PLENARY TALKS

Statistical Properties of Poincaré Recurrences and Their Applications

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In the present talk we analyze statistical properties of Poincaré return times sequences for chaotic dynamical systems. The theoretical results are discussed in the frameworks of local and global approaches and are illustrated by numerical calculations for several discrete-time and continuous-time systems. The local approach is based on Poincaré's theorem an d Kac's theorem that establishes the interrelation between the mean return time and a probability measure of a local vicinity of a given point. The global approach uses the notion of Afraimovich-Pesin dimension (AP-dimension) that is introduced as a characteristic of Poincaré recurrences for the whole set. Statistical properties of Poincaré retirm times are studied in the presence of external noise sources. We also establish the interrelation between the statistics of Poincaré ecurrences and the fractal dimension of limit sets, as well as Lyapunov exponents and entropy.
The physical significance of the AP-dimension for Poincaré recurrences is discussed. In conclusion, we present some applications of the Poincaré recurrences theory to the problems of detecting stochastic resonance and stochastic synchronization effects in an overdamped Kramers oscillator and a cubic map with attractor crisis. We also consider the diagnostics of chaotic synchronization in two coupled Lorenz systems by calculating the AP-dimension.

Phase transition in an open aggregation-fragmentation system

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Motivated by the phenomenology of transport of vesicles through the Golgi apparatus in the cell, we have studied a multispecies model with injection of one species at one end and outflow at the other. Our model incorporates both single particle and stack motion, and includes aggregation upon contact, chipping or the breaking off of a single particle, and interconversion between species. This model exhibits interesting phase transitions. In the absence of stack hopping, the system can enter a phase in which the mass grows indefinitely in one spatial region, coexisting with a region with a steady value of the mean mass. On the other hand, in the absence of interconversion, there is a phase transition as the injection rate is increased: the system passes from a phase with normal fluctuations, to one in which the total mass shows very large fluctuations. These fluctuations are of the order of the total mass itself, and their time dependence shows signatures of intermittency, as in a turbulent system. We investigate the phases with both diffusive and directed transport in the bulk and with different boundary conditions.
⋆Work done together with Himani Sachdeva (TIFR) and Madan Rao (RRI and NCBS-TIFR, Bangalore)

A Short Journey to the Structures of Matter

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Confinement by attractive forces implies the appearance of a minimum quantum kinetic energy which is increasing as the confinement becomes stronger and thus counterbalances the pressure of the attractive forces and leads to the equilibrium structures of the Cosmos from the protons and neutrons to the neutron stars and beyond. This basic idea coupled with dimensional analysis provides semiquantitative results for atoms, molecules, condensed matter, planets, etc. Some examples of these results will presented in my talk and possibly during the question period depending on the interest of the audience [1].

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Packing of wires in cavities and growing surfaces

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We investigate the morphologies and maximum packing density of thin wires packed into spherical cavities. Using simulations and experiments with nylon lines, we find that ordered as well as disordered structures emerge, depending on the amount of internal torsion. We find that the highest packing densities are achieved in a low torsion packing for large systems, but in a high torsion packing for small systems. An analysis of both situations is given in terms of energetics and comparison is made to analytical models of DNA packing in viral capsids. In two dimensions we also find that wires can crumple into different morphologies and present the associated morphological phase diagram. Our results are based on experiments with different metallic wires and confirmed by numerical simulations using a discrete element model. We show that during crumpling, the number of loops increases according to a power-law with different exponents in each morphology. Furthermore, we observe a power-law divergence of the structures bulk stiffness similar to what is observed in forced crumpling of a membrane. We also investigate the morphology of thin discs and rings growing in circumferential direction. Recent analytical results suggest that this growth produces symmetric excess cones (e-cones). We study the stability of such solutions considering self-contact and bending stress. We show that, contrary to what was assumed in previous analytical solutions, beyond a critical growth factor, no symmetric e-cone solution is energetically minimal any more. Instead, we obtain skewed e-cone solutions having lower energy, characterized by a skewness angle and repetitive spiral winding with increasing growth. These results are generalized to discs with varying thickness and rings with holes of different radii. Simple experiments with cardboard confirm the simulations.

Connecting the Micro-dynamics to the Emergent Macro-variables: Self-Organized Criticality and Absorbing Phase Transitions in the Deterministic Lattice Gas

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We reinvestigate the Deterministic Lattice Gas introduced as a paradigmatic model of the $1/f$ spectra (Phys. Rev. Lett. 64, 3103 (1990)) arising according to the Self-Organized Criticality scenario. We demonstrate that the density fluctuations exhibit an unexpected dependence on systems size and relate the finding to effective Langevin equations. The low-density behaviour is controlled by the critical properties of the gas at the absorbing state phase transition. We also show that the Deterministic Lattice Gas is in the Manna universality class of absorbing state phase transitions. This is in contrast to expectations in the literature, which suggested that the entirely deterministic nature of the dynamics would put the model in a different universality class. To our knowledge this is the first fully deterministic member of the Manna universality class.

Nonlinear Model Reduction for Complex/Multiscale Systems

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We present and illustrate the use of data mining/manifold learning techniques for the coarse-graining and reduction of microscopic (atomistic, stochastic, agent based) simulations of complex systems. In particular, we show how the reduced representations obtained through such approaches can be linked with scientific computation to accelerate the extraction of coarse-grained information from such multiscale simulations. Our method of choice is the Diffusion Map approach pioneered by R. R. Coifman, and the illustrative examples

come from equilibrium and nonequilibrium thermodynamic simulations, agent based modeling as well as from network dynamic simulations.

Maxwell demons, feedback control, and fluctuation theorems

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As illustrated by the Maxwell demon and its sequels, feedback can be utilized to convert information into useful work. The recently developed fluctuation theorems turn out to be a powerful tool to analyze the energetics of feedback controlled systems. Using these theorems, we devise a method for designing optimal feedback protocols for thermodynamic engines that extract all the information gained during feedback as work. Our method is based on the observation that in a feedback-reversible process the measurement and the time-reversal of the ensuing protocol both prepare the system in the same probabilistic state. We illustrate the utility of our method with two examples of the multi-particle Szilard engine.

Chaotic Destruction of Anderson Localization in Nonlinear Lattices

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We discuss what happens to Anderson localization in a disordered lattice if a nonlinearity is present. The situation is relevant for lattices of coupled oscillators, for a Bose-Einstein condensate (described by a nonlinear Gross-Pitaevsky equation) in a disordered potential, and to light propagation in a disordered nonlinear medium. Our main model is a discrete Anderson chain with a nonlinear term (nonlinear Schroedinger lattice with disorder). We discuss three problems: (i) How an initially localized wave packet spreads; (ii) How a regular wave is transmitted through a nonlinear disordered layer; and (iii) How a thermalization in a finite disordered lattice occurs. In all cases nonlinearity leads to a weak chaos and delocalization.

News on Statistical Mechanics for Complex Systems

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Strong thermodynamical arguments exist in the literature which show that the entropy S of say a many-body Hamiltonian system should be extensive (i.e., $S(N)N$) independently from the range of the interactions between its elements. If the system has short-range interactions, an additive entropy, namely the Boltzmann-Gibbs one, makes the job. For long-range interactions, nonergodicity and strong correlations are generically present at virtually all thermodynamical conditions (not only at possible critical points), and nonadditive entropies becomes necessary to preserve the desired entropic extensivity. Such is the case of the entropy S_q introduced in 1988 in order to generalize Boltzmann-Gibbs statistical mechanics. Such is also the case of the entropy S_δ introduced in 2009 and recently advanced for reconciling black holes with thermodynamics. These points, as well as recently related ones (concerning the q-Fourier transform, large-deviation theory, connections to nonlinear quantum mechanics, and others) will be briefly presented.

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INVITED TALKS

Spin Transistor Action from Hidden Onsager Reciprocity

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We investigate generic Hamiltonians for confined electrons with weak inhomogeneous spin-orbit coupling. Using a local gauge transformation we show how the SU (2) Hamiltonian structure reduces to a U (1)×U (1) structure for spinless fermions in a fictitious orbital magnetic field, to leading order in the spin-orbit strength. Using an Onsager relation, we further show how the resulting spin conductance vanishes in a two-terminal setup, and how it is turned on by either weakly breaking time-reversal symmetry or opening additional transport terminals, thus allowing one to switch the generated spin current on or off. We numerically check our theory for mesoscopic cavities as well as Aharonov-Bohm rings.

Neuronal avalanches as a self-organized critical phenomenon

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Neuronal avalanches are a novel mode of activity in neuronal networks, experimentally found in vitro and in vivo, and exhibit a robust critical behavior. Avalanche activity can be modeled within the self-organized criticality framework, including threshold firing, refractory period and activity-dependent synaptic plasticity. The size and duration distributions confirm that the system acts in a critical state, whose scaling behavior is very robust. Next, we address the question how a system with no characteristic response can ever learn in a controlled and reproducible way. Learning in the model occurs via plastic adaptation of synaptic strengths by a non-uniform negative feedback mechanism. Learning is a truly collective process and the learning dynamics exhibits universal features. Even complex rules can be learned provided that the plastic adaptation is sufficiently slow. Finally, the temporal organization of neuronal avalanches is given by the alternation between states of high and low activity, named up and down states, leading to a balance between excitation and inhibition controlled by a single parameter. During these periods both the single neuron state and the network excitability level, keeping memory of past activity, are tuned by homeostatic mechanisms.

The Second Law For the Transitions Between the Non-equilibrium Steady States

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We show that the system entropy change for the transitions between non-equilibrium steady states arbitrarily far from equilibrium for any constituting process is given by the relative entropy of the distributions of these steady states. This expression is then shown to relate to some recent similar relations regarding the transitions between the equilibrium states.

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On the interplay between chaos and order in a time-dependent barred galaxy model

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We study the distinction and quantification of chaotic and regular motion in a time-dependent Hamiltonian barred galaxy model. Recently, a strong correlation was found between the strength of the bar and the relative chaotic motion in the phase space of the time independent system. Here, we attempt to further explore this connection by studying the interplay of chaotic and regular behavior of the orbits when the mass parameters of the model evolve in time. This happens for example when one introduces linear time dependence in the parameters of the model to mimic, in some general sense, the effect of self-consistent interactions of the N-body problem. We propose a new way of using the GALI method as an efficient chaos detection tool to estimate the relative fraction of chaotic vs. regular trajectories in the phase space of such time-dependent potentials. We also find that the GALI indices, unlike the Lyapunov exponents, are able to capture short lived dynamical transitions during which an orbit can enter and exit islands of regular motion in time dependent case. Finally, we revisit the time independent problem and discuss a recent application of q-Gaussian statistics, which was able to distinguish weakly from strongly chaotic orbits even for the relatively short time intervals that correspond to one Hubble time in galactic evolution.

How Nature performs super-efficient transport in complex networks

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The uncontrollable interaction of a transmission network with a noisy environment is usually assumed to deteriorate its transport capacity, especially for quantum networks. However, for billions of years Nature has been implementing super-efficient, extremely fast, and remarkably robust energy transport in light-harvesting networks involved in photosynthesis. Motivated by very fascinating and recent breakthrough experiments, based on ultra-fast nonlinear spectroscopy of these pigment-protein photosynthetic complexes, we have investigated the key mechanisms by which noise may actually aid transport through a dissipative network by opening up additional pathways and suppressing the ineffective ones. One important ingredient is the presence of quantum coherence (experimental evidence) allowing the system to explore many different paths simultaneously. The second one is noise (theoretical evidence) enhancing the hopping probability between network sites and suppressing the destructive interference, that, otherwise, would trap energy (or information) in some localized states. These very recent achievements have given rise to a new exciting and rapidly developing research field, known as quantum biology, focused on the investigation of quantum effects in biological systems. An overview of our main achievements in this direction will be presented here. Finally, by deeper understanding of how Nature very well exploits quantum coherence and environmental noise to get very efficient and robust energy transfer, we might pave the way for the realization of a new generation of more powerful solar energy devices and ultrafast communication network technologies based on quantum phenomena.

Quantization and Analysis of Morphometric Changes in Brain Tissues due to Neurodegenerative Diseases

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Neuropsychiatric disorders have been demonstrated to manifest shape differences in brain tissues, e.g., in cortical structures. Many tools are available to quantize the changes in the morphometry (shape and size) of the brain tissues due to a disease (over time). I will only present two such tools, Labeled Cortical Distance Mapping (LCDM) and Large Deformation Diffeomorphic Metric Mapping (LDDMM). LCDM is a powerful tool in quantifying such morphometric differences and characterizes the morphometry of the laminar cortical mantle of cortical structures. Specifically, LCDM data are distances of labeled gray matter (GM) voxels with respect to the gray/white matter cortical surface. On the other hand, the LDDMM algorithm can be used to quantize changes in a brain tissue due to a mental disease. LDDMM provides (i) a metric distance to quantize the morphometric differences and (ii) dense one-to-one correspondence vector fields between hippocampal shapes. These algorithms provide information on different aspects of morphometry. As illustrative examples, I will present the analysis of GM in the ventral medial prefrontal cortex (VMPFC) in subjects with major depressive disorder (MDD), subjects at high risk (HR) of MDD, and healthy subjects. Also, I will present the use of LDDMM to analyze changes in hippocampal morphometry due to very mild dementia of Alzheimers type. Our analysis indicates that these tools can be powerful in detecting differences in morphometry of brain tissues.

Charge transfer in DNA: distance-dependence of hole transfer rates

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Charge transport in DNA has been studied intensively the last 15 years due to potential applications in both nanotechnology and biology [1, 2, 3]. Several reviews summarize the results of this effort [4, 5].
Electronic parameters pertinent to charge transfer along DNA are presented. Using a novel LCAO parametrization for π molecular orbitals of planar organic molecules [6], we have calculated the complete set of charge transfer parameters between neighboring bases and also between successive base pairs in DNA, considering all possible combinations between them, for both electrons and holes [7]. These quantities can be used in theoretical models of electron or hole transfer along the DNA double helix, as they provide the necessary parameters for a phenomenological description based on the π molecular overlap.
Using these electronic parameters, we estimate relative reaction rates in order to be compared with corresponding experimental results on hole transfer between guanine radical cations (donors) and GGG traps (acceptors) within appropriately synthesized DNA segments [8, 9]. In these experiments donors and acceptors are separated either by short $(TA)_n$ bridges where the charge transfer rates show an exponential dependence on the length of the bridge for $n = 1-3$ [8], or by bridges containing repeating TA,TA double units between single GC units where a weaker distance dependence (power law) appears [9]. Further, in the former experiments a switching behavior to weak distance dependence has been observed for bridges with $n > 3$, attributed to a change of the mechanism of charge transfer [8]. All these experimental observations are reproduced by our simulations, considering only tunneling as the charge transfer mechanism [10].

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Universality aspects of the random-bond Blume-Capel models on the square and simple cubic lattices

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The effects of bond randomness on the universality aspects of the ferromagnetic Blume-Capel models are investigated by "Extended Ensemble Monte Carlo" strategies, both square and simple cubic lattices are considered.
For the square lattice we implement a two stage Wang-Landau scheme. We find that, the second-order phase transition, emerging (under random bonds) from the second-order regime of the pure model, has the same values of critical exponents as the 2d Ising universality class, with the effect of the disorder on the specific heat being well described by double-logarithmic corrections. However, the emerging second-order transition from the first-order regime of the pure model belongs to a distinctive universality class.
In the case of the simple cubic lattice, we employ a MC scheme based on cluster algorithms and parallel tempering. We find that the emerging second-order phase transition from the second-order regime of the pure model, is compatible with the universality class of the 3d random Ising model. Furthermore, we find evidence that, the emerging second-order transition from the first-order regime of the pure model, belongs to a new universality class. The first finding reinforces the scenario of a single universality class for the 3d Ising model with the three well-known types of quenched uncorrelated disorder (bond randomness, site- and bond-dilution). The second, amounts to a strong violation of universality principle of critical phenomena. The present ex-first-order transition shows sharp differences from the corresponding ex-first-order transitions emerging from the weak and strong first-order transitions of the 3d three-state and four-state Potts models, respectively.

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An almost exactly solvable charge density wave system

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Charge density wave (CDW) systems refer to elastically-coupled particle systems, in which each particle is subject to a periodic potential with a random phase-offset. When driven by an external driving force F , CDWs exhibit threshold behavior with threshold force FT , such that for $F < FT$ all configurations are static (pinned), while for $F > FT$ the CDW slides.

It has been argued long time ago that the depining transition of CDWs constitutes a dynamic critical phenomenon [1, 2]. CDWs exhibit glassy dynamics [3] as well as diverging strains [4] and polarizations [5], as the threshold force FT is approached from below or above.
In this talk we will motivate and present a CDW system that is simple enough to submit to analytical treatment, yet complex enough to capture all the features of criticality near threshold. In particular, we will focus on the subthreshold behavior, describe the characteristics of the CDW configurations as threshold is approached from below and derive analytical expressions for the threshold force as well as the configurations at and near threshold.

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Does the functional network reveal the topological organization?

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Real world complex systems can be viewed and described as networks of interacting elements. Here, we distinguish the structure of the network, the nature of the interaction, and the dynamics of the nodes. Experimental results typically do not access the network structure, which is then inferred by the dynamics of the nodes. From the dynamics of the nodes one then constructs a network of functional relations, termed functional network. It is generally believed that the functional network reflects the structural organization of the network. A fundamental question towards the understanding of complex systems concerns the relation between functional and structural network. Using synchronization as a paradigm for network functioning, we show that the functional network, given by the pairwise syn- chronization, can drastically differ from the topological network. We uncover the mechanism for this abrupt change between functional and structural networks and unveil the topological implications on the network functioning.

Tempering quantitative tools for an improved analysis of complex systems

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The analysis of complex phenomena, either natural or man-made, poses very interesting challenges not only about the impact of the findings and their impact, but on development of reliable quantitative tools that turn raw data sets into valuable information as well.
In this talk, one discusses recent developments introduced in the analysis of non-stationary and non-equilibrium time series ubiquitous in complex systems.
First, one sets forth techniques regarding the approximation of non-stationary time series of measurements by juxtaposing patches of segments of local stationarity. In the long-term, the distribution of the observable is the defined as mixture of short of long wavelength statistics related to the concept of superstatistics, which is one of the proposals that aims at explaining the emergence of a Tsallis statistics in complexity.
Next, one discusses tools for the trustworthy assessment of the dynamical nature in stationary time series as well as the inference of stochastic dynamical equations from an accurate estimation of the Kramers-Moyal coefficients taking into account the sample rating.
Both points will be exemplified with mainstream instances of complexity.

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Nonlinear stochastic differential equations and $1/f$ noise

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Power-law distributions of spectra of signals, including $1/f$ noise, as well as scaling behavior in general, are ubiquitous in physics and in many other fields, including natural phenomena, human activities, traffics in computer networks, and financial markets. This subject has been a hot research topic for many decades. Despite the numerous models and theories proposed since its discovery more than 80 years ago, the subject of $1/f$ noise remains still open for new discoveries
Here we analyze non-linear stochastic differential equations (SDEs) [1, 2] generating signals with $1/f$. The general form of the SDE is

$$dx = \sigma^2(\eta - \lambda/2)x^{2\eta-1}dt + \sigma x^{\eta} dW_t \qquad (1)$$

As a particular case of the proposed SDEs and its modifications are Constant Elasticity of Variance Process, Bessel Process and Squared Bessel Process, which are used for modeling of the financial markets. The power spectral density of the signal generated by SDE (1) is related to the behavior of the eigenvalues of the corresponding Fokker-Planck equation [3]. The proposed SDEs can be modified to get both q-Gaussian distributions of signal intensity, featured in nonextensive statistical mechanics, and $1/f$ behavior of the power spectral density [4]. We also present a couple of models leading to the nonlinear SDE (1). One of them is a point process where the inter-event time stochastically diffuses in a wide region. Another is a simple agent model of herding, providing a microscopic mechanism of the macroscopic description by SDE (1) [5].

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Environmental noise and nonlinearity in biological and physical systems

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The role played by environmental noise in the dynamics of biological and physical systems has been a subject of growing interest and investigation in recent years. Here we show the interplay between environmental noise sources and nonlinearity of the system investigated in three different biological and physical systems. (i) The role of a non-Gaussian Levy noise on the nonlinear transient dynamics of a short overdamped Josephson junction is analyzed. The mean escape time of the junction is investigated considering Gaussian, Cauchy-Lorentz and Levy-Smirnov probability distributions of the noise signals. In these conditions we find resonant activation and the first evidence of noise enhanced stability in a metastable system in the presence of Lvy noise. For Cauchy-Lorentz noise source, trapping phenomena and power law dependence on the noise intensity are observed [1]. (ii) The phenomena of dissonance and consonance in a simple auditory sensory model composed of three neurons are considered. Two of them, here so-called sensory neurons, are driven by noise and subthreshold periodic signals with different ratio of frequencies, and its outputs plus noise are applied synaptically to a third neuron, so-called interneuron. We propose a theoretical analysis with a probabilistic approach to investigate the interspike intervals (ISI) statistics of the spike train generated by the interneuron. We find that at the output of the interneuron, inharmonious signals give rise to blurry spike trains, while the harmonious signals produce more regular, less noisy, spike trains. Theoretical results are compared with numerical simulations [2]. (iii) Finally the dynamics of a quantum particle subject to an asymmetric bistable potential and interacting with a thermal reservoir is investigated. We obtain the time evolution of the population distributions in the position eigenstates of the particle, for different values of the coupling strength with the thermal bath. The calculation is carried out by using the Feynman-Vernon functional under the discrete variable representation [3].

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Nonlinear metadimers: multistability, chaos and localization

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The construction of artificially structured materials with unusual properties, presently refered to as *metamaterials*, has been heavily based on resonant metallic elements ('metaparticles') [1, 2]. The most widely used element is the ubiquitous split-ring resonator (SRR) which, moreover, can become nonlinear and dynamically tunable with the insertion of appropriate electronic componets [3, 4]. In an attempt to reduce losses, the metallic SRRs have been replaced by superconducting ones which are also highly tunable due to the sensitivity of the superconducting state to external fields [5]. Furthermore, it has been proposed that rf SQUIDs (Superconducting Quantum Interference Devices) can be used for the realization of nonlinear magnetic metamaterials [6]
Recently, it was proposed the use of 'dimers', i.e, of pairs of strongly coupled metaparticles, as basic elements for the construction of metamaterials [7, 8]. We have investigated nonlinear metadimers comprising relatively strongly coupled nonlinear metallic SRRs or rf SQUIDs which are excited by either constant and/or alternating magnetic fields. The coupling mechanism between the particles forming a pair is predominantly magnetic, although for metallic SRR metadimers electric coupling has been also considered. The dynamic behavior of metadimers is very rich; we have observed multistability, energy localization and chaotic behavior in wide parameter intervals [9, 10]. Multistability, in particular, allows for switching between different magnetization states. Combined with tunability, it makes these metadimers attractive elements for the developement of future nonlinear and superconducting metamaterials.

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From rock fracture to plate tectonics, evidence of non-extensive statistical mechanics in Earth physics: A review

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The non-extensive statistical mechanics pioneered by the Tsallis group offers a consistent theoretical framework, based on a generalization of entropy, to analyze the behavior of systems with fractal or multi-fractal distribution of their elements. Such systems where long-range interactions or intermittency are important, lead to power law behavior. The question of whether earth systems are described by non-extensive statistical physics, even at the phenomenological level (i.e., without specifying any underlying model), represents a challenge. This is the problem we review here. Our aim is not to present a precise model, but rather to emphasize in simple arguments of physical plausibility. Examples supporting the non-additive behavior of earth system, from rocks fracture (e.g., acoustic emissions) to geodynamic (e.g., plate tectonics, global seismicity) scale are presented.

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Possible origins of the power-law distributions

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The possible origins of power-law distributions are presented as seen from the perspective of high energy multiparticle production processes (summarized in [1, 2]). In these processes one has usually encountered exponential distributions of different sorts, $f(x) \propto \exp(-x/x_0)$. However, recently one observes that almost all of them develop for large x as power-like distribution, $f(x) \propto x^{-\gamma}$. Tsallis distribution, $f_q(x) \propto [1-(1-q)x/x_0]^{1/(1-q)} = \exp_q(-x/x_0)$, seems to be the most natural choice allowing for description of the whole range of x with a one new parameter, q. We discuss origin of such behavior as seen and understood from our experience with describing multiparticle production data. In particular we discuss:

- Fluctuations of scale parameter x_0 in exponential distribution (superstatistics) (resulting in $\exp_q(x)$ distributions with $q > 1$).
- The use of conditional probability resulting in $q < 1$; as special example we consider thermodynamic system containing small number of particles.
- The use of order statistics (understood as distribution of the minimal value of the observable of interest).
- The use of stochastic network approach (in which the scale parameter depends on vari-

able under consideration). In this case one can show, for example, that

$$\exp_q(-x) = \prod_{k=1}^{\infty} \exp[-x^k (1-q)^{k-1}/k]$$

In addition, derivations of Tsallis distribution in statistical physics (where for small system $q \leqslant 1$) are also discussed. The possibility of obtaining Tsallis distribution from Shannon entropy are mentioned as well. Finally, we demonstrate the possibility to check in high energy multiparticle production processes the apparent duality between q parameter (used in Tsallis distributions applied to fit some experimental data, f_q) and $2-q$ parameter resulting from the corresponding Tsallis entropy, S_{2-q} (used to estimate, in the same reactions, multiplicities of produced particles).

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CONTRIBUTED PRESENTATIONS

Generalized Huberman-Rudnick scaling law and robustness of q-Gaussian probability distributions

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We generalize Huberman-Rudnick universal scaling law [1] for all periodic windows of the logistic map and show the robustness of q-Gaussian probability distributions [2] in the vicinity of chaos threshold. Our scaling relation is universal for the self-similar windows of the map which exhibit period-doubling subharmonic bifurcations. Using this generalized scaling argument, for all periodic windows, as chaos threshold is approached [3], a developing convergence to q-Gaussian is numerically obtained both in the central regions and tails of the probability distributions of sums of iterates.

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Effects of the randomly distributed magnetic field on the phase diagrams of the Ising Nanowire

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The effect of the random magnetic field distribution on the phase diagrams and ground state magnetizations of the Ising nanowire is investigated with effective field theory with correlations. Trimodal distribution chosen as a random magnetic field distribution. The variation of the phase diagrams with that distribution parameters obtained and some interesting results found such as reentrant behavior and first order transitions. Also for the trimodal distribution, ground state magnetizations for different distribution parameters determined which can be regarded as separate partially ordered phases of the system.

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Unified scaling law in the coherent noise model

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The waiting time distribution between successive events and the unified scaling law are studied using the Coherent Noise Model. It is shown that, although this model generates uncorrelated event sizes and does not exhibit criticality, it still provides the unified scaling law. We argue the role of characteristic kink observed in the unified scaling law and the meaning of the parameter C used to fix the peak of the kink to unity. Our results indicate that the parameter C is indeed a physical quantity localizing the end of the linear tendency in the scaling law, which corresponds to the completion of the dominance of correlated events in time.

Motif statistics and dynamics on Boolean Networks

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We have developed a modified version of Boolean Kauffmann nets[1], using Boolean masks [2] at the nodes, rather than random Boolean functions. A population of small networks with 7 nodes were evolved under the genetic algorithm [3], holding the degree of the nodes fixed, and with the cost function being defined as the length of the attractor of the dynamics. The evolved population exhibits an excess of linear (loopless) three-motifs [4] relative to a random set of networks with the same number of nodes and edges. The role which this over-represented set of motifs play in the stability properties of the networks is investigated. The properties of the Laplace spectra [5, 6, 7] of typical networks with short periodic attractors vs those exhibiting chaotic behavior are catalogued.

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System size driven coherence in complex networks

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We study the onset of collective behavior in networks of heterogeneous dynamical systems. We

show that a coherent dynamical state emerges in the limit of large networks if the network is increasingly not susceptible to failures, that is, if the difficulty the break the network into disconnected parts grows with the network size. In such case, increasing the network size above a critical size leads the dynamical behavior of the nodes systems to be highly correlated. Our results provide a way to enhance coherent motion in general networks by controlling its local properties.

A Cellular Automata Model for Ant Trails

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We investigate the uni- and bi-directional ant traffic flow in an ant trail by using one-dimesional cellular automata model. It is considered that ants communicate each other by dropping a chemical, called pheromone, on the substrate. Apart form the studies in the literature, it is considered in the model that a) ant colony consists of two kind of ants, good and poor smelling ones; b) ants might make U-turn for some special cases. For some values of densities of good- and poor-smelling ants, the flux and mean velocity of the colony are studied as a function of density and evaporation rate of pheromone. It is shown that phase transition occurs for some special values of parameters used in the model.

UNIVERSALITY OF THE ISING AND $S = 1$ MODEL ON ARCHIMEDEAN LATTICES : AN ACCURATE MONTE CARLO DETERMINATION

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The Ising model $S = 1/2$ and the $S = 1$ model are studied by efficient Monte Carlo schemes on the (3, 4, 6, 4) and the (3, 3, 3, 3, 6) Archimedean lattices. The algorithms used, a hybrid Metropolis-Wolff algorithm and a parallel tempering protocol, are briefly described and compared with the simple Metropolis algorithm. . Accurate Monte Carlo data are produced at the exact critical temperatures of the Ising model for these lattices. Their finite-size analysis provide, with high accuracy, all critical exponents which, as expected, are the same with the well known 2d Ising model exact values. A detailed finite-size scaling analysis of our Monte Carlo data for the $S = 1$ model on the same lattices provides very clear evidence that this model obeys, also very well, the 2d Ising model critical exponents. As a result, we find that recent Monte Carlo simulations and attempts to define effective dimensionality for the $S = 1$ model on these lattices are misleading. Accurate estimates are obtained for the critical amplitudes of the logarithmic expansions of the specific heat for both models on the two Archimedean lattices.

Characteristics of the countries network in the European sovereign debt crisis

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Fears of a sovereign debt crisis developed among investors as a result of the rising private and government debt levels around the world together with a wave of downgrading of government debt in some European states. The aim of this presentation to investigate the characteristics and hierarchical structures of the European sovereign debt crisis by using the debt values and percentage of Gross Domestic Product (GDP) of the countries move together over time. We obtain the topological properties among the countries based on debts of European countries over the periods of 2000-2011 by

using the concept of hierarchical structure methods (minimal spanning tree, (MST) and hierarchical tree, (HT)), which were introduced by Mantegna [1] and Mantegna and Stanley [2]. The MST and HT are known as useful tools to perceive and detect the global structure, taxonomy and hierarchy in financial data. We perform the bootstrap techniques to investigate a value of the statistical reliability to the links of the MSTs [3, 4]. We also use a clustering linkage procedure in order to observe the cluster structure much better [3, 4]. From the structural topologies of these trees, we identify different clusters of countries according to their level of debts and economic ties. Our results show that the Eurozone's fiscally troubled economies, specifically Spain, Greece, France, Ireland, Belgium, Italy, Austria and Portugal are located as a cluster with each other in the center of the MST.

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Traveling and pinned fronts in bistable reaction-diffusion systems on networks

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Traveling and pinned fronts in bistable reaction-diffusion systems have been broadly studied for classical continuous media and regular lattices. In this talk we focus on the network analogs of such non-equilibrium patterns. We consider traveling and stationary patterns in bistable one-component systems on random Erdös-Rényi and hierarchical tree networks. Numerical simulations reveal that traveling e fronts exist in such network-organized systems. They represent waves of transition from the one stable state into the other, spreading over the entire network. The fronts can furthermore be pinned, thus forming stationary structures. While pinning of fronts has previously been already considered for chains of diffusively coupled bistable elements, the network architecture brings about significant differences. Particularly, an important role is played by the number of links (i.e. the degree) of a node. For regular trees with a fixed branching factor, the pinning conditions can be analytically determined. It can also be shown that the transition from traveling to standing fronts corresponds to a saddle-node bifurcation. For large Erdös-Rényi o e networks, stationary patterns are approximately described by a mean-field theory.

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Luneburg lens waveguide networks

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We investigate certain configurations of Luneburg lenses that form light propagating and guiding networks. We study single Luneburg lens dynamics and apply the single lens ray tracing solution to various arrangements of multiple lenses. The wave propagating features of the Luneburg lens networks are also verified through direct numerical solutions of Maxwell's equations. We find that Luneburg lenses may form efficient waveguides for light propagation and guiding [1]. The additional presence of nonlinearity improves the focusing characteristics of the networks. Additionally, we study numerically the angle distribution for rays emerging from Luneburg lens as well as the time distribution for the ray travel time in a Luneburg lens.

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GMPC as 1d Potts-like model and the helix-coil transition in biopolymers

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We summarize the results of our investigations of helix-coil transition both in single-strand (polypeptides) and two-strand (polynucleotides) macromolecules. The Hamiltonian of the Generalized Model of Polypeptide Chain (GMPC) is introduced to describe the system in which the conformations are correlated over some dimensional range . The Hamiltonian does not contain any parameter designed especially for helix-coil transition and uses pure molecular microscopic parameters (the energy of hydrogen bond formation, reduced partition function of repeated unit, the number of repeated units fixed by one hydrogen bond, the flexibility of chain, the energies of interaction between the repeated units and the solvent molecules). We evaluate the partition function using transfer-matrix approach. An important problem of relation between GMPC and many particle one-dimensional Potts model is solved. We describe the influence of solvent interaction with biopolymer, both with competing and non-competing for hydrogen bond formation ways, considered stacking and hydrogen bonding simultaneously, the influence of side-by-side interaction and took into account structural heterogeneity of biopolymers. System cooperativity we describe in terms of two-particle correlation function and correlation length. Handling of the problem of solvent influence on helix-coil transition we obtained, depending on energy of solvent-macromolecule interaction, how solvents change transition temperature and interval. We obtained, that two type interaction of solvent brings to appear low temperature coil-helix transition, which we connect with cold denaturation. We considered joint stacking and hydrogen bonding interactions, using two-scale GMPC. Here we solved two problems- generalized stacking and restriction of helix regular sequence. Stacking on the background of H-bonding increases stability and decreases cooperativity of melting, restriction of helix regular sequence brings to appear new correlation peak, which nature is anticooperativity in long helical sequences. We also took into account two biopolymers side-by-side interactions, which brings to different effects. In case of effective attraction, the cooperativity rises sharply, in case of effective repulsion; the shape of melting curve is two-phase with high and wide correlation length in a plateau on denaturation curve.

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Travelling waves in nonlinear magnetic metamaterials

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Magnetic metamaterials composed of split-ring resonators or U-type elements may exhibit dis- creteness effects in THz and optical frequencies due to weak coupling. We consider a model one- dimensional metamaterial formed by a discrete array of nonlinear split-ring resonators with each ring interacting with its nearest neighbours. The existence and uniqueness results of periodic and asymptotic travelling waves of the system are presented. The existence and the stability of periodic and asymptotic waves are also computed and discussed numerically.

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Hysteresis Analysis in Simple Charge Density Wave Systems

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We are interested in hysteresis behaviour in Charge Density Waves (CDW) systems which are elastically-coupled particle systems in periodic potentials with random phase-offset. Such systems have static (pinned) solutions when subjected to an external force which is below a threshold force. Actually, CDWs have two unique and distinct threshold configurations, corresponding to reaching the threshold via positive or negative force increments[1]. We are interested in the hysteresis behaviour of CDWs when cycled between these two threshold forces, whether the system settles into a steady-state hysteresis loop after many such cycles, and if so how this behavior depends on the particular forcing cycle.

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Critical Exponents on Scale Free Networks from Spectral Renormalization Group

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We generalize the field theoretic Renormalization Group (RG) a lá Wilson [1] to arbitrary networks, by expanding the fluctuations of the order parameter in the eigenvectors of the graph Laplacian and eliminating the modes with the largest eigenvalues [2]. We obtain the eigenvectors and eigenvalue distributions of the graph Laplacian for periodic, hierarchical and Barabas-Albert networks [3] with different degree distributions, and explicitly perform numerical integrations over the effective Gaussian hamiltonian in order to compute the renormalization factors and thereby the critical exponents. We are able to recover the known values for the exponents of the Gaussian model on periodic lattices in two and three dimensions. Work is under way to incorporate the ψ^4 type of terms and compare with the existing literature on critical phenomena on networks. The Laplace spectrum is known to directly yield information on the dynamics [4]. Therefore extending the field theoretic RG method in this manner opens the way to the investigating the dynamics of systems living on complex networks, such as amorphous materials and structural glasses.

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Environmental noise and nonlinearity in biological and physical systems

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Existence of natural and half-life radio-active sources on earth and their decay products in the environments such soil, rocks, building materials,

food, water and air is basic reason for radiation that people exposed to. Due to the fact that these radioactive sources are disproportionate in the environment, and doses people exposed to as a result of inner and outer radio-activation largely differ in accordance with daily routines.
Radon is the only radio-active gas appearing as a result of uranium decay and existing in the nature. Because the source of Radon is uranium and uranium's disproportion in the nature, it is necessary to determine its average value in the soil. Annual concentration ratios determined by Turkish Atomic Energy Authority (TAEK) is 400 Bq/m^3 at homes and 1000 Bq/m^3 at workplaces on average in Turkey.
In this study, Radon gas was measured at salt cave located in the province, Cankiri. Sixty-six Radon detector (Cr-39) were placed in different points of the cave. These detectors were left at these places for approximately sixty days and analysed in an isolated Radon measurement laboratory in CNAEM at the end of that period. According to the results of the analyses, average Radon concentration activity was measured as 201.68 Bq/m^3.
As a consequence, it was observed that the results found are considerably below the values determined by TAEK.

Statistical properties of small systems

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Statistical mechanical treatment of macroscopic systems consisting of an assem- bly of particles starts with the Boltzmann formula along with the use of a statistical ensemble averaging techniques for the probability distribution of particles in the system. The relationship between thermodynamics and statistical physics is valid in the thermodynamic limit - when the number of particles involved becomes very large. Here we study statistical proporties in the opposite regime - at both the nano scale, and when deviation from Boltzman formula become important.
The question of the issue of the application of thermodynamics on the nanoscale began to emerge after the nucleation reaction was discovered in the early 1930s and continues to be asked to this day. It was clear right from the beginning that as the system size decreases one has to deal with fluctuations. In this context, the first such considerations were on temperature fluctuations. As the result Tsallis distribution repleaces Boltzman formula. We discuss statistical proporties of small system and demonstrate that Tsallis distribution is the natural description of such system.
Fluctuations in systems containing a relative small number of constituents have been studied to examine how those differ from their macroscopic counterparts. We analyze ensemble in which energy (E), temperature (T) and multiplicity (N) can all fluctuate and with the help of nonextensive statistics we consider relation connecting all fluctuating variables. In particular fluctuations of energy and multiplicity has been considered. Dependence of heat capacity on the size system (characterized by the number od particles N) is discussed. Fluctuations of the energy are, in general, given by the sum of two components: one obtained in the case of no fluctuations (the kinetic component) and one originating by fluctuations (the potential component). Deviation from $Var(N) \sim 1/N$ relation has been demonstrated in multiparticle production processes where the sub-Poissonian distribution (for small N) as well as super-Poissonian distributions (for larger N) are observed.

A Probabilistic Latent Semantic Approach to Classification of Literary Texts

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Probabilistic Latent Semantic Analysis (pLSA)[1][2] is an unsupervised learning algorithm to mine keywords or main concepts in large data sets. The algorithm returns mixture probabilities based on a latent class model which can be used for classifications.[3]
In this poster, I present a pLSA approach to the

classification and analysis of literary texts in terms of differentiations and similarities by genres, by eras and by authors.

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Dynamic phase transition properties and hysteretic behavior of a ferrimagnetic core/shell nanoparticle in the presence of a time dependent perturbation

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In recent years, influences of small-size and surface effects on the magnetic properties of magnetic nanoparticles have provided a conspicuous and productive field for the interaction between theoretical works [1] and technological [2], as well as biomedical applications [3, 4]. As the physical size of a magnetic system reduces to a characteristic length, surface effects become dominant on the system, hence, some unusual and interesting magnetic phenomena can be observed, which may differ from those of bulk materials [5]. It is a well known fact that physical properties of a bulk material are independent from size; however, below a critical size, nanoparticles often exhibit size-dependent properties, and some unique phenomena have been reported, such as superparamagnetism [6, 7], quantum tunneling of the magnetization [8], and unusual large coercivities [9]. On the other hand, a mag- netic system exhibits nonequilibrium phase transition properties in the presence of a driving magnetic field. Namely, when a magnetic material is subject to a periodically varying time dependent magnetic field, the system may not respond to the external magnetic field instantaneously which causes interesting behaviors due to the competing time scales of the relaxation behavior of the system and periodic external magnetic field.
Nonequilibrium DPT properties of small magnetic systems needs particular attention and the following questions need to be answered: (i) What is the effect of the amplitude and frequency of the oscillating magnetic field on the dynamic phase transition properties (i.e. critical and compensation temperatures) of the nanoparticle systems? (ii) What kind of physical relationships exist between the magneto-optical properties (compensation point and coercivity) of the particle and the system size? In order to clarify these questions we present some results regarding the dynamic phase transition features and stationary-state behavior of a ferrimagnetic small nanoparticle system with a core-shell structure.

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Nonlinear DNA dynamics: nonlinearity versus dispersion

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We study the impact of dispersion and nonlinearity on DNA dynamics. Nonlinear dynamics of DNA can be viewed as an interplay between nonlinearity and dispersion [1]. This means that nonlinearity increases wave amplitude and decreases its width, while the impact of dispersion on the wave is opposite, which we demonstrate.
We rely on the helicoidal Peyrard-Bishop (HPB) model [2]. All important details and derivations regarding this model can be found in a review paper [3]. A basic equation, describing DNA dynamics, is nonlinear Schrödinger equation (NLSE), which includes a dispersion parameter P and a nonlinear parameter Q. Both of them depend on five internal parameters, describing DNA geometry and chemical interactions between nucleotides. According to the interplay between nonlinearity and dispersion we should expect that the wave amplitude is an increasing function of Q and a decreasing function of P, while the impact of dispersion and nonlinearity on the wave width Λ is opposite. However, according to the HPB model, the corresponding relations are: $A \propto (PQ)^{-1/2}$ and $\Lambda \propto P$. This absurd can be solved assuming that P and Q are mutually dependent. We show how functions $Q(P)$ and $P(Q)$ can be obtained. Also, we show how this can be used to find a possible interval for the most intriguing internal parameter, describing helicoidal structure of DNA. This result is compared with the one obtained earlier using different methods [4].
As NLSE appears in several branches of physics and determination of the parameters is always important but difficult problem we believe that our procedure can be widely used.

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