaotic circle map. This property aims to overcome the disadvantages of pseudo

random number generators. Analysis and test results show that the proposed generator is suitable for practical applications.

Keywords: pseudo randomness, random number generators, irreducible polynomials, chaos, circle map.

Quantum Correspondence of Classical Phase Space Structures in the Correlation Diagram of Eigenenergies versus Planck Constant

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The correlation diagram of eigenenergies versus Planck constant has been proven as a suitable and useful tool for the study of the quantum manifestations of chaos in molecular systems. In this communication, we present calculations on the nonlinear Li-CN and highly nonlinear K-CN molecular systems, showing how the regular classical structures (Kolmogorov-Arnold-Moser tori) embedded in the chaotic sea in phase space (mixed-chaos regime) are manifested in the correlation diagram as emerging diabatic states, which can remain hidden if only a fixed value of the Planck constant is considered (typically $\hbar$ = 1 a.u.). Additionally, the quantum transition from order to chaos is studied, in the framework of the scars frontier stated in the literature, for the two-regions (regular and chaotic) Li-CN correlation diagram and for the apparently chaotic K-CN correlation diagram, leading to the proposal of a schematic correlation diagram arrangement for a generic molecular system.

Keywords: Quantum chaos, quantum-classical correspondence, Eigenenergies correlation diagram, Nonlinear molecular systems.

Bifurcation Structures of a Cobweb Model with Memory and Competing Technologies

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In this paper we study a simple model based on the cobweb demand-supply framework with costly innovators and free imitators. The evolutionary selection between technologies depends on a performance measure which depends on the degree of memory. The resulting

dynamics is described by a two-dimensional map. The map has a fixed point which may lose stability either via supercritical Neimark-Sacker bifurcation or flip bifurcation and several multistability situations exist. We describe some sequences of global bifurcations involving attracting and repelling closed invariant curves. These bifurcations, characterized by the creation of homoclinic connections or homoclinic tangles, are described through several numerical simulations. In particular, the bifurcation mechanism leading to invariant closed curves may be associated with a pair of cycles, a saddle cycle and an attracting one (node or focus), and the appearance/disappearance may be related to a saddle-connection, called homoclinic connection.
Particular bifurcation phenomena are also observed when the parameters are selected inside a periodicity region. We shall show that as long as we move inside the region, there exist peculiar situations in which an attracting closed curve coexists with a periodic orbits. Such coexistence eventuality first appears and then disappears due to global bifurcations occurring within the periodicity region.

Keywords: memory, heterogeneous technologies, homoclinic connection, invariant curves, global bifurcations.

Studies on Briggs Rauscher Reaction employing Mixed Organic Substrate Systems: An Experimental Approach

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Experimental studies on Briggs Rauscher (BR) system employing mixed organic substrates and Mn(II) as the catalyst are reported having Malonic acid (MA) as the main substrate whereas itaconic acid (IA), citraconic acid (CsA) and mesaconic acid (MsA) act as the co-substrates. It may be noted that no oscillations were observed when the co-substrates were used alone and the addition of these to the main system provides different modes of oscillatory behavior such as entrainment, independent, partial inhibition or complete inhibition. The influence of initial reagent concentrations on the types of oscillations have been carried out in detail and these oscillations were followed by observing the change in iodide ion concentration. The oscillatory parameters like induction period, time period and approximate iodide ion concentration show a different trend while changing the concentrations of mixed organic substrates, potassium iodate, manganese(II) sulphate, hydrogen peroxide and sulphuric acid. The favourable reaction conditions and most appropriate reagent concentrations for optimal oscillatory behavior of the system under investigation are reported. The effect of organic substrates on Dushman reaction, which is one of the

essential reaction steps in BR system, have been investigated using spectrophotometry and cyclic voltammetry. Further, the electron paramagnetic resonance (epr) studies indicate the important role of free radicals in influencing the reaction dynamics. It is found that rate of iodination reaction of the organic substrates is dependent on their structure/available reaction sites for iodination and as such this work gives a new approach to distinguish between cis/trans (CsA/MsA) isomers using spectrophotometry.

Keywords: Briggs Rauscher reaction, Dushman reaction, cyclic voltammetry, Mixed substrate, Cis/Trans isomers.

Global Phase Dynamics in the Finite-Size Kuramoto Model

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Partial synchronization in the Finite-Size Kuramoto Model with distributed frequencies displays a much more complex dynamics than the solved case of the thermodynamic limit. Many questions, such as the time evolution of the mean value of the order parameter over time or the dependence on the sampling distribution remain unsolved. Due to the similarity to a thermodynamic phase transition, the scaling of fluctuations of the order parameter was quantified by Daido, Chaté, Pikovsky and others. We now take a different perspective. Ensemble sizes are chosen rather small (e.g. fifty) to observe considerable footprints of finiteness. Considering that the global phase of the complex order parameter is not defined in any symmetric state due to the vanishing order parameter, there is a transition from coupling strengths for which those are visited to a regime where the order parameter has a lower bound. The transition point and also the mean global phase velocity depend on higher moments of the frequency sample. Furthermore, we analyze fluctuations of the global phase and Lyapunov exponents.

Keywords: Synchronization, Kuramoto Model, Finite Size.

Chaos in a Delay Mathematical Model for AIDS-related Cancer

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We study a delay model for the dynamics of AIDS-related cancer. Cancer is a major burden in HIV infected patients, and as such,

understanding the epidemiology and the mechanisms behind it is extremely important. Our model consists of four classes, the cancer cells, the healthy cells, the infected cells and the virus. We show numerically the existence of periodic orbits arising by Hopf bifurcation from an endemic state. Moreover, we observe the appearance of chaos, due to a cascade of period doubling bifurcations.

Keywords: HIV, AIDS-related cancer, chaos, delay.

Poverty Traps and Indeterminacy in Macroeconomic Models

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In our work, using the same argument by Nishimura-Shigoka (2006), we prove the existence of a stable cycle, which is the solution of both the deterministic and stochastic system, obtained by adding a stochastic variable (Wiener process) to the control variable n.

Poverty traps and indeterminacy in macroeconomic models may be caused by externalities or increasing returns to scale. By choosing a random variable with bounded support (as the sunspot variable) we achieve an approach to study sunspot fluctuations. The sunspot variable has a natural interpretation of a change in perceived present discounted wealth.

Differently from Lucas, Romer analyzed by Nishimura-Shigoka, in our model there are more equilibrium points and there's a chance of escaping a situations of development (or poverty) trap.

We study the consequences on growth rates, varying parameters of our mode, and carry out simulations of the stochastic equations of the model making comparison between simulated and real data on the variables/indicators of development.

Following Slobodyan (2009), we find that – even if there is a stable cycle – if the initial conditions are enough far from the steady state with low production and wealth, it is possible to go to another steady state with better conditions.

The result means that for the economy that started very close to the trap, the probability of escape from it is low and there is no way out if expectations are very pessimistic and the sunspot variable cannot fix expectations if they are too low to begin with. In fact, the stochastic term added to one of the variable of the system (the sunspot variable) is proportional to the current level of the variable itself. On the contrary, very optimistic expectations (very close to the boundary) lead to a great number of escapes within very short time.

Therefore, in a pessimistic state the sunspot variable exercises very small influence in absolute terms. The only realistic chance of escape

comes when the distance to the boundary is not exponentially large and the sunspot influence is not negligible. So, for any non-zero initial condition, there is a positive probability that the trajectory will not converge to the poverty trap. A solution starting outside of the "sufficiently small neighborhood" of the poverty trap is not guaranteed to converge to it or to remain near it at all. Therefore, following a sunspot variable leaves the possibility that the economy will escape poverty trap.
We perform some numerical simulations of SDE's system to understand how important sunspot-driven fluctuations could be for the economy's escape from the poverty trap: first we choose a "realistic" noise magnitude; then, with Matlab software, we calculate simulated trajectories (numerical simulations of SDE are based on a stochastic Taylor expansion).
The most important result is that the probability of escaping the trap is not negligible only when the initial condition is not very far from to the trap boundary.
In the end, we conduct a comparison between the simulated data and actual data from time series (GNP, capital, interest rate) to test the accuracy of the model in foreseeing the real data and real behavior of the economy.

Model of the Human Cardiovascular System with Autonomous Regulation

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We proposed a model, which describes a number of processes in the human cardiovascular system, including the main heart rhythm, slow regulation of the heart rhythm and blood vessels by the autonomous nervous system, baroreflex process and dynamics of the blood pressure. The model takes into account the process of respiration. It is shown that this model gives quantitative agreement between the statistical and spectral properties of the model signal and experimental data. The proposed model also demonstrates the experimentally observed synchronization effect between the paced respiration and autonomous regulation of mean arterial pressure with the frequency of about 0.1 Hz.

Keywords: Cardiovascular system, Modeling, Baroreflex, Blood pressure regulation, Respiration.

Diffractals at Millimeter Waves and Waves Catastrophes in Fractal Randomly Inhomogeneous Media: Theory and Experiments

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The results of experimental researches of diffractals at wavelength 36 GHz in the millimeter waves range for various coverings were for the first time presented in the given report. Radiation transmission through fractal screens was for the first time theoretically considered in fundamental works of M.V. Berry [1, 2]. The waves which are formed after transmission through such screens were called the diffractals. Catastrophes and fractal regimes in random waves were also described by M.V. Berry in [3]. The pulse duration was 300 ns, the height of radar detection from a helicopter in a hovering mode was within 1000 m in our experiments. The experiment was carried out in summer. An algorithm of finding of a fundamentally new class of signs based on the fine structure of modulated signals scattered by a statistically rough classical and fractal surface was proposed. It was shown that one can form a fundamentally new universal class of signs which the signal fine structure is used in basing on a sample of stationary intrapulse amplitude fluctuations provided selecting the mean form of the pulse. A power form of the space spectrum of irregularities is the main feature of fractal models for waves problems. At that a "tail" of the reflected impulse has also a power form [4 - 6]. In case of the fractal propagation medium while the wavelength decreases the limit of geometrical optics cannot be reached. A total set of critical indexes which define moments of intensity fluctuations depends on the dimension of the topological space of wave propagation. In both cases of catastrophes theories and fractals theories the form of distributions of intensity probabilities is a priori non-Gaussian.

Keywords: Diffractals, Catastrophe theory, Waves, Radio location, Fluctuations, Fractal regimes.

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Postulates of Fractal Radar

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Fractal radar is based on four main postulates: 1 - intelligent signal processing based on the theory of fractional measure, scaling effects and fractional operator's theory; 2 - Hausdorff dimension or fractal dimension *D* of a signal or a radar image (RI) is directly connected with the topological dimension; 3 - robust non-Gaussian probability distributions of the fractal dimension of the processed signal; 4 - "Maximum topology with a minimum of energy" for the received signal. It allows to take advantages of fractal scaling information processing more effectively. The key point of fractal approach is to focus on describing and processing of radar signal (fields) exclusively in the space of fractional measure with the use of the scaling hypothesis and distributions with heavy-tailed or stable distributions (non-Gaussian). Fractal-scaling processing methods of signals, wave fields and images are in a broad sense based on the pieces of information, which isn't usually taken into account and irretrievably lost if classical methods of processing are applied. This work concerns the main radio physical area – radiolocation and its objectives to ascertain what's done and things to do in this field on the basis of the fractal theory. Investigations which were carried out showed the correctness of the path chosen by the author (since 1980) to improve the radiolocation technique. It is necessary to think about the processing of the input signals with a low threshold at high levels of false alarm and then a transition to a low level of false alarms. Moreover, the false alarm probability is never measured in real time. In principle, we need a new metric and new parameters of radar detection.

Keywords: Fractal radar, Fractal dimension, Radar signal, Topology, Low-Contrast Target, Signals detector, Fractal radio systems.

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Application of Chaos Theory, Fractals and Scaling in Logistic Processes, Flows and Management

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Logistics is an integral management tool which enables reaching goals of business organization due to effective control of material and (or) service flows and concurrent flows of documents, information and financial resources. Analysis of transport vehicles routing, study of compromises between resources supply, its transportation and allocation is an important area of researches. Moving of material flows in a logistic chain is impossible without concentration of necessary supplies in certain places which corresponding storages are allocated for. A logistic process in warehouse is rather complicated since it requires total co-ordination of supply functions, cargo processing functions and physical distribution of orders. Up-to-date tendencies in logistics development imply the intensive mastering of new views and directions in exact sciences. Site policy in such provinces as marketing, finances, production, logistic and leadership is being developed on the basis of the worked out strategy to provide a united approach to the organization activity. In this work the authors propose a synergetic physical and mathematical approach which ultimately uses the fractal theory, scaling effects and fractional operators. The fractal theory is one the main units when using a system and synergy approach. Fractal organizations and processes are based on the order and chaos conditions which spill over to each other in accordance with scaling laws. The multiobjective synthesis of mathematical and physical directions (fractional dimension, strange attractors, scaling, distributed environments, non-Markovian processes (hereditarity), artificial intelligence, theory of games, neural network, cellular automation, phase transition topology and so on) with specificity of transport and warehouse logistics which was considered by the authors in this work allows turning to the new synergetic statement of the main business problem for the purpose of searching for new optimal strategies. The features of the fractal mathematical modelling in logistics proposed by the authors will be presented in the report.

Keywords: Logistics, Management, Chaos theory, Fractals theory, Scaling, Modeling.

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Nonlinear Fractal Condenser as a New Fractal Radio Element

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Physical simulation of fractional integral and differential operators allows to create radio elements with passive elements, simulating nonlinear impedances $Z(\omega)$ with frequency scaling ln{$Z(\omega)$}= -ηln{$A(j\omega)$}, where $0 \le \eta \le 1$, $A - const$, ω - angular frequency basing on the modern nanotechnologies. For that purpose the model of impedance $Z(\omega)$ was created in the form of an unlimited chain (continuous) fraction. In case of a finite stage of building the equivalent circuit for *RC* chains with using the *n*-th matching fraction for the given continuous fraction one can adjust frequency ranges which the necessary power law of impedance of the form $\omega^{-\eta}$. In this particular case we will for the first time fulfill a "non-linear" fractal capacitor. Thus, independently of the [1], our model of the impedance $Z(\omega)$ in the form of an endless chain (continuous) fraction was created. In case of the final stage of construction of the equivalent electrical circuit of *RC* chains when the corresponding *n*-th fraction of the considered continued fraction is used, we can adjust the frequency bands in which there will be a power-law dependence of the impedance ω. In this case, we first in practice implement the nonlinear "fractal capacitor" or the fractal impedance [2]. Basing on nanophase materials one can also create planar and volume nanostructures which simulate the considered above “fractal” radio elements and radio devices of microelectronics i.e. the question is about building an element base of new generation. In particular, an elementary generalization of Cantor set at physical level allows to proceed to so called Cantor blocks in the planar technology of molecular nanostructures. Application of fractal structures also allows to create media which show complex reflecting and transmitting properties in a wide frequency range and able to simulate three-dimensional photon and magnon crystals which are the new media of information transfer. Thus, fractal structures always have a self-similar series of resonances which lead to logarithmic periodicity of working zones. The related topologic fractal structure allows to modulate the electromagnetic waves transmission coefficient. The lowest frequency of weakening corresponds to wave lengths which can significantly enhance the outer sizes of the fractal plate and makes such fractal structures be the superwave reflectors. The obtained results allow to extend the applied above calculation method on the basis of algorithms of a numerical solution of hyper-singular integral equations to a wide class of electrodynamic problems which appear during researches of fractal magnon crystals, fractal resonators, fractal screens, fractal radar barriers and also other fractal frequency-selective surfaces and volumes which are required for realizing the fractal radio systems [3].

Keywords: Fractional integral and differential operators, Fractal condenser, Fractal impedance.

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Fractal Dimension for a Random Attractor for a Stochastic Parabolic Equation

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We estimate the upper bound of the fractal dimension of a random attractor of a stochastic parabolic equation with additive white noise.

Reconstruction of the Network Connectivity and Node Parameters in Networks of Time-Delay Systems from Chaotic Time Series

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A method is proposed for the reconstruction from time series the architecture of couplings and parameters of elements in networks consisting of coupled oscillators described by delay-differential equations. The method is based on minimizing for each element in the network the objective function that characterizes the distance between the points of the recovered nonlinear function. The proposed approach allows one to reconstruct the delay times, parameters of inertia, nonlinear functions, and coupling coefficients for all elements in the network. The method can be applied to networks consisting of nonidentical nodes with different coupling architectures. We used two algorithms for separating the recovered coupling coefficients into significant and insignificant coefficients. The first of them is based on the K-means clustering. The second algorithm is based on constructing the dependence of the sum of objective functions for all elements in the network on the number of coupling coefficients in the model equations. The efficiency of the method is shown for chaotic time series of the model and experimental networks.

Keywords: Networks of chaotic oscillators, Nonlinear time-delay systems, Time series analysis, Parameter estimation.

The Multi-Dimensional Boole Type Multi-Dimensional Transformations: Their Ergodic and Mixing Properties

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We study the ergodic and mixing properties of the generalized multidimensional Boole type transformations in Rn by means of the discretization and analytical tools. The invariant measures are con structed as the fixed points of the corresponding Frobenius-Perron operator and its finite-dimensional stochastic discretizations

Keywords: Frobenius-Perron operator, discretizatrion, fixed points, invariant measure, ergodic measure, Boole type transformations, ergodicity and mixing.

Complete, Incomplete and Essentially Incomplete Markets

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We classify stochastic market models in terms of completeness. We say that the model is complete and arbitrage-free, if the unique equivalent martingale measure exists. In the incomplete case usually the model can be completed by adding new assets based on the same sources of stochasticity. If this trick does not work, the model is called essentially incomplete. Here we offer examples of all three cases based on alternating processes with jumps and with different switching regimes.

Keywords: Piecewise linear process, Hidden Markov chain, Equivalent martingale measure, Self-exciting process, Poisson process, Telegraph process, Renewal process, Esscher transform.

The Geometry of Transition States

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The usual identification of reactive trajectories for the calculation of reaction rates requires very time-consuming simulations due to the ingent number of particles that form the bath that surrounds the system under study. Thus, several different methods have been developed to speed up these extremely demanding calculations, while adequately describing the reaction process. Transition State Theory (TST) [1] is certainly one of the most successful methods for this purpose. TST is able to (i) identify reactive trajectories, and (ii) compute reaction rates. This theory is based on the study of the transition state or activated complex that is formed when the reaction takes places, evolving from the reactants to the products. The transition state is an intermediate configuration that lives in the top of the energetic barrier that separates these two states, and acts as a bottleneck for chemical reactivity.
In this talk we will present a time-dependent version of TST based on the identification of the phase space objects that act as separatrices for chemical reactivity. These structures, which are invariant manifolds, are attached to the transition state trajectory, a very particular trajectory that remains randomly moving or jiggling in the vicinity of the barrier top for all times. As we will demonstrate, our procedure is able to identify reactive trajectories uniquely and compute reaction rates without any numerical simulation. The accuracy of our calculations is demonstrated by adequately computing rates in chemical systems under the action of Markovian [2] and non-Markovian [3] friction, whose dynamics is described using the Langevin Equation and the Generalized Langevin Equation, respectively.

Keywords: Transition state theory, invariant manifolds, Langevin Equation, Generalized Langevin Equation, Markovian friction, non-Markovian friction, white noise, colored noise, memory, correlation, stochastic system, molecular systems.

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Diabolical Points, Repulsion and Chaos

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Eigenvalues crossings (diabolical points) or repulsion are well known in physics and can be observed in the spectrum of many systems.
Several interesting physical phenomena have been associated with such repulsion or crossings.
In particular, eigenvalue repulsion in the spectrum of a quantum system signals the emergence of quantum chaos.
Points where we have a large number of eigenvalues crossings are due to the presence of symmetries in the system.
What are the conditions for crossing to occur? What are the consequences of a crossing or a repulsion in the dynamics of a system?
These are just some of the issues that we will try to address in this presentation.

On a Tricomplex Distance Estimation for Generalized Multibrot Sets

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In this paper, we present a distance estimation formula that can be used to ray traced 3D slices of Multibrot sets generated by tricomplex polynomials of the form η^p+c where p is any integer greater than 1.

Keywords: Tricomplex dynamics, Generalized Multibrot sets, Distance estimation, Ray tracing, 3D fractals.

High Frequency Voltage Control Oscillator for Chaotic Electronic Phase Loop Look

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Chaotic signals are useful in many applications such as secure communications, Chaos attacks on electronics, neural networks, etc. Thus there is a great demand for generators of chaotic signals. In this work, a Chaotic Voltage Control Oscillator (CVCO) is studied, designed and realized in the range of (0.3-0.6) GHz. Theoretical studies are performed using first MATLAB to achieve bifurcation diagram and phase portraits as function of diode voltage. Second, Advanced Design System (ADS) software electrical simulations including the effects of transmission lines is used to perform dynamic chaotic behaviors of the CVCO. Time domain and spectral measurements are achieved using 12 GHz Oscilloscope and 8 GHz spectrum analyzer.

Keywords: chaos, voltage control oscillator, chaotic Colpitts oscillator, bifurcation, power spectrum.

Post-Surgical Seizure Control of Epilepsy Patients: The Role of Nonlinear EEG Interrelation and Quantitative Image Analysis

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Epilepsy surgery is a potentially curative treatment option for pharmacoresistent patients. In the diagnosis and evaluation of surgery candidates the techniques of magnetic resonance imaging (MRI) and electroencephalography (EEG) play key roles. Here we will demonstrate how methodology of nonlinear time series analysis and quantitative image analysis may support decision making in the clinical setting.
Surrogate corrected nonlinear interrelation of intracranial EEG signals may help characterize the brain regions where seizures start (i.e. the seizure onset zone, “focus”) or are concentrated in regions whose resection is associated with seizure freedom (Andrzejak et al., 2011, 2012; Rummel et al., 2015). Extraction of morphometric features from structural MRI, on the other hand may help identify subtle epileptogenic lesions.
In the contribution we will combine nonlinear EEG analysis and structural image analysis to “electro-structural ictogenicity mapping” of the epileptogenic network. We will present illustrative examples where this technique provided clinically relevant and objective markers of target tissue for surgery and conclude that this approach may be used to optimize and individualize epilepsy surgery in the near future.

Keywords: nonlinear time series analysis, surrogate time series, magnetic resonance imaging, electroencephalography, epilepsy.

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Zone and Quantitative EEG Measures: Towards Prediction of Post-Surgical Seizure Control. PloS ONE 10, e0141023

Modeling and Research Information Properties of Rucklidge Chaotic System using LabView

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The generation and application of chaotic attractors have been studied with increasing interest and have become a central topic in research due to its great potential in chaos communication technology. In communication systems using deterministic chaos big problem is the selection of the same circuit parameters of generator that generate chaotic signal. Small deviation parameters on the receiving side makes it impossible to decrypt the received message. The solution to this problem is to create software that allows to generate and explore Rucklidge chaotic system. The software has been created in one of the most modern system LabView (LabVIEW 2015 for Windows).

Keywords: Chaotic modeling, Rucklidge, LabView.

Control of Chimera States in Networks of Phase Oscillators

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Chimera states are intriguing dynamics that arise in networks of coupled oscillators. In a chimera state the network splits into two groups: some oscillators are almost synchronized, while the remaining show an asynchronous behaviour. Recent studies have considered the possibility of controlling chimera states. This can for example mean controlling the position of the asynchronous group in ring networks. Likewise control can aim at generating chimeras for parameter settings for which no chimeras arise without control. We address the problem of controlling the chimera state in the basic setting of phase oscillator ring networks using a pacemaker oscillator. Furthermore we study the effect of different frequencies of the pacemaker on the network dynamics. Inserting a pacemaker oscillator in the network breaks the symmetry of the system and allows for the control of the chimera state. After the pacemaker is switched on, the incoherent group centers around it. Furthermore, the presence of a pacemaker oscillator allows for the formation of chimera states in parameter regions where they do not form spontaneously. We

also study how changing the pacemaker frequency affects the Kuramoto order parameter of the system. Specifically, we see that there are some frequency values that have a particularly strong impact on the evolution of the dynamics. Some frequencies stabilize the position and size of the incoherent group, while others can destroy the two-group configuration, typical of the chimera state. We investigate how these frequencies are related to intrinsic physical quantities of the dynamics, such as the natural frequency of the system or the oscillation frequency of the incoherent group.

Keywords: Chimera states, nonlinear dynamics, control, phase oscillators

Nonlinear Resonances in a Two-Layer Shear Flow Interacting with Two Vortices in Bottom Layer

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This paper explores a dynamical system governing the motion of two point vortices embedded in the bottom layer of a two-layer rotating flow experiencing linear deformation and their influence on fluid particle advection. If the deformation is stationary, the vortices can move periodically in a bounded region. We focus our attention on the upper layer where the bottom-layer singular point vortices induce a regular velocity field with no singularities. In the upper layer, we determine a steadystate regime featuring weak influence of the vortex. Thus, in the upper layer, the flow's streamlines look like there is only external linear deformation. In this case, fluid particles move along trajectories of almost regular elliptic shapes. However, the system dynamics changes drastically if the underlying vortices cease to be stationary and instead start moving periodically generating a nonstationary perturbation for the fluid particle advection. Due to periodic nature of the perturbation, a vast spectrum of resonance phenomena appears. Analyzing the conceivable resonances observable in the upper-layer of the flow is the main goal of the study. An analysis, based on comparing the eigenfrequencies of the steady-state fluid particle rotation with the ones of the vortex rotation, is carried out and parameters ensuring effective fluid particle stirring are determined. The process of separatrix reconnection of close stability islands leading to an enhanced chaotic region is reported and analyzed

Keywords: Chaotic advection, Geophysical Flows, Chaotic advection in oscillatory flows, Vortex Flows, Nonlinear resonances, Separatrix reconnection.

Hyperchaos-Based Stream Cipher for Smartphone

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In this paper, we present a stream cipher based on the Chen hyperchaotic system for secure saved data on smartphone. The used hyperchaotic system generates simultaneously four signal outputs taken as encryption keys to cipher all type of saved data files on Smartphones such as image, pdf, word, audio and video files. The generated hyperchaotic keys are characterized by high quality randomness which is confirmed by passing the standard NIST statistical tests. In addition, security analysis of the proposed encryption scheme, based on One-Time Pad cipher, confirms its robustness against different attacks. For more validation, the proposed hyperchaos-based stream cipher has been implemented in an Android-based application which can be installed and run in all smartphone models. For this, an example of experimental results is given for image ciphering.

Keywords: Chen hyperchaotic system, Smartphones security, Stream cipher, One-Time Pad cipher, Andoid apps.

Digital Currency Parity Rates Forecasting with Neural Networks

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In this decade, digital currency, especially, Bitcoin which is the first and most popular one became the most widely used investing method by people and small companies. Its dynamics change rapidly therefore one can buy Bitcoins with less price and then sell later with higher price in a short period. However, predicting these periods is very though. This study presents the prediction of Bitcoin / U.S. Dollars and Bitcoin/ Euro exchange rates by using artificial neural networks. Neural networks can generalize from past trends that needs high experience and devise trading rules that account for changing market conditions. Using neural networks one can obtain the predictive information alone or with other available analytical tools such as attractor reconstruction. to fit the trading style, risk property and capitalization. The neural network will help minimize the above factors by simply giving an estimated exchange rate prediction for a future day. Both Bitcoin / U.S. Dollars and Bitcoin / Euro exchange data used in this study is for the time interval from 2011 to 2016 (by the end of the 2016 December).

Keywords: Neural Networks, Digital Currency, Bitcoin, Time Series Analysis.

Centre Bifurcations of Periodic Orbits for Some Special Three Dimensional Systems

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In this paper, the bifurcated limit cycles from centre for a special three dimensional quadratic polynomial system and the Lü system are studied. For a given centre, the cyclicity is bounded from below by considering the linear parts of the corresponding Liapunov quantities of the perturbed system. We show that five limit cycles and only one limit cycle can bifurcate from the centres for the three dimensional system and the Lü system respectively.

Keywords: Centre bifurcation, periodic orbits, Lü system, Liapunov quantities.

Some Topics about Chaotic Behaviour in High Frequency Economic Time-Series

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We illustrated how generic and plausible is chaos in theoretical models using an adaptive version of the fundamentalist vs chartist model in the forex market proposed by Fenández Díaz. Moreover, we apply new methods derived from nonlinear time series and chaos analysis to detect the presence of chaotic behaviour to describe the dynamic of three tick-tick pairs of exchange rates. First, we use BDS test recursively to observe structural changes in order to apply several contrasts on the homogeneous regions. Second, we investigate if our data show time dependence and nonlinearity. Third, we apply a single feed-forward neural network to estimate Lyapunov Spectrum. Finally, we will compare the results obtained between tick-tick series and daily data to show how the time interval used to reconstruct the attractor is transcendent in order to find the true dynamics of the underlying generating process of the analyzed financial series.

Keywords: Nonlinear Dynamics, Deterministic Chaos, Lyapunov Spectrum, High Frequency Economic Time-Series.

Oscillatory Orbits in the Elliptic Restricted Planar Three Body Problem

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The restricted planar three body problem models the motion of a massless body under the Newtonian gravitational force of two bodies evolving in Keplerian ellipses.
Since Chazy (1922), it is known that the possible states the body $q(t)$ can approach as time tends to infinity are four:
- Hyperbolic: $||q(t)|| \to \infty$ and $||\dot{q}(t)|| \to c > 0$ as $t \to \pm\infty$.
- Parabolic: $||q(t)|| \to \infty$ and $||\dot{q}(t)|| \to 0$ as $t \to \pm\infty$.
- Bounded: $\limsup_{t\to\pm\infty} ||q|| < +\infty$.
- Oscillatory: $\limsup_{t\to\pm\infty} ||q|| = +\infty$ and $\liminf_{t\to\pm\infty} ||q|| < +\infty$.

Examples of all these types of motion, except the oscillatory ones, were already known by Chazy.
In this talk, we prove the existence of oscillatory motions for any value of the masses of the primaries assuming they move in ellipses whose eccentricity is small enough, as a consequence of the transversal intersection of the stable and unstable manifolds of periodic orbits at "infinity", and using techniques of Arnold diffusion. We would like to explore the possibility of extending these methods to models in molecular dynamics.

Keywords: restricted planar three body problem, Newtonian gravitational force, Kepler problem, oscillatory motion, invariant manifolds, Arnold diffusion, molecular dynamics.

This is a joint work with M. Guardia and P. Martin.

Studies of Langmuir Caviton Turbulence by Ionospheric Experiments

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An intense HF wave in plasma may become modulationally unstable to the formation of Langmuir solitons or cavitons called Strong Langmuir Turbulence (SLT). The process is well-modeled by the Zakharov equations [1, 2]. The chaotic regime of caviton turbulence has been explored numerically revealing a plethora of nonlinear phenomena such as hysteresis, fixed points, limit cycles, transition to chaos and bursty turbulence [3, 4]. Recent advances in high-powered HF radiowave transmitters have achieved nonlinearity ratios (wave intensity to background plasma pressure) among the highest in the world. Advances

in diagnostic radar instrumentation have enabled the study of SLT in great detail over a wide region of parameter space. We report studies of controlled experiments on HF-induced caviton turbulence in ionospheric plasmas and tests of results of caviton turbulence studies. Applications of results such as scalings, are made to ionospheric turbulence effects such as scintillation of GPS signals.

Keywords: Solitons, cavitons, plasma turbulence, nonlinear waves, experiments, strong Langmuir turbulence, space plasmas.

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On Recurrent Solutions in High-Dimensional Non-Dissipative Lorenz Models

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A recent study suggested that the nonlinear feedback loop of the three-dimensional non-dissipative Lorenz model (3D-NLM) plays a role as a nonlinear restoring force in producing nonlinear oscillatory solutions as well as linear periodic solutions near a non-trivial critical point. In this study, the role of the nonlinear feedback loop and its extensions in producing recurrent or quasi-periodic solutions is further examined using a five- and seven-dimensional non-dissipative Lorenz models (5D-NLM and 7D-NLM). An analytical quasi-periodic solution with two incommensurate frequencies is first presented using the 5D-NLM. We use the analytical solution to verify the numerical solutions of the 5D-NLM and then apply the methods to solve the 7D-NLM numerically.
While the nonlinear feedback loop of the 3D-NLM consists of a pair of downscaling and upscaling processes, the extended feedback loop in the 5D-NLM (7D-NLM) introduces two (four) additional pair of downscaling and upscaling processes that are enabled by two (four) high wavenumber modes. The second and third pairs of downscaling and upscaling processes provide two-way interactions among the primary (the largest scale), secondary, and tertiary (the smallest scale) modes. By comparing the numerical simulations using one- and two-way interactions, we illustrate that proper representation of two-way interactions is crucial for capturing accurate quasi-periodic solutions.

Keywords: Lorenz model, nonlinear feedback loop, quasi-periodicity, recurrent solutions, downscaling and upscaling.

The Existence of a Family of Chaotic Attractors in some Non-Ideal Hydrodynamic Systems

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The resonant oscillations of the free surface of a liquid in a cylindrical tank with excitation of such oscillations by energy source of limited power are considered. These problems are described by non-ideal, in sense Sommerfeld-Kononenko, pendulum dynamic systems. For the first time these models have been constructed and investigated in [1, 2]. The aim of this work is identifying and studying the steady-state regular and chaotic motions of the system "tank with a fluid - excitation source" in the case of vertical excitation of tank platform. Such studies have been initiated in [3], where a mathematical model of the system, which takes into account the interaction between excitation source and tank with a fluid, was built. In this work, as well as in [4], it was shown that there are several types of chaotic attractors of such dynamic systems.
Using the technique developed in [5] a large complex of numerical calculations for identification a new characteristics of chaotic and regular attractors of dynamic systems "tank with a fluid - excitation source" was carried out. In this work it was discovered a family of both regular and chaotic attractors that exists in enough large neighbourhood of an origin of coordinates of a phase space of systems. Phase portraits of these attractors placed one inside another without any intersection or contact. In the space of parameters of the systems chaotic attractors of the family have sufficiently small basins of attraction. The projections of the phase portraits of attractors of this family are similar in their geometric structure with a clearly noticeable scaling. Also Poincaré maps, phase-parametric characteristics and Fourier-spectrums of chaotic attractors family are similar. The transition to chaos occurs for all attractors of the family, according to two scenarios of either Feigenbaum or Pomeau-Manneville.

Keywords: chaotic attractor, non-ideal hydrodynamic systems.

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Modeling and Simulation of Human Death Probability Density

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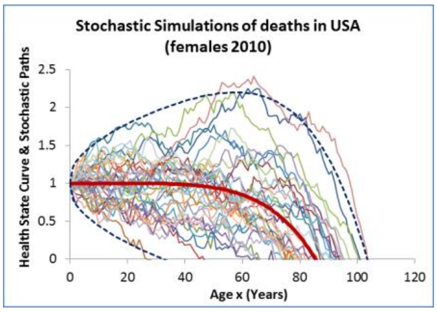
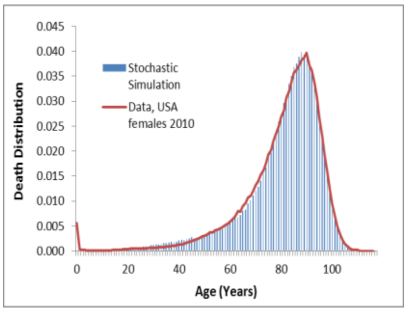
We propose and apply a methodology of stochastic simulations to reconstruct the death probability density function for the population of a country. The first exit time theory is applied to find the adequate model. Then the model parameters are estimated by the appropriate non-linear fitting technique. In the following stochastic simulations are done to reproduce the data sets and validate the accuracy of the model. An application follows to the US female deaths at 2010 with excellent results presented in the next figure.





A B

Fig. 1A. Model fit and Stochastic simulation paths for female deaths in USA (2010). (k1=0.9452) Generating Model: $f(x)=1-(bx)^c$. Parameters estimated (b=0.01164, c=5.348, σ=0.06929, k=2.5)

Fig. 1B. Female death data in USA, 2010 and simulation graph after 300.000 stochastic paths generated.

Keywords: Stochastic simulations, USA data, HMD, First exit time theory, data reconstruction, fitting, modeling, Death probability density.

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Looking for Chaos in Copper Historical Prices

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Knowing the inherent characteristics of a price time series is the preface of forecasting future prices. This study tries to use chaos theory to investigate the behavior of copper prices. Keeping the mathematical definition of chaos as a standard frame, the known chaos tests were applied based on a discipline. The Lyapunov exponent and the BDS test (Brock, Deckert, Scheinkman, 1986) approved the evidence of nonlinear behavior and possible evidence of chaos for the gathered data. However, the close returns test, as a direct test of chaos, rejected the presence of chaos in copper return series. Finally, a GARCH (generalized autoregressive conditional heteroskedasticity) type model was fitted on the series under study to capture this nonlinearity. The BDS test results indicated that there was no longer any nonlinearity in the filtered data. It was concluded that the stochastic methods should be applied to predict future copper prices.

Keywords: Chaos, the BDS test, Lyapunov exponent, the close returns test, nonlinear dynamics.

Irreversibility and Physics of Evolution

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The first steps in the construction of the physics of evolution based on the proposed earlier deterministic mechanism of irreversibility of system dynamics are made. The mechanism of irreversibility was found due to the fact that the equations of the dynamics of bodies were obtained taking into account the structure of the body. The basic concepts of physics of evolution are introduced. One of these concepts is the principle of duality symmetries (PDS). According to the PDS, the body dynamics depends not only on the symmetry of space, as in the case of a material point, but the symmetries of the body. Based on PDS, the foundations of the physics of evolution are constructed. It is shown how the laws of system dynamics are determined on the basis of the laws of the dynamics of their elements. The concept of evolutionary nonlinearity responsible for the violation of symmetry of system dynamics is introduced. How the infinite divisibility of matter followed from the laws of mechanics are shown. The D-entropy, defined as the ratio of the change of internal energy of the system to its full value are proposed. The rationale of the laws of thermodynamics, statistical physics, on the basis

of the obtained equations of motion of the system, is provided. The principles of constructing a hierarchical world picture based on the laws of physics are offered.

Keywords: Classical mechanics, Lagrange equation, irreversibility, holonomic constrains, entropy, chaos.

The Chaotic Universe's Cosmogony: the Universe's Perpetuum Mobile, Multivariance of the Universe and the "Boiling" Universe Hypothesis

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The paper investigates the complex universalization of the Universe's cosmogony, covering all stages of existence of the Universe and resolving the main external and internal contradictions unlike particular axiomatic theories. The structural formalism of cosmogony is obtained, developing generally accepted theories by means of fundamentally important concepts of Absolute Chaos, Harmon, Universe's Perpetuum Mobile, multivariance of the Universe, hypotheses of the "boiling" Universe, inverted Universe's cosmogony, etc. A great number of degrees of infinity and the possibility of unlimited multivariance of the Universe as well as the other interpretation of the known scientific data are substantiated. The Universe's cosmogony has great general scientific importance and can be used in different fields of knowledge.

Keywords: Universe's Model, Universe's Cosmogony, Chaos, Harmony, Perpetuum Mobile.

On a Certain Generalization of the Iterated Function Systems

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In 2008 Miculescu and Mihail introduced a generalization of the notion of iterated function systems. Namely, instead of selfmaps of a metric space X, they considered mappings f_i: $X^m \to X$, where X^m is the Cartesian product of m copies of X, and m is a natural number. It turned out that the systems of such mappings (called GIFSs) can generate unique fractal sets A in the sense of the condition

$$A=f_1(A^m)U\ldots U f_n(A^m)$$

and the fractal theory can be developed also in this setting.

During the talk I will present basic results on GIFSs and GIFS's fractals. In particular, I will show the counterpart of the Hutchinson-Barnsley theorem, present the code space for GIFSs and construct a Cantor set which is a fractal generated by some GIFS, but cannot be obtained as an attractor of any IFS.

Keywords: iterated function systems, fractal, attractors, Hutchinson-Barnsley theory.

Long-Term Stability of Locally Stable Dynamical Systems Perturbed by White Noise

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The influence of small stochastic perturbations of white noise type on a dynamical system with a locally stable equilibrium is considered. The perturbed system is described by the Ito stochastic differential equations such that the noise does not vanish at the equilibrium. It is known that in this case almost all trajectories sooner or later escape from any bounded domain and the stability on the infinite time interval holds for a relatively narrow class of globally stable systems. Therefore, the problem of stability under persistent perturbations of white noise type on a finite time interval is meaningful. We analyze the stochastic stability of the equilibrium on a finite time interval and describe the classes of perturbations such that the stability holds for polynomially and exponentially long time intervals with respect to a small perturbation parameter.

Keywords: dynamical system, stochastic perturbation, stability.

Non-Integrability of the Huang–Li Nonlinear Financial Model

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We consider the Huang Li-nonlinear financial system recently studied in the literature. It has the form of three first order differential equations

$$\dot{x} = z + (y - a)x, \quad \dot{y} = 1 - by - x^2, \quad \dot{z} = -x - cz,$$

where (a, b, c) are real positive parameters. We show that this system is not integrable in the class of functions meromorphic in variables (x, y, z).

We give an analytic proof of this fact analyzing the properties of differential Galois group of variational equations along certain particular solutions of the system.

Keywords: Huang–Li nonlinear financial system, chaotic finance model, Poincare sections, non-integrability, non-Hamiltonian systems, differential Galois theory.

DNS Study on Chaotic Behavior of the Late Flow Transition and Turbulence

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Turbulence exists ubiquitously in all macroscopic fluid flows throughout the world. Fluid flow (including turbulence) is controlled by conservation of mass, momentum and energy, or by Navier-Stokes equations, and computations including direct numerical simulation (DNS), large eddy simulation (LES), Reynolds-Averaged Navier-Stokes(RANS) all give unique solution (different unique solutions of course). The turbulent flow is chaotic, looking like random in experimental observations, which means the measurement in the morning could be different from one in the afternoon for same experiment. This work is an effort to reveal why a unique and deterministic solution of turbulence has randomness and chaotic behavior in experimental observation and why DNS, LES, and RANS give different flow structures. By using high order DNS solution, we show the chaotic behavior of late flow transition and turbulence is really deterministic and unique as DNS solutions obtained by scientists all over the world are same or similar. The turbulent flow in our observation by eyes or experiment measurement is not only related to the time and space (t and X) but also to the averaged span (Δt and ΔX). This would give people impression that turbulence is random, but the physical solution is unique and deterministic.

Keywords: Turbulence, Navier-Stokes Equations, Deterministic Solution, Chaotic Behavior, Direct Numerical Simulation(DNS).

Structure and System of the Poetic Literary Texts of V. S. Vysotsky: Chaos or Order?

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This report analyzes the structure of the poetic literary texts. Here it discussed how we have to consider the process of creating literary works: as a chaotic stream of consciousness or as a deliberate creative process?
According to the ancient Greek philosophy, the chaos (χαωσ) means a chaotic mix of constituent elements of the world. The chaos was represented by the ancient Greeks through primitive elements as an abyss, a complete gloom and a fog. As a result of chaos overcoming an order became in the form of the cosmos (κωσμωσ) meaning order of all constituent elements (in the nature, in the state and the society). The representation about an initial state of the world as absence of any mounting or organization in the amorphous and chaotic form was inherent in not only the ancient Greek philosophy, but other ancient philosophies (ancient Egyptian, ancient Indian, ancient Chinese etc.).
A transition from the chaos to the cosmos, from the elements of isolated sounds and words to the ordered poetic text, from the chaotic art products to the ordered system of literature can be also considered as a process of development of fiction in the form of art, i.e. as a complex system of art. That is why the processes of self-organization play the principal role here.
Self-organization of the literary poetic text is a new uninvestigated domain of system theory. Moreover, the understanding of self-organization processes as well as self-renewal of poetic structure is key for an analysis of system prosody functioning. These processes determine both occurrences of new poetic texts in the belles-lettres and their interrelation with the already known works of art. The functioning of systems prosody directly depends on the language environment as well as processes of self-organization occurring in a language under investigation. In particular, the process of self-organization of poetic literary texts of V. S. Vysotsky is analyzed in the given research.

Keywords: self-organization of literary text, chaos, structure, system.

Wavelet Analysis of Nonlinear Dynamic Microcirculatory Regulatory Processes in vivo - from Stochasticity to Determinism

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Calcium oscillator is realized between smooth muscle cell and endothelial cell is main pacemaker complex involved in regulation of vasculature tone also known as vasomotion.

Calcium increase in endothelial cells (ECs), are known to induce a significant decrease of the calcium level in smooth muscle cells (SMCs) which lead to relaxation of the blood vessels. However, the role of the endothelium for vasomotion is still controversial in the literature. In a previous works of our group we have reconciled the seemingly contradictory findings and shown that the endothelium only modulates vasomotion.

Most of the models used in medicine for analysis of regulation of vasomotion are deterministic. This means that the external factors that can cause effects of fluctuations (because of internal noise and microscopic inhomogeneities) are neglected.

This is common approach in modeling also of cardiovascular system (macrocirculation), data of these investigations is taken by Doppler ultrasonography. In Macrocirculation the number of elements involved in the process under interest are sufficiently large. In this case, stochastic fluctuations do not affect the average behavior of the ensemble, mainly because they statistically cancel each other out and we are able to detect only major oscillations and stochastic noise.

In analysis of the non-linear signal of vasomotion, on microcirculatory level it is well known that the behavior of a few Calcium channels is random, but that the dynamics of neurons and under-regulated vegetative neuronal regulation of SMCs behavior are very well described by deterministic equations of the Hodgkin-Huxley type.

During investigation of 50 male BALB-C mice with preliminary implanted chambers for observation of micro-blood vessels in vivo, through intravital microscopy. By means Intravital microscopy we are able to analyse on microscopic level fine mechanisms of regulation in cardiovascular system, i.e. microcirculation. Microcirculation regulation, dependent by time of synchronization of a multitude of individual cellular oscillators. The concept of calcium release and uptake by the smooth muscle calcium stores, synchronized by sarcolemmal ion channels, and sometimes influenced by endothelial factors, may provide further understanding of this little-understood phenomenon.

Wavelet analysis is an accurate and reliable tool for studying signals with changes of phase and frequency. Arterioles between 45 and 80 mkm in diameter were measured. Spectral range of oscillations with physiological relevance are found, from 0.0095 to 1.2 Hz, and four subintervals are revealed, (0.0095-0.02 Hz), (0.02-0.05 Hz), (0.05-0.14 Hz) and (0.14-1.2 Hz), by wavelet analysis. In this work our group applied wavelet Daubechies analysis. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform.

Keywords: Ca-oscillator, SMCs, ECs, vasomotion, vasculature tone, wavelet analysis, microcirculation, stochasticity, determinism.

Slow Passage through the Resonant Bifurcation from a Robust Heteroclinic Cycle

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In this paper, we consider the slow passage problems through the resonant bifurcation from a robust heteroclinic cycle. The system we consider is the 3-dimensional Lotka-Volterra system with higher order terms, and the slowly ramping of the controlled parameter could be linear or periodic.

Both delay and memory effects, which are reported previously by S. M. Baer, can be observed when ramping the controlled parameter linearly. Remarkably, the way the onset of bifurcation for different initial controlled parameter in our system is quite different from that in Baer's papers. In our system, if the initial controlled parameter is closer to the static resonant bifurcation point, then the onset of dynamic resonant bifurcation point moves farther away from the static resonant bifurcation point. In contrast, the system considered by S. M. Baer behaves in another round.

When periodically ramping the controlled parameter, we show that there exists a stable invariant torus for the system. Moreover, the invariant torus is determined by the amplitude of the controlled parameter but independent of the initial values.

Chaotic Dynamics of Ice Crystals Scattering Sunlight

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We are reporting the existence of the nonlinear dynamics in some curious phenomena observed in the context of atmospheric optics: jumping Sun dogs, halo formation and the miracle of Sun. A possible connection between these light patterns of the atmospheric optics and light scattering in small particles of the ice crystals could be based in the concept of diffracted rays.

Keywords: Chaotic Modeling, Jumping Sun Dogs, Ferrofluids, Parlaseric Circle.

Chaos, Bubble, Drops, and Foams

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One of the best examples of a dynamical system exhibiting chaotic behavior is the bubble formation from a nozzle. This system presents a myriad of routes to chaos, such as period doubling route, intermittence route and period-adding route, just to cite some of them. We have developed this study from the paradigmatic case of a chaotic system, the dripping faucet experiment, suggested by Rössler. In addition to this aspect, drops and bubbles can create foam, and the fluid dynamics of foams is nonlinear, and we have observed the butterfly effect in foam systems. According to the Nobel Prize winner Pierre-Gilles de Gennes, bubbles, drops and foams can be considered as fragile objects, due to the ephemeral feature of these systems. In this paper we present the main features of the chaotic behavior of these fragile objects, indicating some general concepts that sum up the main aspects of chaotic systems in two phase flow and correlated systems.

Keywords: Bubble, drop, Foam, antibubbles, integrate-and-fire dynamics, circle map.

Applications of Chaotic Systems in Steganography Algorithms

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Chaotic systems are used in many information security applications due to their rich features. One of these application areas is steganography. In this study, chaos-based steganography studies have been examined and basic problems have been listed.

Keywords: chaos, steganography, computer science application.

Cognitive Perception of Complex Scenes in the Process of Eye Tracking Studies

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The article presents studies which involve the way of perceiving complex scenes in the task of scenery analysis for their usefulness in the artificial intelligence methods. The studies were conducted using the eye-tracker SMI Red 500. A series of experiments was carried out on a group of people registering particular trajectories of attention. Observer’s task was to form a conclusion that would approve or disapprove the thesis that was formulated in the question concerning the presented scene. Next, the analysis of developed series of the scenery components was performed. Observations of the experiments’ results may significantly develop artificial intelligence algorithms used in processing and recognizing of images. The analyses of conducted measurements showed some differences in perception of complex scenes for particular persons that took part in experiment as well as some similarities and differences in same-sex groups.

Keywords: eye tracking, cognitive science, neuropsychology.

Chaotic Solutions and Global Indeterminacy in The Romer Endogenous Growth Model

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This article is aimed at developing some results on the existence of chaotic behaviour and indeterminacy in a modified version of Romer's model, (see Slobodyan S., 2006).
More in detail, we study the dynamics of a non-linear three-dimensional system associated to the Romer model of endogenous growth, a system with a single equilibrium point, which is already know to possesses a rich spectrum of behaviour that goes, as the parameters of the model are changed, from a stable equilibrium point, to more complex dynamics. We exploit a route to chaos via the existence of a homoclinic orbit to a saddle-focus equilibrium. This involves the existence of horseshoes close to the homoclinic orbit, but possibly also periodic attractors and strange attractors.
By using the undetermined coefficient method, we analytically demonstrate that there exists a homoclinic orbit of a Shilnikov type that connects the single equilibrium point to itself (see, Shang D., Han M., 2005). Furthermore, the nature of the growth paths in this chaotic regime might depend on the initial conditions, and looked noisy, like the simple function of a stochastic process.
It might be thus impossible to characterize the system for a full set of parameter spaces, and the boundary of a chaotic region. We describe the "routes to chaos", and a bifurcation diagram, where one could see how a change in some parameters can lead to a series of bifurcations: the emergence of a saddle-focus, of a homoclinic orbit, and chaos.
Finally, the economic intuition behind our results are deeply exploited and fully investigated.

Squeeze Film Dynamics of Grooved Rotating Disks

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A computational model model is presented for the engagement process of two grooved, rotating disks by linking the mechanical force acting on the disks to a model for squeeze film flow. The Greenwood-Williamson model of asperity contact, and flow factors are used to capture the effect of rough surfaces. The density function from measured roughness is used to characterize the mechanical contact. The effects of temperature change in the fluid and disks are simulated by a simple heat transfer

model. In addition, the compressive strain of the disk material is included when computing the film thickness.
The model's predictive ability is assessed by comparison with experimental data. The combination of squeeze film flow in the interface, grooves, and porous media creates a chaotic overall behavior. The flow is characterized by disorder, non-repeatability and intermittency, which in effect define turbulent flow conditions although formally the flow remains laminar. This unexpected behavior is visible in the laboratory, and is duplicated in the numerical simulations by introducing small perturbations in the boundary conditions.
Numerical tests with different mesh resolution levels indicate that the flow contains significant sub-grid information that cannot be captured by standard numerical simulations. This chaotic behavior of squeeze-film flow between rotating disks has serious implications in the torque profile of the system, which translate into energy losses and environmental problems in practical applications.

Keywords: Numerical modeling, Squeeze-film flow, Rotating disks, Asperity contact.

A Novel Class of Highly Efficient &Accurate Time-Integrators in Nonlinear Computational Mechanics

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A new class of time-integration-algorithms is presented for strongly nonlinear dynamical systems. These algorithms are far more superior to the currently common time integrators in computational efficiency and accuracy. To develop these new class of time-integrators, first, the Variational Iteration Method (VIM) is recast into a Local Variational Iteration Method (LVIM) over a finite interval of time, where variations of the nonlinear term are not restricted. Then three modified formulae of LVIM are derived using the properties of the Lagrange multipliers, and are labeled as Algorithm-1, 2, and 3, respectively. By using Chebyshev polynomials as trial functions and Dirac-Delta functions as the test functions over the finite time interval, the three algorithms are developed into three different discrete time-integrators through the collocation method. These time integrators are labeled as Chebyshev Loca! l Iterative Collocation (CLIC) methods. Through examples of the forced Duffing oscillator, the Lorenz system and the multiple coupled Duffing oscillator, it is shown that the presently developed algorithms are far more superior to the fourth-order Runge-Kutta (RK4) and ODE45 of MATLAB, in predicting the chaotic responses of very strongly nonlinear dynamical systems over long-periods of time. These algorithms can be gainfully employed in the time-integration of semi-discrete second order

differential equations in time, after spatial discretization, to study the long-term chaotic responses of beams, plates, and shells.

Keywords: Strongly nonlinear system, Variational iteration method, Collocation method, Chebyshev polynomials, Chaos.

Dynamics of Extending Marine Risers in Installation Subjected to Ocean Current

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In this work, the dynamics of lateral vibration of marine riser in installation is studied. The riser is modeled as an Euler-Bernoulli beam hanging vertically in the floating drilling platforms or vessels and vibrates in the plane of the cross current flow. Wave height and wave period are taken into consideration of the current velocity distribution along the riser axis, i.e., the wave is varying positive and negative periodically respect to time and the value at the sea level is larger than that in deep sea. Besides, in the installation process, length of the riser is varying with time, increasing or decreasing at particular velocity. The riser is subjected to lateral fluid force, induced by cross current flow and axial extension force, induced by weight of blow out preventers. These effects render the riser vibrating at various frequency and amplitude, which would to some extent lead to fatigue and damage to the riser. This is the aim of this work. The governing equations of motion are derived via Hamiltonian's principle. Boundary conditions are modified into the governing equations, thus classic boundary conditions are obtained for numerical calculation. Effects of the weight of blow out preventers, velocity of cross current flow and extending rate of the riser have been discussed. Results show that a larger increasing ratio would destabilize the system; different ratio should be adopted under various current flow load cases. The weight of blow out preventers enhance the stability of the tip of the riser but would destabilize the system at some particular current velocity.

Keywords: Marine riser, installation, stability, chaotic motion.

Variational Principles and Applications of Local Topological Constants of Motion for Non-Barotropic Magnetohydrodynamics

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Variational principles for magnetohydrodynamics (MHD) were introduced by previous authors both in Lagrangian and Eulerian form. In this paper we introduce simpler Eulerian variational principles from which all the relevant equations of non-barotropic MHD can be derived for certain field topologies. The variational principle is given in terms of five independent functions for non-stationary non-barotropic flows. This is less than the eight variables which appear in the standard equations of barotropic MHD which are the magnetic field $\vec{B}$ the velocity field $\vec{v}$, the entropy s and the density ρ. The case of non-barotropic MHD in which the internal energy is a function of both entropy and density was not discussed in previous works which were concerned with the simplistic barotropic case. It is important to understand the rule of entropy and temperature for the variational analysis of MHD. Thus we introduce avariational principle of non-barotropic MHD and show that five functions will suffice to describe this physical system.

We will also discuss the implications of the above analysis for topological constants. It will be shown that while cross helicity is not conserved for non-barotropic MHD a variant of this quantity is. The implications of this to non-barotropic MHD stability is discussed.

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Humanoid Locomotion Generation and Control based on Van der Pol Oscillators

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Extended Controlling legged-robot locomotion can be thought of as a complex problem, which is difficult to solve with too many parameters that are hard to tune. Conventional controllers based on neural networks suffer less flexibility in both, the implementation, and the tuning of the neurons' connections weights. The idea of coupling a simple nonlinear controller with a controlled plant and ending up with a Van der Pol oscillator is considered in this paper. This fascinating idea in dealing with the locomotion problem has already been approached by some researchers such as Attilio [1] and Atay [2]. Yet, its implementation on biped robots, as well as its robustness, have not been discussed. Other locomotion controllers based on a nonlinear oscillator, termed central pattern generator (CPG), have been developed (Jiangsheng et. al. [3], Marilyn [4], Matsuoka [5], Seo et. al. [6]). Although significant progress has been made using small numbers of tightly coupled neurons, those approaches have some limitations in implementing and adapting them to a changing environment. For instance, the stability of a walking robot requires controlling many joints, and thus, too many parameters of the coupled oscillators will need tuning (Kale et. al. [7]). Some trials towards simplification of locomotion pattern generator have been conducted (Zaier and Kanda [8], Nakada et. al. [9]) using piecewise linear oscillators. The research framework in Zaier and Kanda [8] is based on piecewise linear functions that shape the locomotion pattern using recurrent neural network and sensory feedback. Although the method provides a comprehensive knowledge about the robot dynamics and allows easy implementation of sensory feedback and much flexibility to include reflexes capability to the humanoid robot, the locomotion controller includes too many neurons and connecting wires with weights hardly tuned. The work in Nakada et. al. [9] deals with the phase response properties of Matsuoka's oscillator, which has been interpreted as a piecewise linear oscillator with phase resetting control.
In this paper, we will introduce the Van der Pol oscillator as a closed loop control system that includes both the plant and the corresponding feedback controller (Fig. 1). The plant will consist of a cart-inverted pendulum system, which is a simplified model of the humanoid robot. As a result, a nonlinear feedback controller will be obtained. The inputs to the controller are the velocity and position of the zero moment point (ZMP) of the cart-inverted pendulum. The parameters of the controller will be tuned so that the closed loop system will exhibit a stable limit

cycle. The robustness of the controller against plant uncertainty and time-varying delay feedback signals will be discussed throughout simulation results. Experimental validation of the controller performance will be conducted on a Bioloid / Darwin-Op2 humanoid robot. The locomotion controller is expected to be very compact and simple to tune. The robot dynamics coupled with this controller through sensory system is expected to show natural looking motion.

Keywords: Humanoid, Van der Pol Oscillator, Central Pattern Generator, Limit cycle, nonlinear controller.

Chaos in Demand Management Models

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In a scientific work presents a synergistic approach to creating models of demand for products and services, non-linear mathematical model of steady demand management and the results of computer modeling problems. Explore the area of sustainability, attractors of system and the scenario of possible emergence of chaos.

Researches within the project on management of steady demand resulted in the following results:

1. The dynamic nonlinear model of demand – the offer, provided by system of the evolutionary equations, where as the main variables the consumer budget and the income of the consumer is used is developed. It is shown that if demand is rather fully described by the specified set of variables, then it has the unique steady condition - a limiting attractor the cycle representing fluctuation of the income around optimum value. The value itself is determined by the operating parameters. The transition to self-oscillating mode demonstrates that significantly increase their income consumer can not.

2. The controlling variables, which essentially change a situation are probed. In this regard, reviewed the process of managing change in demand due to changes in the consumer budget. Computer modeling shows change ofconsumer preferences towards products and services of the increased comfort.

The computer control system for steady demand based on synergy model, allows to make fixed monitoring of demand on the basis of phase trajectories of development, to determine steady conditions of demand, to manage demand on the basis of modeling of managing parameters, to perform search of steady optimal solutions, to build the strategy of behavior in the market in the conditions of the competition.

3. Dynamic management model by demand taking into account attraction of a bank loan is constructed. Emergence of new steady limiting cycles, which configuration reflects degree of complexity of the

economic activity necessary for stability in the conditions of rigidity of credit liabilities is shown. The chaotic behavior in these conditions is observed.
4. At a computer research such ratio of values of the operating parameters, at which there is an opportunity to appear in a chaotic attractor of Lorentz has been found. This situation is not predicted as the chaotic attractor arose only at a certain combination of the operating parameters. Therefore, having changed values of some of them, , it is possible to avoid area of anattraction of a chaotic attractor. Researches showed that the main parameter conducting system to chaos is the loan capital in the form of the credit.

Keywords: Economy, Demand, Dynamic nonlinear modeling, Model of demand for products and services, Chaotic simulation.

Field Theoretical Model of General Vector Admixtures Advected by Fully Developed Turbulent Flows

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The chaotic turbulent motion of fluids with advected agents ris modeled using the field theoretical A model of general vectorial admixture. The model encompasses the important magnetohydrodynamic scenario as well as the important A=0 model. We apply the renormalization group statistical techniques and Feynamn diagramatic methods to obtain analytic results. Our study involves not only general admixture of vectorial nature but includes also parity violations in order to closely ressemble real experimental flows of fully developed turbulence. Furthermore, the active nature of the admixture with a continuous variation of interaction parameters allows to characterize the important parameters of the underlying chaotic turbulent motion.

Keywords: fully developed turbulence, vector admictures, magnetohydrodynamics, renormalization group, statistical approach to chaotic motion.

Hybrid Integrated Chaotic Laser in Butterfly Packaging Scale

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We designed and developed a hybrid integrated chaotic laser in butterfly packaging scale (30mm*15mm*7.7mm) for the requirement of the widespread chaos applications. In our design, we use a convex lens to collimate the light which emits from the semiconductor laser chip. Another convex lens focus the collimated light to the tapered optical fiber to output. Between these lenses, we place a mirror with a certain transparent and reflecting ratio which acquired by the simulation results, to provide the optical feedback to generate the chaotic light. Unlike previous researches which developed on chip level requiring complex processing and growing techniques, all device and elements in this chaotic laser are easy to get and the packaging technique is mature. With the advantages of the high performance, low consumption and convenient fabrication, this chaotic laser will lay a foundation for the application which need chaotic source.

Keywords: Chaotic laser, Hybrid integration, Packaging scale.

Chaos in the Flows, Driven by Torsional Oscillations of Boundaries

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We have numerically studied the transition to turbulent flow in a layer of a viscous incompressible fluid confined between concentric spherical boundaries performing counter-rotational oscillations. The rotation speeds of both spheres were modulated at the same frequency and amplitude. The transition to turbulence was caused by an increase in the amplitude of velocity modulation beginning with the state of rest. Using the concept of instantaneous frequency/phase of flow, it is established that the turbulence develops in a limited region of liquid layer, outside which the flow remains laminar. The turbulent region of flow exhibits intermittency of the chaos–chaos type.

Keywords: Chaotic modeling, Intermittency, Navie-Stocks equations, Direct numerical simulation, Hilbert transform.

Transition to Cycle-Chaos Intermittency Flow in Rotating Spherical Layer

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Turbulent flows of a viscous incompressible fluid in a layer between counter-rotating concentric spheres under the action of the modulation of the velocity of the inner sphere have been studied numerically. The obtained solutions revealed temporal alternation of the laminar and chaotic flow states occupying the entire spatial region of the flow in the spherical layer. Factors responsible for the transition to chaos and the appearance of intermittency during this transition were established.

Keywords: Chaos modelling, intermittency, Navie-Stocks equations, Direct numerical simulation.

Transition to Two-Dimensional and Three-Dimensional Turbulence under Action of Spherical Boundary Velocity Modulation

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Turbulent flows of a viscous incompressible fluid in a layer between rotating concentric spheres under the action of the modulation of the velocity of one of the spheres have been studied experimentally and numerically. The possibility of the formation of turbulence with spectra qualitatively similar to spectra obtained in measurements in the upper atmosphere is established: with the slope close to –3 at low frequencies and close to –5/3 at high frequencies and with the negative longitudinal velocity structure function of the third order. It has been shown that such spectra are formed in the regions of a flow that are strongly synchronized under the action of the modulation of the rotational velocity.

Keywords: Two- and three- dimensional turbulence, Navie-Stocks equations, experiment, Direct numerical simulation.

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