XVI Reunión de Mecánica Estadística de No equilibrio y Física Nolineal
XVI Conference on Nonequilibrium Statistical Mechanics and Nonlinear Physics

MEDYFINOL'08

Hotel Club del Lago, Punta del Este, Uruguay
December 1-5, 2008

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PROGRAM

Sunday, November 30

17:00 – 20:00 Registration

Monday, December 1

08:00 – 09:00 Registration

08:55 – 09:00 Opening Remarks

Chair: **Cristina Masoller**

09:00 – 09:30	**Ezequiel Albano** (La Plata, Argentina): *Dynamic Behavior of the 1D Ising Ferromagnet with long-range interactions*
09:30 – 10:00	**Ian Levin** (Porto Alegre, Brazil): *Collision-less relaxation in non-neutral plasmas and gravitational systems*
10:00 – 10:30	**Andrea Rapisarda** (Catania, Italy): *Chaos and nonergodic dynamics in long-range interacting systems*

10:30 – 11:00 Coffee break

Chair: **Arturo Marti**

11:00 – 11:30	**Katja Lindenberg** (San Diego, USA): *Continuous time random walk for open systems: Fluctuation theorems and counting statistics*
11:30 – 12:00	**Alexander Blumen** (Freiburg, Germany): *Continuous time quantum walks on complex networks*
12:00 – 12:30	**Manuel Caceres** (Bariloche, Argentina): *Evolutionary formalism from random Leslie matrices*
12:30 – 13:00	**Gerardo Garcia-Naumis** (UNAM, Mexico): *Thermal relaxation and low frequency vibrational anomalies in simple models of glasses: a study using non-linear Hamiltonians*

13:00 - 14:00 Lunch

Chair: **Orazio Descalzi**

15:00 – 15:30	**Hernan Solari** (Buenos Aires, Argentina): *Lessons from a mathematical model for the big Yellow Fever epidemic (Buenos Aires, 1871)*
15:30 – 16:00	**Marcel Clerc** (Santiago, Chile): *Interaction and coarsening dynamics of dissipative soliton in parametrically driven Newtonian fluid*
16:00 – 16:30	**Harald Pleiner** (Mainz, Germany): *Influence of sedimentation on convective instabilities in colloidal suspensions*
16:30 – 17:00	**Helmut Brand** (Bayreuth, Germany): *Influence of boundary conditions on localized solutions of the cubic-quintic Complex Ginzburg-Landau Equation*

17:00 – 17:30 Coffee break

Chair: **Osvaldo Rosso**

17:30 – 17:50	**Orazio Descalzi** (Santiago, Chile): *Noise induces partial annihilation of colliding dissipative solitons*
17:50 – 18:10	**David Laroze** (Arica, Chile): *Amplitude equation for stationary convection in viscoelastic ferrofluid*
18:10 – 18:30	**Hector Mancini** (Pamplona, Spain): *Dynamics, control and synchronization in Benard-Marangoni convective patterns*
18:30 – 18:50	**Marta Rosen** (Buenos Aires, Argentina): *Rayleigh-Plateau instability produced with gravity oscillation*
18:50 – 19:10	**Alexey Snezhko** (Argonne, USA): *Pattern formation and complex dynamics in driven magnetic granular ensemble*
19:10 – 19:30	**Günter Radons** (Chemnitz, Germany): *Lyapunov modes in extended systems*
19:30 – 19:50	**Daniel A. Vega** (Bahía Blanca, Argentina): *Block copolymer pattern alignment induced by substrate topography*

20:30 Welcome drink

Tuesday, December 2

08:30 – 09:00 Registration

Chair: **Miguel Arismendi**

09:00 – 09:30	**Peter Hanggi** (Augsburg, Germany): *The ring of Brownian motion: Stochastic resonance and ex(e/o)rcising demons with Brownian motors*
09:30 – 10:00	**Marcia Barbosa** (Porto Alegre, Brazil): *The generic mechanism for water-like anomalies*
10:00 – 10:30	**Roberto F. S. Andrade** (Bahia, Brazil): *Scaling properties of fluid flow in a porous media: a model based on Apollonian packing*

10:30 – 11:00 Coffee break

Chair: **Marcia Barbosa**

11:00 – 11:30	**Gabriel Mindlin** (Buenos Aires, Argentina): *The physics and neural control of birdsong*
11:30 – 12:00	**Dante Chialvo** (Chicago, USA): *Galileo was right, also about tonal consonance*
12:00 – 12:30	**Miguel Arismendi** (Mar del Plata, Argentina): *Converting genetic network oscillations into somite spatial pattern*
12:30 – 13:00	**Maximino Aldana** (Morelos, Mexico): *Critical dynamics in genetic networks: examples from four kingdoms*

13:00 - 14:00 Lunch

14: 00 Poster Session I

Chair: **Raul Rechmann**

15:00 – 15:30	**Celso Grebogi** (Aberdeen, UK): *Fractal skeletons: the universality in death by starvation*
15:30 – 16:00	**Frank Schweitzer** (Zurich, Switzerland): *Non-linear voter models: The transition from invasion to coexistence*

16:00 – 16:30 **Emilo Hernandez-Garcia** (Mallorca, Spain): *Species clustering in models of biological competition*
16:30 – 17:00 **Francesc Sagues** (Barcelona, Spain): *Physics of colloids: from collective assemblies to single swimmers*

17:00 – 17:30 Coffee break & Poster Session I

Chair: **Gabriel Mindlin**
17:30 – 17:50 **Miguel Hoyuelos** (Mar del Plata, Argentina): *Nonequilibrium entropy of Markov processes*
17:50 – 18:10 **Adriano Batista** (Campina Grande, Brazil): *AC-driven Duffing oscillators under correlated noise and non-Markovian dissipation*
18:10 – 18:30 **Veronica Marconi** (Córdoba, Argentina): *Novel ratchet effects for the motion of elastic interfaces*
18:30 – 18:50 **María Florencia Carusela** (Buenos Aires, Argentina): *Induced current in classical and quantum damped ratchets*
18:50 – 19:10 **Itzhack Dana** (Ramat-Gan, Israel): *Quantum-resonance ratchets: theory and experiment*
19:10 – 19:30 **Jaime Cisternas** (Santiago, Chile): *Stochastic model calculation for the carbon monoxide oxidation on iridium(111) surfaces*

21:30 – 23:00 Poster Session I

Wednesday, December 3

08:30 – 09:00 Registration

Chair: **Sergio Cannas**
09:00 – 09:30 **Eleonora Catsigeras** (Montevideo, Uruguay): *Biological neuronal networks as deterministic dynamical systems*
09:30 – 10:00 **Marcelo Magnasco** (New York, USA): *Dynamical and statistical criticality in a model of neural tissue*
10:00 – 10:30 **Jürgen Kurths** (Potsdam, Germany): *Dynamics on complex networks with time varying topology*

10:30 – 11:00 Coffee break

Chair: **Eleonora Catsigeras**
11:00 – 11:30 **Theo Geisel** (Goettingen, Germany): *Self-organized criticality in neuronal systems*
11:30 – 12:00 **Sergio Cannas** (Cordoba, Argentina): *Emergent self-organized complex network topology out of stability selection pressure*
12:00 – 12:30 **Kunihiko Kaneko** (Tokyo, Japan): *Dynamical systems problems inspired by biology*
12:30 – 13:00 **Adi Bulsara** (San Diego, USA): *Coupling nonlinear oscillators for fun and profit*

13:00 - 14:00 Lunch

Chair: **Alejandra Figliola**

15:00 – 15:30	**Silvina Ponce –Dawson** (Buenos Aires, Argentina): *Propagation of calcium waves and synaptic plasticity*
15:30 – 16:00	**Gustavo Martinez-Mekler** (Cuernavaca, México): *Calcium network dynamics and sperm motility*
16:00 – 16:30	**Mario Cosenza** (Mérida, Venezuela): *Generalized synchronization of chaos in autonomous systems*
16:30 – 17:00	**Claudio Mirasso** (Mallorca, Spain): *Delayed but still in time: a neural mechanism for zero lag long range synchronization in the brain*

17:00 – 17:30 Coffee break and Poster Session II

Chair: **Silvina Ponce - Dawson**

17:30 – 17:50	**Alejandra Figliola** (Buenos Aires, Argentina): *About the effectiveness of different methods for the estimation of the multifractal spectrum of natural series*
17:50 – 18:10	**Hilda Larrondo** (Mar del Plata, Argentina): *Quantifiers for stochasticity of chaotic pseudo random number generators*
18:10 – 18:30	**Maria Carmen Romano** (Aberdeen, UK): *Traffic jams in the cell: lost in translation*
18:30 – 18:50	**Guillermo Solovey** (Buenos Aires, Argentina): *Multiple scales in calcium signals*
18:50 – 19:10	**Alexandre Souto Martinez** (São Paulo, Brazil): *Generalized continuous and discrete population dynamics models*
19:10 – 19:30	**Raul Rechtman** (Morelos, Mexico): *Complexity of the wind tree model*

21:30 – 23:00 Poster Session II

Thursday, December 4

08:30 – 09:00 Registration

Chair: **Celia Anteneodo**

09:00 – 09:30	**Damián Zanette** (Bariloche, Argentina): *Beyond networks: opinion formation in triplet-based social structures*
09:30 – 10:00	**Marcel Ausloos** (Liege, Belgium): *Entropy correlation distance method applied to the Gross Domestic Product of rich countries*
10:00 – 10:30	**Marta Gonzalez** (Boston, USA): *Understanding individual human mobility patterns*

10:30 – 11:00 Coffee break

Chair: **Damian Zanette**

11:00 – 11:30	**Celia Anteneodo** (Rio, Brazil): *Unraveling the stochastic dynamics of financial markets*
11:30 – 12:00	**Jose Roberto Iglesias** (Porto Alegre, Brazil): *Crime and punishment: the economic burden of impunity*
12:00 – 12:30	**Raul Donangelo** (Montevideo, Uruguay): *Early warnings of catastrophic changes in ecosystems*

12:30 – 13:00 **Jason Gallas** (Porto Alegre, Brazil): *Cascades of hubs and spirals in phase diagrams of simple flows*

13:00 - 14:00 Lunch

14: 00 Poster Session III

Chair: **Jose Roberto Iglesias**

15:00 – 15:20 **Guillermo Cecchi** (New York, USA): *Topological effects of synaptic time-dependent plasticity*

15:20 – 15:40 **Pablo Balenzuela** (Buenos Aires, Argentina): *Critical functional networks: Similarities between brain dynamics and Ising model*

15:40 – 16:00 **Guillermo Ortega** (Madrid, Spain): *Complex network analysis of human electrocorticographic data*

16:00 – 16:20 **Leonardo Brunnet** (Porto Alegre, Brazil): *Coordinated motion influences typical scales of cell sorting*

16:20 – 16:40 **Marco Idiart** (Porto Alegre, Brazil): *A process of k%-max winner take all mediates tuning orientation on cells of the visual cortex*

16:40 – 17:00 **Jorge Mazzeo** (Buenos Aires, Argentina): *Multiscale characteristics of cell proliferation in the developing central nervous system of chick embryos*

17:00 – 17:30 Coffee break and Poster Session III

Chair: **Pablo Balenzuela**

17:30 – 17:50 **Raul Montagne** (Recife, Brazil): *Quasi-long-range order in active nematics and background flux*

17:50 – 18:10 **Hugues Chaté** (Saclay, France): *Modeling and understanding active matter: variations on the Vicsek model*

18:10 – 18:30 **Angel Plastino** (Buenos Aires, Argentina): *Aspects of quantum phase transitions*

18:30 – 18:50 **Araceli Proto** (Buenos Aires, Argentina): *Consequences of the dynamical properties of the specific heat in semi quantum nonlinear hamiltonians*

18:50 – 19:10 **Leszek Szybisz** (Buenos Aires, Argentina): *Spontaneous symmetry breaking and first-order phase transitions of adsorbed fluids*

19:10 – 19:30 **Nicolas Wschebor** (Montevideo, Uruguay): *Non-perturbative renormalization group approach to out-of-equilibrium problems*

21:30 – 23:00 Poster session III

Friday, December 5

08:30 – 09:00 Registration

Chair: **Francisco Tamarit**

09:00 – 09:30 **Jose R. Rios Leite** (Recife, Brazil): *Time delays in the synchronization of chaotic systems*

09:30 – 10:00 **Tom Gavrielides** (New Mexico, USA): *Mutually coupled semiconductor lasers with rotated optical feedback*

10:00 – 10:30 **Jorge Tredicce** (Nice, France): *Cavity soliton laser based on mutually coupled semiconductor microresonators*

10:30 – 11:00 Coffee break

Chair: **Araceli Proto**

11:00 – 11:30 **Francisco Tamarit** (Córdoba, Argentina): *The storage capacity of a bidimensional Hopfield neural network with complex topology*

11:30 – 12:00 **Ricardo Velluti** (Montevideo, Uruguay): *Auditory neuronal networks in sleep and wakefulness*

12:00 – 12:30 **Alessandro Villa** (Grenoble, France): *Spatiotemporal patterns of activity in cerebral neural networks: a dynamical systems perspective*

12:30 – 13:00 **Claudio Dorso** (Buenos Aires, Argentina): *Community detection in networks*

13:00 - 14:00 Lunch

Chair: **Angel Plastino**

15:00 – 15:20 **Inés Caridi** (Buenos Aires, Argentina): *Clusters in networks with incomplete information: The disappeared in Argentina (1975-1984)*

15:20 – 15:40 **Silvia London** (Bahia Blanca, Argentina): *Convergence across the American countries*

15:40 – 16:00 **Panayotis Panayotaros** (Ciudad de Mexico): *Localized coherent structures in the discrete NLS equation*

16:00 – 16:20 **Jose Suarez-Vargas** (Venezuela): *Synchronization transitions and multistability in the route to oscillation death of coupled nonlinear oscillators*

16:20 – 16:40 **Carlos Argolo** (Alagoas, Brazil): *The threshold of coexistence of a predator-prey probabilistic model in a fractal and in a square lattice*

16:40 – 17:00 **Cesar Sampaio** (Recife, Brazil): *Dynamics of the volatility distributions on Complex Networks*

17:00 – 17:10 Closing Remarks

TALKS

(Alphabetical order)

(INVITED) Ezequiel V. Albano, D. Rodríguez, M. Bab, Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas (INIFTA), Facultad de Ciencias Exactas, Universidad Nacional de La Plata, Argentina
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Dynamic behavior of the 1D Ising ferromagnet with long-range interactions

The dynamic behavior of the Ising model, with power-law decaying interactions of the form $1/r^{d+\sigma}$, is simulated in d = 1 dimension for σ= 0.75, by using the Monte Carlo method. This value of σ is selected because we expect that critical exponents will be far from both the mean-field values σ= 0.5 and the strong Kosterlitz-Thouless behavior. Both the standard relaxation of ordered configurations and the short-time dynamics of disordered configurations are studied and rationalized in terms of scaling arguments. By measuring the time dependence of physical observables, such as the magnetization, susceptibility, Binder cumulant, correlation function, etc, the critical temperature and all the relevant critical exponents can be determined, including the static (β,γ,μ) and the dynamic (z) ones. Also, the scaling exponent of the initial increase of the magnetization is evaluated. Based on this evidence we conclude that the study of the dynamic behavior of the system allows the complete characterization of its critical properties.

(INVITED) Maximino Aldana, Instituto de Ciencias Físicas, UNAM, Morelos, México
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Critical dynamics in genetic networks: examples from four kingdoms

The coordinated expression of the different genes in an organism is essential to sustain functionality under the random external perturbations to which the organism might be subjected. To cope with such external variability, the global dynamics of the genetic network must possess two central properties. (a) It must be robust enough as to guarantee stability under a broad range of external conditions, and (b) it must be flexible enough to recognize and integrate specific external signals that may help the organism to change and adapt to different environments. This compromise between robustness and adaptability has been observed in dynamical systems operating at the brink of a phase transition between order and chaos. Such systems are termed critical. Thus, criticality, a precise, measurable, and well characterized property of dynamical systems, makes it possible for robustness and adaptability to coexist in living organisms. In this talk investigate the dynamical properties of the gene transcription networks reported for S. cerevisiae, E. coli, and B. subtilis, as well as the network of segment polarity genes of D. melanogaster, and the network of flower development of A. thaliana. By analyzing hundreds of microarray experiments to infer the nature of the regulatory interactions among genes, and implementing these data into the Boolean models of the genetic networks, I will show that, to the best of the current experimental data available, the five networks under study indeed operate close to criticality. The generality of this result suggests that criticality at the genetic level might constitute a fundamental evolutionary mechanism that generates the great diversity of dynamically robust living forms that we observe around us.

(INVITED) Fernandes Silva Andrade[1], **R. Sousa de Oliveira**[1], **J. S. de Andrade Jr.**[2]
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[2] Departamento de Física,Universidade Federal do Ceará, Brazil
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Scaling properties of fluid flow in a porous media: a model based on Apollonian packing

The low Reynolds number fluid flow in porous media is investigated with the help of the well-known two-dimensional Apollonian packing in a channel of height H. The packing is constructed by drawing, initially, the centers of four identical tangent circles of radius $H/4$, on the corners of a square of side $H/2$ placed in the middle of the channel. Next generations are obtained by including new tangent circles in the space limited by the initial four units. As the maximum tangents circles, which optimize the occupation of the space, do not allow for fluid flow, we uniformly reduce the values of the radius of the circles from the configuration of the tangents circles. The first purpose is to find the conditions under which Darcy's law is verified, for different values of the reduction factor. For each value of the void fraction, we measure the dependence of the permeability with respect to the applied pressure gauge, identifying the maximal value of the Reynolds number for which the linear relation established by the law of Darcy is obeyed. These results allow us to further analyze the variation of the permeability with the porosity, establishing the scaling limit of validity expressed by the Kozeny-Carman relations.

(INVITED) Celia Anteneodo, R. Riera, A. Cortines, Universidad Pontificia Católica, Rio de Janeiro, Brazil
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Unraveling the stochastic dynamics of financial markets

A special focus of econophysics has been the analysis of the fluctuations of prices and other observables in financial markets. The challenge stands on the observed non-trivial behaviors, such as long temporal correlations, non-Gaussianity and scaling laws, whose origins are not fully understood. In this presentation we discuss, from direct analysis of empirical data, possible mechanisms responsible for the observed anomalous probability distributions of stock market indices and trading volumes. As one possible approach we evaluate the Kramers-Moyal equation that describes the evolution of the observed probability densities through timescales. Another fruitful approach consists in scrutinizing the possible presence of slow fluctuations of inner parameters that characterize the dynamics in short timescales, since doubly stochastic processes can lead to power law distributions. The applicability of these methods can be of theoretical interest beyond the particular problems focused here.

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The threshold of coexistence of a predator-prey probabilistic model in a fractal and in a square lattice

We study the critical behavior of a stochastic model that describes two population biology problem: The threshold of species coexistence in a predator-prey system. We simulate the above model by Monte Carlo procedure on a regular square lattice and also on a fractal lattice, the sierpinsky carpet. We determine the critical phase boundaries related to the transition between an active state, where prey and predators present a stable coexistence, and a predator absorbing state. For both lattices, a finite size scaling analysis is employed to determine the order parameter, correlation length and susceptibility exponents. The numerical estimates of the critical exponents of the regular 2-d dimensional lattice coincide with those of the directed percolation universality class. We argue if the critical exponents of the fractal lattice are different from the directed percolation ones. We check the validity of the hyperscaling relation for both the regular and the fractal lattice and present the data collapses curves.

(INVITED) **Miguel Arizmendi**[1], **K. I. Mazzitello**[1], **H. G. E. Hentschel**[2]
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Converting genetic network oscillations into somite spatial pattern

The segmentation of vertebrate embryos, a process known as somitogenesis, depends on a complex genetic network that generates highly dynamic gene expression. Many of the elements of the network have been identified, but their interaction and their influence on segmentation remain poorly understood. The Clock and Wavefront model, the best known somitogenesis model, postulates the existence of a longitudinal positional information gradient down the axis of vertebrate embryos. This gradient interacts with the cellular oscillator stopping the oscillations and producing a rapid change in locomotory and adhesive behavior of cells when they form somites. The genetic oscillation in the presomitic mesoderm (PSM) is the somite clock, and the moving interfaces at the anterior end of the PSM where the positional information reaches a critical value is called the wavefront. It is the interaction between the clock phase and the positional information that controls somitogenesis. A somitogenesis clock has been identified in chick, mouse, zebrafish, and frog, which consists of oscillatory gene expression in the presomitic mesoderm. Two major questions are how somitogenesis clock oscillations are generated, and how they regulate segmentation. A recent proposal for the mechanism underlying these oscillations involves negative-feedback regulation at transcriptional and translational levels, also known as "delay-model" [J. Lewis, Curr. Biol. 13, 1398 (2003)]. In this talk we present an extension of the "delay model" by taking into account the interaction of the oscillation clock with the determination front, in order to consider the pattern formation problem in the zebrafish embryo. Comparison is made with the known properties of somite formation in the zebrafish embryo. We also show that the model can mimic the anomalies formed when progression of the determination wavefront is perturbed and make an experimental prediction that can be used to test the model.

(INVITED) **Marcel Ausloos**, GRAPES, Physics Department, Univ. Liege, Belgium
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Entropy correlation distance method applied to the Gross Domestic Product of rich countries

Theil index is much used in economy and finance; it looks like the Shannon entropy, but pertains to event values rather than to their probabilities. Any time series can be remapped through the Theil index. Thus, linear correlation coefficients can be evaluated between such time series, thereby allowing to define a statistical distance, - to be contrasted to the usual correlation distance measure for the time series. As an example this entropy-like correlation distance method (ECDM) is applied to the Gross Domestic Product (relative increments) of rich countries in order to test some globalization process. Hierarchical distances (or "linear network") structures are constructed and analysed. The role of time averaging in finite size windows is discussed. It is also shown that the mean distance between the most developed countries actually decreases in time, - which we consider to be a proof of globalization. It is stressed that the entropy correlation distance measure is more suitable in detecting a phase transition, like a globalization process than the usual statistical (correlation based) measure.

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Critical functional networks: Similarities between brain dynamics and Ising model

In the last years, a lot of effort has been done in the characterization of functional brain networks in order to describe large scale brain organization. Even when the brain is at rest, complex spatio-temporal organization in fMRI experiments reveals the presence of dense local correlations with few long range connections, long living meta-stable states and anticorrelated non-local structures. In this work, we show that these features associated to complex brain functional networks can be found in a paradigmatic case of critical behavior with just nearest neighbors interactions on a square lattice: the Ising model at critical temperature.

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The generic mechanism for water-like anomalies

Some liquids in nature are known as anomalous liquids since they exhibit unexpected behavior upon variations of its thermodynamic conditions. Water is the canonical example of those anomalous liquids and, therefore, the anomalies found in many of these liquids are known as water-like anomalies. Water expands upon cooling at fixed pressure, diffuses faster upon compression at fixed temperature, and become less organized upon increasing density – or equivalently upon compression – at constant temperature. These are the density, diffusion, and structural anomalies of water, respectively. Using collision driven molecular dynamics we show that two scales potentials always exhibit water-like anomalies. Potentials in which two preferred distances are present always exhibit water-like anomalies, but sometimes they are in an inaccessible region, as inside a crystal phase. This is the case for the square-shoulder potential

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AC-driven Duffing oscillators under correlated noise and non-Markovian dissipation

Here we propose a method to determine what kind of random motion (diffusion, subdiffusion, or superdiffusion) microscopic particles have in a fluid. This is accomplished by measuring the memory function, which is associated to non-Markovian dissipation and correlated noise [1]. In our proposed method, a microscopic brownian particle is attached to the middle of a doubly-clamped resonator beam, which is subsequently ac driven and immersed in a fluid. Using a beam with lateral dimensions of the order of nanometers, most of the drag is generated in the surface of the microscopic particle, hence the measured memory function will be nearly that of the free brownian particle. Here, we show how memory effects in dissipation, qualitatively and quantitatively, alter the dynamics of the microscopic particle attached to the resonator beam (whose equations of motion are equivalent to those of the Duffing oscillator). We further show how memory functions corresponding to different dissipative regimes (diffusion, subdiffusion, and superdiffusion) affect the oscillator. In particular, we obtain universal power laws for

the absoption when the driving frequency is small. For subdiffusive memories the power law exponents $\nu<2$, for diffusive memories $\nu= 2$, and for superdiffusive memories $\nu>2$ [2].
[1] R. Morgado et al., Phys. Rev. Lett. V89, 100601 (2002).
[2] A. A. Batista et al., Phys. Rev. E V77, 066216 (2008).

(INVITED) Alexander Blumen[1], E. Agliari[1,2], O. Mülken[1]
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Continuous time quantum walks on complex networks

Recent findings suggest that processes such as the electronic energy transfer through the photosynthetic antenna display quantum features, aspects known from the dynamics of charge carriers along polymer backbones. Hence, in modeling energy transfer one has to leave the classical, master-equation-type formalism and advance towards an increasingly quantum-mechanical picture, while still retaining a local description of the complex network of molecules involved in the transport, say through a tight-binding approach. Interestingly, the continuous time random walk (CTRW) picture, widely employed in describing transport in random environments, can be mathematically reformulated to yield a quantum-mechanical Hamiltonian of tight-binding type; the procedure uses the mathematical analogies between time-evolution operators in statistical and in quantum mechanics: The result are continuous-time quantum walks (CTQWs). Now, while the CTQW problem is then linear, and thus many results obtained in solving CTRWs (such as eigenvalues and eigenfunctions) can be readily reutilized for CTQWs, the physically relevant properties of the two models differ vastly: Thus, in the absence of traps CTQWs are time-inversion symmetric and no energy equipartition takes place at long times. Also, the quantum system keeps memory of the initial conditions, a fact exemplified by the occurrence of quasi-revivals [1]. In this talk we will discuss this and additional features, such as the topology dependence of CTQWs, ranging from very efficient transport on regular lattices [2] to localization and trapping effects on fractal or hyper-branched structures [3]. We furthermore will compare the CTQW results to the corresponding CTRW results on topologically equivalent networks. This allows us to systematically explore the similarities and differences between purely classical and purely quantum mechanical processes.
[1] O. Mülken, A. Blumen, Phys. Rev. E 71, 036128 (2005); Phys. Rev. E 73, 066117 (2006).
[2] O. Mülken, V. Bierbaum, and A. Blumen; J. Chem. Phys. 124, 124905 (2006).
[3] E. Agliari, A. Blumen, and O. Mülken; J. Phys. A, in press (2008).

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Influence of Boundary Conditions on Localized Solutions of the cubic-quintic Complex Ginzburg-Landau Equation

We investigate the influence of the boundary conditions and the box size on the existence and stability of various types of localized solutions (particles and holes) of the cubic-quintic complex Ginzburg-Landau equation as it arises as a prototype envelope equation near the weakly hysteretic onset of traveling waves. Two types of boundary conditions are considered for one spatial dimension, both of which can be realized experimentally: periodic boundary conditions, which can be achieved for an annulus and Neumann boundary conditions, which correspond to zero flux, for example in hydrodynamics. We find that qualitative differences between the two types of boundary conditions arise in particular for propagating and breathing localized solutions. While an asymmetry in the localized state is always connected to motion for periodic boundary conditions, this no longer applies for Neumann boundary conditions. In the case of Neumann boundary conditions we observe that breathing localized states can no longer exist below a certain box size, which is comparable to the “width” of the localized state.

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Coordinated motion influences typical scales of cell sorting

A self-propelled particle model is introduced to study cell sorting occurring in some living organisms. This allows evaluating the influence of intrinsic cell motility separately from differential adhesion with fluctuations, a mechanism previously shown to be sufficient to explain a variety of cell rearrangement processes. Besides, we also study differential velocity without differential adhesion as a mechanism to induce segregation. We find that the tendency of cells to actively follow their neighbors greatly reduces segregation timescales. A finite-size analysis of the sorting process reveals clear algebraic growth laws as in physical phase-ordering processes, albeit with unusual scaling exponents.

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Coupling nonlinear oscillators for fun and profit

Unforced overdamped bistable dynamical systems cannot oscillate (i.e. switch between their stable attractors). However, a number of such systems subject to carefully crafted coupling schemes have been shown to exhibit oscillatory behavior under carefully chosen operating conditions. This behavior, in turn, affords a new mechanism for the detection and quantification of target signals having magnitude far smaller than the energy barrier height in the potential energy function $U(x)$ for a single (uncoupled) element. The coupling-induced oscillations are a feature that appears to be universal in systems described by bi- or multi-stable potential energy functions $U(x)$, and are being exploited in a new class of dynamical sensors being developed by us. In this work we describe one of these devices, a Coupled Core Fluxgate Magnetometer (CCFM), whose operation is underpinned by this dynamic behavior. We also outline other devices that are still under development as well as a tantalizing application in bistable genetic oscillators.

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Evolutionary formalism from random Leslie matrices

We present a perturbative formalism to deal with linear random matrix difference equations. We generalize the concept of the population growth rate when a Leslie matrix has random elements (i.e., characterizing some degree of disorder in the vital parameters). The dominant eigenvalue, of which defines the asymptotic dynamics of the mean value population vector state, is presented as the effective growth rate of a random Leslie model (i.e., effective Perron-Frobenius eigenvalue). This non-trivial eigenvalue is calculated from the largest positive root of a secular polynomial. Analytical, exact and perturbative results are presented for several models of disorder.

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Emergent self-organized complex network topology out of stability selection pressure

Although most networks in nature exhibit complex topology the origins of such complexity remains unclear. We introduce a model of a growing network of interacting agents in which each new agent's membership to the network is determined by the agent's effect on the network's global stability. It is shown that out of this stability constraint, scale free networks emerges in a self organized manner, offering an explanation for the ubiquity of complex topological properties observed in biological networks.

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Clusters in networks with incomplete information: The disappeared in Argentina (1975-1984)

In this presentation we describe a method developed in order to recognize communities in networks with lacking information. The method was conceived to be applied to the problem of people disappeared in the argentine province of Tucuman during the period 1975-1984. The information collected by the EAAF is used to build a social network in which the missing are replaced by nodes (hereafter referred as such) and links stand for relations established according to different criteria reflecting characteristics of the nodes as for example : political affiliation, date of disappearance, etc. The main hypothesis underlying this calculation is that strongly correlated subsets of nodes have ended up in the same CCD (clandestine detention centre) and afterwards they probably were disappeared (buried, cremated, etc.) in the same place. Through these calculations we aim to provide new, undetected, information to the EAAF in order to find the remains of the missing. We discuss different methods to validate our findings and to select the best set of parameters of the model. Encouraging results have already been obtained and will be shown in this presentation.

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Induced current in classical and quantum damped ratchets

In a previous work we found transport in a classical overdamped ratchet externally forced. The transport current arises by two different conditions: a) by increasing the external driving and b) by adding an optimal amount of noise while the system remains sub threshold. In this work, we study an underdamped one case. It is worth to note that the necessary condition to obtain transport is the presence of damping in addition to the asymmetries in the potential. On the other hand, we also study analytically and numerically the quantum analog of the same system and explore the conditions in order to establish transport.

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Biological neuronal networks as deterministic dynamical systems

The network of n >= 2 synaptically connected neurons can be modeled as a deterministic system, and thus studied with the theoretical tools of the Dynamical Systems Theory in a qualitative description, rather than using a quantitative method. Also Ergodic Theory known results are applicable. The abstract mathematical tools provide rigorously proved properties of some n-neurons system models and the qualitative tasks of its spike trains. Some systems are mathematically proved to exhibit several characteristic structurally stable limit cycles in the evolution of its internal spikes. Those limit cycles are not modified by the external small random perturbations, but the system can jump from one cycle to other when an external excitation spikes some of the sensorial neurons of the system. The system has a response capable of processing a large amount of information from the environment.

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Topological effects of synaptic time-dependent plasticity

Connections between individual neurons in the brain arise first from the spatial distribution of axons and dendrites within neural tissue. Local synaptic modification rules are known to shape patterns of connectivity in local neural tissue and local microcircuit topology. Global brain network topology, however, is believed to emerge largely from patterned area to area connectivity determined during development. One proposal for a rule governing this level of organization, the "no strong loops hypothesis", considered only patterning mechanisms to implement its specific area to area network topological constraint. Here, we show that the local Spike Timing-Dependent Plasticity (STDP) rule has the effect of reducing the trans-synaptic weights of closed loops of any length within a simulated network of neurons. We further prove analytically that anti-loop learning and STDP are equivalent for the case of a linear network. Thus a notable local synaptic learning rule yields structures dominated by feed-forward connections at their largest scale. Given its widespread occurrence in the brain, we propose that STDP must be involved in eliminating long range synaptic loops among individual neurons across all brain scales, up to, and including, the scale of global brain network topology.

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Modeling and understanding active matter: variations on the Vicsek model

The model introduced by Vicsek et al. in which self-propelled particles align locally with neighbors is, because of its simplicity, central to most studies of collective motion or “active” matter. After reviewing briefly its main properties, we show how it can be expanded into three main directions: changing the symmetry of the particles and/or of their interactions, adding local cohesion, and taking into account the fluid in which the particles move.

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Galileo was right, also about tonal consonance

The fundamental neuro-physiological bases involved in the perception of music and speech are still under discussion. Among them, the neural basis of consonance, one of the most universal aspects in which is based tonal music is not understood. We present a mathematical model, based on generic dynamics of excitable media, able to explain at once a number of unsolved issues in music theory.

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Stochastic Model Calculation for the Carbon Monoxide Oxidation on Iridium(111) Surfaces

We study the effect of external noise on the catalytic oxidation of CO on an Iridium(111) single crystal under ultrahigh vacuum conditions. This reaction can be considered a model of catalysis used in industry. In the absence of noise, the reaction exhibits one or two stable stationary states, depending on control parameters such as temperature and partial pressures. When noise is added, for instance by randomly varying the quality of the influx mixture, the system exhibits stochastic reaction rate and switching. In this work we present results for the bistable situation that use white-noise as well as colored-noise approximations.

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Interaction and coarsening dynamics of dissipative soliton in parametrically driven Newtonian fluid

An experimental and theoretical study in the motion and interaction of the localized excitations in a vertically driven small rectangular water container is reported. Close to the Faraday instability, the parametrically driven damped Nonlinear Schrodinger Equation models this system. This model allows characterizing the pair interaction law between localized excitations and the coarsening dynamics exhibited by a gas of these states. Experimentally we have a good agreement with the pair interaction law.

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Generalized synchronization of chaos in autonomous systems

We extend the concept of generalized synchronization of chaos, a phenomenon that occurs in driven dynamical systems, to the context of autonomous spatiotemporal systems. It means a situation where the chaotic state variables in an autonomous system can be synchronized to each other but not to a coupling function defined from them. The form of the coupling function is not crucial; it may not depend on all the state variables nor needs it to be active for all times for achieving generalized synchronization. The procedure is based on the analogy between a response map subject to external drive acting with a given probability and an autonomous system of coupled maps where a global interaction between the maps takes place with this same probability. It is shown that, under some circumstances, the conditions for stability of generalized synchronized states are equivalent in both types of systems. Our results reveal the existence of similar minimal conditions for the emergence of generalized synchronization of chaos in driven and in autonomous spatiotemporal systems.

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Quantum-resonance ratchets: theory and experiment

The purely quantum phenomenon of quantum resonance (QR) in kicked systems is an asymptotic quadratic growth in time of the mean kinetic energy for rational values of a scaled Planck constant. Under QR conditions, an asymmetry may also lead to "ratchet acceleration", i.e., a linear growth in time of the mean momentum in a preferred direction, despite the absence of a biased mean kicking force. Recently [1], general exact results were derived concerning QR and QR ratchets in the free-falling frame of the quantum kicked particle subjected to "gravity" (a linear potential). The general condition for QR in this system was shown to be the *simultaneous* rationality of the scaled Planck constant, the dimensionless gravity parameter, and the conserved quasimomentum β. A QR ratchet acceleration was found to arise even when both the kicking potential and the initial wave packet have a *point symmetry* if their symmetry centers do *not* coincide. The ratchet characteristics were also shown to depend significantly on number-theoretical features of the gravity parameter. In this talk, we shall first summarize the main results of work [1] in the special case of zero gravity. We shall then describe a very recent atom-optics experimental realization [2] of these results for mono-harmonic kicking potentials. In this realization, a Bose-Einstein condensate (BEC) of ^{87}Rb atoms is initially prepared in a superposition of two momentum states and is then exposed to a pulsed standing light wave. The experimental results for the mean-momentum change at *arbitrary* β agree well with the theoretical ones after taking into account the finite quasimomentum width of the BEC. In particular, this width is shown to cause a *suppression* of the ratchet acceleration for resonant (rational) β leading to a saturation of the directed current (the mean momentum) to a finite value as in ordinary (nonaccelerating) ratchets. This finite value is, however, usually larger than that for nonresonant β. Experimental work is in progress concerning the realization of QR ratchets for nonzero gravity parameter in [1].

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Noise induces partial annihilation of colliding dissipative solitons

Partial annihilation of two counter-propagating dissipative solitons, with only one pulse surviving the collision, has been widely observed in different experimental contexts, over a large range of parameters, from hydrodynamic to chemical reactions. However a generic picture accounting for partial annihilation is missing. In this talk we propose a universal mechanism explaining this phenomenon. In terms of a model we show that the existence of partial annihilation can be greatly enhanced and controlled by noise.

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Early warnings of catastrophic changes in ecosystems

The task of providing early indicators of catastrophic regime shifts in ecosystems is fundamental in order to design management protocols for those systems. Here we address the problem of lake eutrophication (the over-enrichment with nutrients leading to algal blooms) using a simple spatial model. We discuss and compare different spatial and temporal early signals announcing these catastrophic events. In particular we consider the spatial standard deviation and its associated patch structure of turbid water regions. The patch sizes exhibit a power law distribution when the lake is close to the eutrophic transition. We also analyze the spatial and temporal early warnings in terms of the amount of information required by each and their respective forewarning times. We then provide a link between spatial and temporal indicators and their interplay. From the consideration of different remedial procedures than can be followed after these early signals we conclude that some of these indicators are, unfortunately, not early enough to avoid the undesired shift to the eutrophic state.

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Community detection in networks

Given a network, the accepted qualitative definition of community is that it is a sub graph such that the nodes belonging to it, are more connected among themselves than to nodes outside the sub graph. The problem of community detection is relevant in many disciplines and the widely accepted criterion to detect them is to maximize the modularity (QN) introduced by Newman and Girvan [Phys. Rev. E 69, 026113 (2004)]. It has been shown that modularity optimization has a resolution limit. Moreover the communities resulting from this approach do not necessarily satisfy the qualitative definition introduced above. In this work we present new approach based on the optimization of new merit factors which strictly adhere to the qualitative definition and that do not present the above mentioned limit resolution problem. This method is tested on well known networks.

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About the effectiveness of different methods for estimating the multi-fractal spectrum of natural series

Complex natural systems frequently present characteristics of scalar invariance. This behaviour has been experimentally verified during the last years and there is a very rich related bibliography, reported from very diverse fields. The multifractal spectrum is a way to evaluate this kind of behaviour. In the last years, different numerical methods to estimate the multifractal spectrum have been proposed. These methods could be classified in those originate from the wavelet analysis and the other from numerical approximations like the Multifractal Detrended Fluctuation Analysis (MFDFA), proposed by Kantelhardt et al [1] . Recently, S. Jaffard and co-workers [2] proposed the Wavelet Leaders Method (WL) that combines the powerful of the wavelet analysis with the efficiency of the multi-resolution analysis. In this work, we compare the effectiveness of the WL with the MFDFA at the particular case of the estimation of natural series multi-fractal spectrum.

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Cascades of hubs and spirals in phase diagrams of simple flows

In a recent work [PRL 101, 054101 (2008)] we reported phase diagrams of simple flows (i.e. dynamical systems described by continuous time, modelled by sets of ordinary differential equations) to contain a certain key point, a "periodicity hub", responsible for organizing the dynamics regularly over wide parameter ranges around it. In this talk we present numerically obtained phase diagrams showing that, surprisingly, hubs emerge in infinite "hub cascades" that accumulate in a regular way on characteristic points of great dynamical richness and lying along peculiar paths in parameter space. To account for aspects of the very complicated phenomena at hand, we digress briefly on the theory of global bifurcations in multidimensional systems. We recall two important nonlocal bifurcations studied in the 1930s (Andronov and Leontovich): the birth of periodic orbits from a homoclinic (separatrix) loop to a saddle, and from a separatrix to a saddle-node. Of importance is also Shilnikov's observation that homoclinic loops to a saddle focus are associated with an infinite countable set of periodic orbits. Descriptions based on linearizations contain some aspects of the phenomenon, but not hub cascades. The phenomenon being reported is truly a global one, was not theoretically anticipated and seems to go beyond presently available theoretical knowledge about homoclinic orbits. The author is supported by the CNPq and by the AFOSR, Contract FA9550-07-1-0102.

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Thermal relaxation and low frequency vibrational anomalies in simple models of glasses: a study using non-linear Hamiltonians

Glasses exist because they are not able to relax in a laboratory time scale toward the most stable structure: a crystal. At the same time, glasses present low frequency vibrational modes (LFVM) anomalies. In this talk, we will present the main features of glass transition and how the speed required for thermal relaxation, LFVM and chemical composition are related through rigidity theory. Then we will present a one dimensional model of glass that allows to study in a systematic way how the number of LFVM influences thermal relaxation. The model is a Fermi-Pasta-Ulam chain with non-linear springs that join second neighbors at random. This mimics the adding of bond constraints in the rigidity theory of glasses. The corresponding number of LFVM decreases linearly with the concentration of these springs, and thus their effect upon thermal relaxation can be studied in a systematic way. The results indicate that the time required for thermal relaxation has two contributions: one depends on the number of LFVM and the other on the localization of modes due to disorder. By removing LFVM modes, relaxation is less efficient since the cascade mechanism that transfers energy between modes stops.

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Mutually coupled semiconductor lasers with rotated optical feedback

A single edge-emitting laser subject to polarization-rotated feedback may exhibit stable square-wave oscillations provided the feedback strength is sufficiently large. Rate equations that take into account the two polarization fields and the delayed feedback correctly describe how these square-waves may appear. More recently, we considered two edge-emitting lasers coupled through polarization-rotated optical feedback and found that asymmetric square-wave oscillations were also possible. Numerical simulations using rate equations now for the two lasers reproduce the experimental observations but indicate a competition with stable pure mode regimes. In this presentation, both new experimental and analytical results are described. Experimentally, we have found that either the coupling strength or the pump currents control the square-wave asymmetry. Analytically, we have investigated the stability of the pure mode solutions. Of particular interest is the observation that the stability of the pure mode solutions can be analyzed as two separate injection laser problems without any delay.

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Self-organized criticality in neuronal systems

Self-organized criticality is one of the key concepts to describe the emergence of complexity in natural systems. The concept asserts that a system self-organizes into a critical state where system observables are distributed according to a power law. It has long been speculated that this phenomenon might also show up in neuronal networks, but so far no genuinely neuronal model has been shown to exhibit full self-organized criticality. Here we consider a network of integrate-and-fire neurons with depressive dynamical synapses, i.e. where the synaptic coupling exhibits fatigue under repeated presynaptic firing [1]. We find self-organized critical avalanches and show that in a range of interaction parameters this adaptation mechanism drives the network into a self organized critical regime by adjusting the average coupling strengths to a critical value. We derive an analytic expression for the mean synaptic strengths and the average inter-spike intervals in a mean-field approach. These mean values obey a self-consistency equation which allows us to characterize the self-organization mechanism. Our theory explains recent experimental results, where neuronal avalanches were observed in multi-electrode recordings of cortical slice cultures [2].
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Understanding individual human mobility patterns

Despite their importance for urban planning, traffic forecasting, and the spread of biological and mobile viruses, our understanding of the basic laws governing human motion remains limited thanks to the lack of tools to monitor the time resolved location of individuals. Here we study the trajectory of 100, 000 anonymized mobile phone users whose position is tracked for a six month period. We find that in contrast with the random trajectories predicted by the prevailing Levy flight and random walk models, human trajectories show a high degree of temporal and spatial regularity, each individual being characterized by a time independent characteristic length scale and a significant probability to return to a few highly frequented locations. After correcting for differences in travel distances and the inherent anisotropy of each trajectory, the individual travel patterns collapse into a single spatial probability distribution, indicating that despite the diversity of their travel history, humans follow simple reproducible patterns. This inherent similarity in travel patterns could impact all phenomena driven by human mobility, from epidemic prevention to emergency response, urban planning and agent based modelling.

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Fractal skeletons: the universality in death by starvation

Nature is permeated by phenomena in which active processes, such as chemical reactions and biological interactions, take place in environmental flows. They include the dynamics of growing populations of plankton in the oceans and the evolving distribution of ozone in the polar stratosphere. I will show that if the dynamics of active particles in flows is chaotic, then necessarily the concentration of particles have the observed fractal filamentary structures. These structures, in turn, are the skeletons and the dynamic catalysts of active processes, yielding an unusual singularly enhanced productivity. I will argue that this singular productivity could be the hydrodynamic explanation for the plankton paradox, in which an extremely large number of species are able to coexist, negating the competitive exclusion principle that asserts the survival of only the most perfectly adapted to each limiting resource. By including finite-size effects, I will define a stochastic description supported on the natural measure of the attractor to show that the death kinetics assume a universal behaviour exhibiting a *1/t* decay law in the population, which becomes distributed on a subset characterised by the correlation dimension of the chaotic flow.

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The ring of Brownian motion: Stochastic resonance and ex(e/o)rcising demons with Brownian motors

Noise is usually thought of as the enemy of order rather as a constructive influence. For the phenomena of Stochastic Resonance [1] and Brownian motors [2-6], however, stochastic noise can play a beneficial role in enhancing detection and/or facilitating directed transmission of information in absence of biasing forces. Brownian motion assisted Stochastic Resonance finds useful applications in physical, technological, biological and biomedical contexts [1, 3]. The basic principles that underpin Stochastic Resonance are elucidated and novel applications for nonlinear classical and quantum systems will be addressed. The presence of non-equilibrium disturbances enables to rectify Brownian motion so that quantum and classical objects can be directed around on a priori designed routes in biological and physical systems (Brownian motors). In doing so, the energy from the haphazard motion of (quantum) Brownian particles is extracted to perform useful work against an external load. This very concept together with first experimental realizations are discussed [2, 4 - 6].

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Species clustering in models of biological competition

We study the properties of niche models of biological species competing for a partially shared resource, of the general form of Lotka-Volterra competition equations [1,2]. The intensity of competition depends on the position of species in an abstract niche space. Depending on the shape of the interaction kernel, a pattern-forming instability may occur which leads either to extinction of species too close to a successful one, or to the formation of clusters of similar species periodically spaced from other groups. We estimate properties of the species distributions, such as the steady number of species and their spacing, for different types of interactions. The effects of adding ecological, evolutionary or numerical effects to the basic niche model, as well as the influence of the choice of carrying capacity function is also discussed.

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Nonequilibrium entropy of Markov processes

The Boltzmann's entropy of a continuous Markov process at local thermal equilibrium, in contact with a reservoir at temperature T, is analyzed. Assuming that a stationary equilibrium state exists, it is demonstrated that the total entropy always increases until equilibrium is reached. Assuming detailed balance, an equation for the entropy density is derived, from which it is possible to obtain expressions for the transport coefficients as functions of the diffusion matrix of a Fokker-Planck equation. Known relations among transport coefficients are derived.

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A process of k%-max winner take all mediates tuning orientation on cells of the visual cortex

Classical experiments in orientation selectivity have demonstrated the relationship between membrane potential and ring rate in neurons of the cat visual cortex: the orientation tuning of cortical cells as measured from their action potentials is considerably sharper than the orientation tuning measured directly from the membrane potential. I addition tuning is contrast independent. Our work here shows that this relationship between the different orientations tuning can be reproduced through a network-mediated winner-take-all process we called k%-max WTA. We found that a simple rule (k%-max) describes the selection process: cells fire if they have excitation within k% of the cell that has maximum excitation. This selection process is robust, working over a wide excitation to inhibition ratio.

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Crime and punishment: the economic burden of impunity

Crime is an economically relevant activity. It may represent a mechanism of wealth distribution but also a social and economic burden because of the interference with regular legal activities and the cost of the law enforcement system. Sometimes it may be less costly for the society to allow for some level of criminality. However, a drawback of such a policy is that it may lead to a high increase of criminal activity that may become hard to reduce later on. Here we investigate the level of law enforcement required to keep crime within acceptable limits. A sharp phase transition is observed as a function of the probability of punishment. We also analyze other consequences of criminality as the growth of the economy, the inequality in the wealth distribution (the Gini coefficient) and other relevant quantities under different scenarios of criminal activity and probabilities of apprehension.

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Dynamical systems problems inspired by biology

After briefly surveying studies in complex systems biology [1], I discuss studies the other way around, i.e., studies of dynamical systems inspired by biology instead of biology from dynamical systems. Three topics are discussed. The first issue concerns with reluctance to relaxation to equilibrium. Biological systems, in general, are kept out from falling to equilibrium. Put differently, is there some mechanism so that relaxation to equilibrium is hindered even in a closed physico-chemical system? It is shown that relaxation to equilibrium in catalytic reaction network is often slowed down as in 'glass'. I discuss how kinetic constraint in reaction network generally leads to glassy relaxation behavior, and also mention that ``transient dissipative structure'' works for maintaining non-equilibrium condition [2]. The second issue concerns with a Hamiltonian system with large degrees of freedom coupled globally with each other. In contrast to the naive expectation on equilibrium systems, it is shown that in a Hamiltonian system with global interaction, collective macroscopic oscillation continues over a large time span before relaxing to equilibrium, whose duration increases with the system size. This collective oscillation is explained by a self-consistent 'swing' mechanism [3]. The third issue regards with coupled dynamical systems motivated to understand differentiation from stem cells. Bifurcation induced by interaction is shown to lead to robust cell differentiation as self-consistent dynamics with internal dynamics and interaction. Relevance of Milnor-type attractors as well as dominance of such attractors in high-dimensional dynamical systems is discussed [1,4,5].

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Dynamics on complex networks with time varying topology

Recent research has revealed a rich and complicated network topology in various model systems as well as in several fields of applications. It will be discussed whether this approach can lead to useful new insights into rather large complex systems or whether it is fashionable only to interpret various phenomena from this viewpoint and publish papers on that. On one side, among such studies it has become very popular to look for a scale-free behaviour by showing log-log plots. This reminds the hunting for low dimensional chaos in the 80ies of the last millennium. On the other side, many promising approaches have already lead to useful applications, e.g. immunization problems (spreading of diseases), functioning of biological/physiological processes as protein networks, brain dynamics, colonies of thermites, or functioning of social networks as network of vehicle traffic in a region or air traffic. A challenging task is to understand the implications of such network structures on the functional organization of the brain activities. This is studied here basing on dynamical complex networks. We investigate synchronization dynamics on the cortico-cortical network of the cat by modelling each node (cortical area) of the network with a sub-network of interacting excitable neurons. We find that the network displays clustered synchronization behaviour and the dynamical clusters coincide with the topological community structures observed in the anatomical network. Our results provide insights into the relationship between the global organization and the functional specialization of the brain cortex. This approach of a network of networks seems to be of general importance, especially for spreading of diseases or opinion formation in human societies or socio-economic dynamics. Therefore, we next study a network of networks with time varying topology for modelling epidemic spreading. We find qualitatively different behaviour there in dependence on the changes of the topology.

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Amplitude Equation for stationary convection in viscoelastic ferrofluid

We report theoretical and numerical results on convection for a magnetic fluid with Oldroyd viscoelastic properties. We focus in the stationary convection for idealized boundary conditions. We obtain explicit expressions of convective thresholds in terms of the control parameters of the system. Close to bifurcation the coefficients of the corresponding amplitude equation are analytically determined. The effect of the viscoelasticity and the Kelvin force are emphasized.

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Quantifiers for stochasticity of chaotic pseudo random number generators

The existence or not of truly Random Number Generators (RNG) is an open philosophical issue. It is well known that it is impossible to obtain them from computers. It is also improbable that we will ever be able to get them from "natural" sources, since one assumes that any system is governed by underlying physical rules. Anyway pseudo random number generators (PRNG) have been extensively used in science and technology and for practical applications the critical issue is to ensure that the selected PRNG has good enough statistical properties for the specific problem at hand. The main issue of this talk is the statistical quality evaluation of random number generators based on chaotic systems, used in engineering applications: digital communications, digital filtering, electromagnetic compatibility, etc. A revision of several recent attempts is made, including forbidden patterns, ordering entropies, statistical complexity measures and recurrence plots, etc. Also new results are presented, as well as a detailed discussion concerning what representations planes are able to show the relevant statistical characteristics.

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Collision-less relaxation in non-neutral plasmas and gravitational systems

Since the pioneering works of Boltzmann and Gibbs, systems with long range interactions have been a major stumbling block to the development of statistical mechanics. The difficulty was already well appreciated by Gibbs, who has noted that the equivalence between statistical ensembles breaks down when the interparticle potentials decays with exponents smaller than the dimensionality of the embedding space. When this happens, systems exhibit some very unusual properties which appear to violate the second law of thermodynamics. In this talk a theoretical framework will be presented which allows us to quantitatively predict the final stationary state achieved by two paradigmatic long range interacting systems during the process of collisionless relaxation: the confined non-neutral plasmas [1] and self-gravitating gases. It will be shown that when the initial one particle distribution function satisfies the virial condition, the non-neutral plasmas and the gravitational systems quickly relax to a metastable state described quantitatively by the Lynden-Bell distribution. On the other hand, if the initial distribution function does not meet the virial requirement, systems undergo violent oscillations. The theory presented allows us to quantitatively predict the density and the velocity distributions in the final stationary state. For gravitational systems it also allows us to calculate the amount of mass lost to evaporation. All the results are in excellent agreement with the dynamics simulations.

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Continuous time random walk for open systems: Fluctuation theorems and counting statistics

We consider continuous time random walks for open systems that exchange energy and matter with multiple reservoirs. Each waiting time distribution for times between steps is characterized by a positive parameter α, which is set to $\alpha = 1$ if it decays at least as fast as t^{-2} at long times and therefore has a finite first moment. A waiting time distribution with $\alpha < 1$ decays as $t^{-\alpha-1}$. A fluctuation theorem for the trajectory quantity R, defined as the logarithm of the ratio of the probability of a trajectory and the probability of the time reversed trajectory, holds for any continuous time random walk. However, R can be identified as a trajectory entropy change only if the waiting time distributions have $\alpha = 1$ and satisfy separability. For nonseparable waiting time distributions with $\alpha = 1$, R can only be identified as a trajectory entropy change at long times, and a fluctuation theorem for the entropy change then only holds at long times. For waiting time distributions with
$0 < \alpha < 1$ no meaningful fluctuation theorem can be derived.

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Convergence across the American countries

The aim of this paper is to apply a new method to study the evolution of real per capita GDP and growth rates of the American countries. The method combines the tools of Symbolic Time Series Analysis [1] with the nearest neighbor single linkage clustering algorithm [2]. Data symbolization allows to obtain a metric distance between two di¤erent countries that is used to construct an ultrametric distance. By analyzing the data of our sample, we derive a hierarchical organization, constructing minimal-spanning and hierarchical trees. From these trees we can detect diferent clusters of countries (according to their proximity) that can be interpreted as convergence clubs.

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Dynamical and Statistical Criticality in a Model of Neural Tissue

In order for the nervous system to work at all, a delicate balance of excitation and inhibition must be achieved. However, when such a balance is sought by global strategies, only few modes remain balanced close to instability, and all other modes are strongly stable. Here we present a simple model of neural tissue in which this balance is sought locally by neurons following anti-Hebbian behaviour: all degrees of freedom achieve a close balance of excitation and inhibition and become critical in the dynamical sense. At long timescales, the modes of our model oscillate around the instability line, so an extremely complex breakout dynamics ensues in which different modes of the system acquire prominence and then extinguish.

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Dynamics, control and synchronization in Benard-Marangoni convective patterns

We present firstly a brief survey about patterns that appear in Benard-Marangoni convection in experiments performed at different scales and symmetries. After the first instability, increasing a control parameter like temperature, usually secondary and higher order bifurcations brings those systems to pre-turbulent states exhibiting time dependent patterns. In this work, we will consider in particular those pre-turbulent states related with square symmetries. A discussion about the physical mechanisms driving the instabilities, and some attempts performed to control and synchronize the chaotic dynamics is included. Setting up of a phase synchronized state is a key feature of many high dimensional electronics, physical, biological and ecological systems among others. Formerly we have shown that phase synchronization can be achieved in these kinds of flows. New results on a square symmetry are now included. These symmetries are representative of local situations appearing in many kinds of extended systems with hexagonal-square patterns with local defects or grain frontiers.

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Novel ratchet effects for the motion of elastic interfaces

The propagation of elastic interfaces on multidimensional periodic, quasi-periodic or disordered potentials is a general and relevant problem of current multidisciplinary interest. It provides both, a challenge in statistical physics and soft condensed matter to develop the basic theory and modeling. And for experimentalists a challenge to optimize the basis for applications in a wide number of modern devices. Paradigmatic experimental examples of this problem are magnetic domain walls in ferromagnetic films, ferroelectric domain walls, contact lines of liquids menisci or fractures. A case of particular interest appears when the pinning potential is asymmetric, favoring the propagation of the elastic interface in one direction. This gives rise to several ratchet effects, which are a potential tool to control the motion at micro and nano scales. This system rises basic physical questions which are relevant for technological applications such as the dynamical magnetic response under an applied external field for different pinning geometries. In particular, solving numerically a generic Phi-fourth model in 2D, we study the magnetic wall dynamics on thin films patterned with an asymmetric array of holes under an external magnetic field applied. We observe for first time rectification effects of Néel walls, in excellent agreement with experiments. Moreover a rectification reversal effect induced by the asymmetric kinked wall motion is obtained at low applied magnetic fields. Dependences on the periodic pinning geometry are analyzed. Our simple phenomenological Phi-fourth-model successfully explain the observed phenomena, suggesting that the interplay among the driving force, elasticity and pinning of domain walls is at the root of the observed macroscopic phenomena (PRL 100, 037203, 2008).

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Calcium network dynamics and sperm motility

We show observations of sea urchin sperms swimming in two and three dimensions. Sperms follow circular trajectories in 2-d and spirals in 3-d. In the experiments the addition of SPERACT, which is a polypeptide secreted by the sperm ovulum, produces calcium oscillations which modify the sperm trajectories. Polypeptides of this type may or may not act as chimio attractants. We present discrete and semi-continuous models of a signaling network leading to the calcium oscillations which qualitatively reproduce some experimental results and may contribute to a better understanding of the underlying processes.

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Multiscale characteristics of cell proliferation in the developing central nervous system of chick embryos

The spatial organization of cell proliferation (CP) is studied within the mathematical framework of stochastic point processes. Numerical series were built recording the Euclidean distances between successive proliferating cells along the cephalic-caudal axis of the optic tectum of chick embryos. The main goal of this work is to assess interactions between proliferating cells. The central hypothesis is that, if proliferating cells behave interactively, such interactions should install some kind of dependency or memory on the signals representing the spatial organization of the proliferative activity. This dependency may be revealed by the value of a scaling index. Several algorithms were applied for computing the estimates: Rescaled Range Analysis, Detrended Fluctuation Analysis, Fano Factor, Power Spectral Density, Dispersional Analysis. Although numerical series representative of CP are non-stationary due to the spatial asymmetric distribution of the proliferation process, the values of scaling indexes estimated by several methods correspond to signals possessing stationary correlations. It is known that the non-stationarity may cause this discrepancy; i.e., several authors highlighted that scaling estimator algorithms may give biased results on non-stationary series. Global trends removal is a usual approach to overcome this pitfall. Analyses of detrended CP series allow the detection of anticorrelation immersed in CP original series. The anticorrelation may be interpreted as the existence of local short range inhibiting interactions between proliferating neuroepithelial cells.

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The physics and neural control of birdsong

Behavior emerges as a subtle interaction between a nervous system, a peripheral one, and environment. In this talk I will review some important recent advances in the field of birdsong production. Songbirds are a wonderful animal model to understand the process of learning a complex behavior: vocalization. I will review some interesting phenomena involving the emergence of complex sounds through the interaction of simple neural instructions and the highly nonlinear vocal organ used to vocalize (the syrinx).

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Delayed but still in time: a neural mechanism for zero lag long range synchronization in the brain

Multi-electrode recordings have revealed zero time-lag synchronization among remote cerebral cortical areas. However, the axonal conduction delays among such distant regions can amount to several tens of milliseconds. It is still unclear which mechanism is giving rise to isochronous discharge of widely distributed neurons, despite of such latencies. In this talk we discuss the synchronization properties of a simple network motif and show that, even in the presence of large axonal conduction delays, distant neuronal populations self-organize into lag-free oscillations. According to our results cortico-cortical association fibers as well as certain cortico-thalamo-cortical loops represent ideal circuits to circumvent the phase-shifts and time-lags associated with conduction delays.

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Quasi-long-range order in active nematics and background flux

Physicists have been looking for common, possibly universal, features of the collective motion of animals, bacteria, cells, molecular motors, as well as driven granular objects [1, 2]. Among the emergent properties of these groups of active or self-propelled particles distinctively out-of-equilibrium features have been found, such as the existence of long-range orientational order in two-dimensional ferromagnetic flocks of polar SPPe. Another set of striking intrinsically nonequilibrium properties have recently been predicted by Ramaswamy and co-workers [1]. They considered, in particular, the case of apolar but oriented SPP and argued that such active nematics should differ dramatically from the usual (equilibrium) case. In particular, their approach, based on the analysis of hydrodynamic equations derived from symmetry arguments, predicts that giant density fluctuations arise in the ordered phase of such media. In[1], it is also hinted at the possibility of true long-range order and of a different isotropic-nematic transition out of equilibrium, but no definitive statement is offered. Resolving these issues is nevertheless crucial, especially in view of the predicted giant density fluctuations, and all the more so since, in polar SPP, the transition to true long-range order was shown to be discontinuous A minimal microscopic model is proposed [3] for active nematic particles similar in spirit to the Vicsek model for self-propelled polar particles. In two dimensions, we show that this model exhibits a Kosterlitz-Thouless-like transition to quasi-long-range orientational order and that in this non-equilibrium context, the ordered phase is characterized by giant density fluctuations. Collective behavior of active nematics on a substrate in two dimensions is also discussed.

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Complex network analysis of human electrocorticographic data

Localization of the epileptogenic zone is an important issue in epileptology, even though there is not a unique definition of the epileptic focus. By using complex network analysis of electrocorticographic (ECoG) data we identify three singular areas in the temporal lobe of epileptic patients, the node with highest local synchronization power, the most connected node, and the node with highest interactions load. Connectivity in the data is extracted from the Minimum Spanning Tree (MST) of global correlations. We address the question whether removal of these nodes during the surgery is crucial in the suppression or reduction in the quantity of post-operative seizures. From five ECoG records, local areas with high synchronization power appear to be significantly involved in the development of epileptic seizures. Although the other two areas seem not to be fundamental in the seizures onset and development, they might be part of the seizure cortical spreading. Moreover, the approach proposed shed new light in cortical connectivity patterns in the human temporal lobe. All the analyzed records are during the inter-ictal state.

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Localized coherent structures in the discrete NLS equation

The discrete nonlinear Schrodinger equation is a nonlinear lattice system that arises in many physical systems such as coupled waveguide arrays, Bose-Einstein condesates, biomolecules, etc. We present analytical and numerical results on the existence, and stability of localized coherent structures, especially single- and multi-peak breathers seen near the limit of vanishing intersite coupling.

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Aspects of quantum phase transitions

A unified description of i) classical phase transitions and their remnants in finite systems and ii) quantum phase transitions is here presented. The ensuing discussion relies on the interplay between, on the one hand, the thermodynamic concepts of temperature and specific heat, and, on the other one, the quantal ones of coupling strengths in the Hamiltonian. Our considerations are illustrated by recourse to an exactly solvable model of Plastino and Moszkowski.

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Influence of sedimentation on convective instabilities in colloidal suspensions

Colloidal binary mixtures (compared to molecular ones) are characterized by a slow diffusion and often by a strong Soret effect. Such a combination leads to various specific features for the thermal convection instabilities in those materials. In particular, for experimentally accessible Rayleigh numbers the bifurcation diagram for a Benard-type instability resembles that of an imperfect bifurcation, although it is of the standard forward type, albeit at such a very low Rayleigh number, where the times scales are prohibitively large [1]. The case when the Soret coefficient is negative shows an even richer variety of phenomena [2]. In particular, for heating from below there is a linear oscillatory instability, whose amplitude, however, relaxes to zero on the long turn and is, thus transient only. At higher Rayleigh numbers a finite amplitude stationary instability coexists with the linearly stable convection-free state. By heating from above short-length-scale convective structures occur, whose wavelength depends strongly on the Rayleigh number. Regarding pattern selection, including stationary rolls, square and crossroll patterns [3], essentially the same sequence of stable structures as for molecular liquids is found for positive Soret coefficients. For negative ones neither stable roll nor travelling wave convection is possible. In the case of ferrofluids, the particles are ferromagnetic and strongly influenced by an external magnetic field. For the convective instabilities the action of the Kelvin force and the magnetophoretic effect are important. A striking feature is the enhanced significance of the boundary layer due to the magnetic boundary condition. The bifurcation scenario in terms of the external field as (an additional) control parameter shows an even more pronounced "imperfect" character [4]. In this talk we deal with the influence of sedimentation on the convective instabilities. First, it is shown that a ferrofluid stratified due to earth's gravity is prone to a convective instability in a strong enough magnetic field, even in the absence of a temperature gradient. The stationary convection velocity, however, is rather small and given by the balance of concentration advection and sedimentation [5]. Second, we discuss the influence of sedimentation on thermal convective instabilities of (non-magnetic) colloidal binary systems. For the linear stability analysis different ground states are considered, one with a homogeneous concentration distribution, two with a linear concentration gradient either due to sedimentation alone, or due to sedimentation and thermal diffusion. An oscillatory instability is identified, whose frequency vanishes above a second threshold leading to a stationary one. The nonlinear treatment, both numerical and approximately analytical, reveals non-unique stationary solutions as well as the coexistence between a stationary convective and a convection-free solution. It is shown that in experiments this situation can lead to a hysteretic behavior of the system [6].

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Propagation of calcium waves and synaptic plasticity

Variations in the concentration of intracellular calcium are involved in synaptic plasticity, a modification of synaptic strength thought to be related to learning and memory. The conditioning stimuli that induce synaptic plasticity can produce modifications both on the synapses that are stimulated and on others. In 2000, Nishiyama et al presented experimental evidence that the specificity and polarity of the synaptic changes depend upon the spatiotemporal distribution of the calcium concentration in the postsynaptic neuron. These authors suggested that a calcium propagating signal could explain their findings. In this talk I will describe a mathematical model developed together with Ana Calabrese with which we analyze the conditions under which some of the behaviors described by Nishiyama et al could be elicited. From these results, we conclude that the probability that a calcium wave will propagate depends on the relative buildup velocity of calcium and of a co-agonist of the receptors through which calcium is released from internal stores.

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Consequences of the dynamical properties of the Specific Heat in semi quantum nonlinear Hamiltonians

A generalized phase space, V, endowed with a positive definite metric is defined using the mean values of a set of relevant operators, founded through the Maximum Entropy Principle. The Specific Heat (SH) of a Hamiltonian can be expressed terms of the components of the covariant metric tensor, in terms of the extensive variables (the mean values) as well as in terms of the intensive ones (the Lagrange multipliers). It can be shown that the SH of the system, represented by a given Hamiltonian, is not only a thermodynamical quantity but also a dynamic concept.

In this contribution we analyze the consequences emerging from the dynamical properties of the SH whose value can be varied using Initial Conditions, for the case of semi quantum nonlinear Hamiltonians.

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Lyapunov modes in extended systems

Hydrodynamic Lyapunov modes, which have recently been observed in many extended systems with translational symmetry, such as hard sphere systems, dynamic XY-models, or Lennard-Jones fluids, are nowadays regarded as fundamental objects connecting Nonlinear Dynamics and Statistical Physics. After a short introduction into the concept of Lyapunov modes, the solution to one of the puzzles, the appearance of good and of vague modes, is presented here for the model system of coupled map lattices: The structural properties of these modes are related to the phase space geometry, especially the angles between Oseledec subspaces, and to fluctuations of local Lyapunov exponents [1]. The numerical calculation of these quantities is achieved with the new algorithm proposed in [2]. In this context we report also on the possible appearance of branches in the Lyapunov spectra of inhomogeneous systems [3], similar to acoustic and optical branches for phonons.

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Chaos and nonergodic dynamics in long-range interacting systems

Chaoticity and nonergodic dynamics of the Hamiltonian Mean Field and Kuramoto model will be discussed in detail, addressing similarities and differences between the two models. The possible application of the qgeneralized Central Limit Theorem [1] in the metastable nonergodic regime of the models will also be discussed [2–5].

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Complexity of the wind tree model

The wind tree model was presented by Paul and Tatiana Ehrenfest as a simple tool to discuss the time reversal and ireversibility paradoxes (english translation in M. J. Moravcsik, The Conceptual Foundations of the Statistical Approach in Mechanics, Ithaca N. Y., Cornell University Press, 1959.) We discuss some aspects of this model as regards microscopic chaos and local complexity.

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Time Delays in the synchronization of chaotic systems

Coupled chaotic systems may present isochronous, time delayed or time advanced synchronized dynamics. Using two optically coupled semiconductor lasers we experimentally and theoretically investigated the stability conditions for chaos synchronization, measuring and calculating the lead-lagging time between chaotic low frequency fluctuations on the power output of the two lasers. Each laser had chaos due to feedback with a fixed delay time. The optical coupling signal had a second, independent, characteristic time. The stability condition for isochronous, time leading or time lagging chaos synchronism is shown to depend on the relation between the individual feedback time and the inter-units coupling time. An intermittent time leadership exchange is also characterized for symmetrically coupled identical lasers. The theoretical model corresponds to a set of equations for two mono mode lasers with feedback and including optical coupling. Numerical solutions show the robustness of the synchronization conditions with respect to small incertitude on the lasers parameters, consistent with the experimental observations.

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Traffic jams in the cell: lost in translation

The "central dogma" in cell biology is that the genetic information coded in the DNA is first transcribed to messenger RNA (mRNA) molecules and then translated into proteins. We focus on the process of translation, i.e., how "molecular machines" called ribosomes translate the messenger RNA molecules into proteins that can be utilized by the cell for a huge variety of different processes. In order to model the process of translation, we propose a simple stochastic model based on the totally asymmetric exclusion process. We focus on the role that different distributions of nucleotides, i.e., different mRNA sequences, play in the maximal flow or production rate of proteins that can be achieved. We then relate the rich dynamical behaviour generated by the model to the different biological functions of the computed proteins.

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Physics of colloids: from collective assemblies to single swimmers

Two different aspects of the physics of driven colloidal particles will be discussed. In the first part I will report on the collective organization of paramagnetic particles placed above the periodic stripes of a uniaxial magnetic film. An external field modulation induces vibration of the stripe walls and produces random motion of the particles. Defects in the stripe patterns favour particle nucleation into large clusters above a critical density. Mismatch between particle size and pattern wavelength generates assemblies with different morphological order. At even higher field strengths, repulsive dipolar interactions between the particles induce cluster melting. In the second part I will show how anisotropic paramagnetic colloidal particles dispersed in water and floating above a flat plate can be endowed with controlled propulsion when subjected to an horizontal precessing magnetic field. During cycling motion, stronger viscous friction at the bounding plate, as compared to fluid resistance in the bulk, creates an asymmetry in dissipation that rectifies rotation into a net translation of the suspended objects. We combine a report of experimental observations with a theoretical analysis that fully characterizes the swimming velocity in terms of the relative strength and frequency of the actuating magnetic field.

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Rayleigh-Plateau instability produced with gravity oscillation

This paper studies the formation of droplets in a Faraday experiment. In this system, a layer of liquid is subjected to a vertical vibration. The parameters of control are the acceleration (in units of g) and the frequency. The fluid transition from gravitational to capillary waves appears at a frequency within 16 Hz. So in the range studied (50 to 200 Hz), where the mechanism of formation of surface waves is dominated by capillary forces, a fingered structure appears and leads to droplet ejection when the threshold value of the control parameters is exceeded. In low viscosity fluids, threshold value doesn't depend on itself but on the surface tension instead. Moreover, this predominance of the surface tension takes part in the instability that gives rise to the droplet ejection. The behavior of the system shows a convective Rayleigh instability where the ratio of the surface energy to the kinetic energy per unit length is small and the perturbation can only be propagated and amplified in the downstream direction. A viscoelastic polymer was added to the base fluid, producing a slight modification of the surface tension and showing that the fundamental aspects of the ejection mechanism were not altered.

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Dynamics of the Volatility Distributions on Complex Networks

We perform a computer simulation study for the volatility within the context of multi-agent dynamics in financial markets. We consider the USDF model of price formation on complex networks and introduce the parameter pF for the fraction of fundamentalists agents present in the system. The results reproduce some of the stylized facts of financial time series. By varying the concentration of fundamentalists in the interval [0.10:0.90], the average volatility shows a linear dependence with this parameter in the region where there is not a percolative cluster of fundamentalist agents, while in the region where the percolative cluster exists one has a power-law dependence on the concentration. We also consider DFA statistics to obtain the Hust exponents of volatility series for different values of pF and conclude that they are persistent in all cases. Moreover, the corresponding spectra of H show multifractality in the regions with $pF<0.5$ and $pF>0.60$, whereas one has a typical fractal behavior in the regime $0.50<pF<0.60$. From the simulation we estimate $D=1.4$ for the fractal dimension of the financial market.

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Nonlinear Voter Models: The Transition from Invasion to Coexistence

In nonlinear voter models (NVM) the transitions between two states (-1,+1) depend in a nonlinear manner on the frequencies of these states in the neighborhood. We investigate the role of these nonlinearities on the global outcome of the dynamics for different types of networks. Particular emphasis is given to a NVM with a memory-dependent transition rate [1], where the transition of a state into the opposite state decreases with the time it has been in its current state. Counter-intuitively, we find that the time to reach a macroscopically ordered state can be accelerated by slowing-down the microscopic dynamics in this way. This holds for different network topologies, including fully-connected ones. For two-dimensional regular networks, we investigate the role of nonlinearities by determining a phase diagram in the parameter space that distinguishes between different dynamic regimes [2]. A pair approximation allows us to identify three regimes for NVM: (i) complete invasion, (ii) random

coexistence, and -- most interestingly -- (iii) correlated coexistence. These findings are contrasted with predictions from the mean-field phase diagram and are confirmed by extensive computer simulations of the microscopic dynamics.

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Pattern formation and complex dynamics in driven magnetic granular ensemble

A fundamental issue in the study of far-from-equilibrium complex systems is how collective ordering arises from the dynamics of discrete interacting components. Recently, remarkable nontrivially ordered dynamic self-assembled structures ("magnetic snakes") has been discovered in the ensemble of magnetic microparticles suspended on the liquid/air interface and energized by an alternating magnetic field in a certain range of excitation parameters. These structures emerge as a result of the competition between magnetic and hydrodynamic forces. Strong induced vortex flows on the surface of the liquid finalize the rich hydrodynamic picture of the magnetic snake. Self-assembled snakes have a complex magnetic ordering. The segments of the snake exhibit long-range antiferromagnetic ordering mediated by the surface waves, while each segment is composed of ferromagnetically aligned chains of microparticles. The structure has the ability to exhibit self-propulsion due to magnetically actuated instability regimes spontaneously breaking the symmetry of the surface flows in the vicinity of the structure. Instability of the dynamic structures with respect to self-generated surface flows in the liquid will be demonstrated (self-assembled magnetic swimmers). The mechanism of the pattern formation, self-propulsion and nontrivial magnetic properties of the generated dynamic self-organized patterns will be discussed.

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Lessons from a mathematical model for the big Yellow Fever epidemic (Buenos Aires, 1871)

We will review the steps taken for the construction of an epidemic model for diseases vectorized by the mosquito *Aedes aegypti*. The supporting mathematical structure is a density-dependent Poisson process and the advantages over ordinary differential equations will be highlighted (the disadvantages are rather obvious). The construction of the model goes through different stages and whenever possible, comparison with field and laboratory results is performed. The last check is produced with the mortality statistics of the Yellow Fever epidemic outbreak in Buenos Aires, 1871. The comparison with field data presented many encouraging agreements and a few, but important, disagreements. Further inquiry on the disagreements has revealed biological and epidemiological mechanisms that have not been accounted for previously (and then, not build into the original model) and that are being confirmed by biological and epidemic data. Biological mechanisms previously not considered by biologists and medical doctors, such as: regulatory effect of larvae competition for food, random egg hatching, egg and adult diapause in *Aedes aegypti*, and the contributions of public policies to the epidemic development in 1871 are some of the aspects highlighted by the consistency requirements imposed by mathematical modeling.

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Multiple scales in calcium signals

The hierarchical organization of living organisms at all levels, from single cells to the brain, has its counterpart at the level of cell signals. Moreover, cells themselves are very complex objects that integrate a broad spectrum of phenomena. This is why there is a large diversity of possible strategies to understand signaling mechanisms at the cellular level, each focusing on a particular phenomena or spatio-temporal scale. In this talk, I will focus on intracellular calcium signaling. The importance of these signals is that the calcium ion is involved in a variety of signaling pathways associated to such diverse phenomena as fertilization, cell death or neuronal communication. For this reason, calcium is said to be a universal messenger whose spatio-temporal distribution determines the subsequent cell's behavior. I will show how we combine experiments with mathematical modeling to build a complete description of intracellular calcium signals. In particular, an original analysis of experimental observations gives us quantitative information on the properties of the calcium release and a model we developed opens the way to simulate this system on experimentally relevant time scales and despite large intracellular gradients.

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Generalized continuous and discrete population dynamics models

A particular one-parameter generalization of the logarithm (and its inverse) function is suitable to unify most of the popular population dynamics models into simple formulae. A physical interpretation is given to this new introduced parameter in the context of the continuous Richards model. From the discretization of the continuous Richards' model (generalization of the Gompertz and Verhuslt models), one obtains a generalized logistic map and we briefly study its properties. We generalize the (scramble competion) theta-Ricker discrete model. In contrast to previous generalizations, from the generalized theta-Ricker model one is able to retrieve either scramble or contest models.

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Synchronization transitions and multistability in the route to oscillation death of coupled nonlinear oscillators

We describe transitions in synchronization states in the route to oscillation death (OD) for different coupled nonlinear oscillators by varying the coupling strength of the system. Moreover, we show that by slightly modifying the type of coupling and the oscillators' nonlinearity, there arises multistability in the system. Complex chaotic or quasi-periodic motion, intermingled with 1:1 and general m:n phase-locked stable limit cycles, coexist in the phase space for the same set of parameters. We describe how a hierarchy of bifurcation phenomena, along with the complex interplay among the coexisting stable structures, eventually lead to their annihilation, remaining only stable fixed points as global attractors of the dynamical system. This systematic investigation allowed us to conclude that a necessary condition for the onset of OD, in all the systems studied, is the presence of 1:1 locking. Therefore we can generalize by stating that if a given coupled system is unable to show 1:1 synchronization, it will never stop oscillating, as long as only the coupling strength is varied.

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Spontaneous symmetry breaking and first-order phase transitions of adsorbed fluids

A density functional formalism is applied to investigate the wetting behavior of fluid Ne adsorbed on planar substrates or confined in a slit composed of two parallel solid identical walls. The selected substrates are alkalies (Cs, Rb, K, Na, Li, and Mg) which exhibit increasing attractive strength leading to a variety of wetting situations. The study is performed over the complete range of temperatures spanned from the triple point T_t up to the critical one T_c of the fluid. For this purpose, an effective attractive pair potential for the fluid-fluid interaction was built on the basis of a separation procedure. This approach yields a good description of properties of the liquid-vapor interface at coexistence in the whole range of temperatures of interest. Accurate *ab initio* adsorption potentials were utilized. Wetting temperatures, first-order phase transitions and the related prewetting phenomenon are studied and compared with other microscopic calculations and experimental data. It is important to emphasize that in the slit geometry we found for the less attractive surfaces that the fundamental states exhibit asymmetric density profiles. This is the first realization of spontaneous symmetry breaking for the case of realistic representations of the fluid-substrate interactions. This effect is analyzed as a function of temperature, slit's width, and coverage.

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The storage capacity of a bidimensional Hopfield neural network with complex topology

In this work we analyze numerically the storage capacity of a Hopfield neural network defined on a complex scale-free network embedded in a two-dimensional square lattice. Until now, most of the effort in trying to model neural systems has been directed towards the use of mean-field-like arquitectures, mainly because regular low dimensional lattices had shown to be very limited in order to provide the network with a reasonable retrieval performance. We first analyze the topology of the emerging architecture and then study the retrieval capacity. Surprisingly, this network does not seem to present a retrieval-non-retrieval transition, as in fact occurs with the original Hopfield model. We compare our results with other previously obtained in literature and show that this bidimensional network improves most of the previous results.

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Cavity soliton laser based on mutually coupled semiconductor microresonators

We report on experimental observation of localized structures in two mutually coupled broad-area semiconductor resonators, one of which acts as a saturable absorber. These structures coexist with a dark homogeneous background and they have the same properties as cavity solitons without requiring the presence of a driving beam into the system. They can be switched individually on and off by means of a local addressing beam.

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Block copolymer pattern alignment induced by substrate topography

We study the kinetics of ordering of a cylinder forming block copolymer thin film confined to lie on a sinusoidal substrate. The process of ordering of a 30nm thick thin film is analyzed trough atomic force microscopy in the tapping mode. We found that the extrinsic curvature plays an important role in the mechanism of evolution towards equilibrium. The anisotropic motion of disclinations leads to the alignment of the block copolymer cylinders in the direction perpendicular to substrate topography.

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Auditory neuronal networks in sleep and wakefulness

Sensory information about the environment and the body continuously modulates central nervous system (CNS) activity during the sleep/wakefulness cycle. Although profoundly modified, the processing of sensory information is still present during sleep. On the other hand, sleep is a distinct physiological state in which the brain and the body show major changes of most physiological parameters. The brain is a different one, i.e., its network has changed from a waking mode into a sleeping mode. Every sensory system presents an efferent pathway with centrifugal fibers reaching its own receptors and nuclei of the afferent pathway, introducing a base for reciprocal interaction between the sensory input and the CNS state. Although we do not completely understand how the brain processes sensory information, it is currently accepted that neuronal networks can change depending on the information they receive. Neuronal assembly is a concept defined by the temporally correlated neuronal firing associated to some functional end. The most likely information coding is the ensemble coding by cell assemblies. Neuronal groups connected with several other neurons or groups can introduce cooperation and integration among widely distributed cells even with different functional properties to sub-serve a new state or condition. A neuron firing in a functional associated group may process some information and, some time later may become associated to other competing and activated neuronal groups for different functional purposes, e.g., on passing from wakefulness to sleep.

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Spatiotemporal patterns of activity in cerebral neural networks: a dynamical systems perspective

The simultaneous recording of the time series formed by the timing of neuronal discharges produced by a cell assembly reveals important features of the dynamic of information processing in the brain. Experimental evidence of firing sequences with precision of few milliseconds over intervals lasting hundreds of milliseconds have suggested that particular topologies of converging/diverging chains of neuronal assemblies may propagate the activity with the necessary time accuracy. Simulation studies of critical phases of brain development suggest the emergence of stimulus-driven cell assemblies that will form the 'wiring' of the adult brain out of randomly connected large scale networks. These results are presented from the viewpoint of dynamical systems and chaotic attractors.

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Non-perturbative renormalization group approach to out-of-equilibrium problems

The recent renaissance of renormalization-group (RG) studies (under the vocables exact RG, or non-perturbative RG) offers an unprecedented opportunity for analytical approaches of difficult out-of-equilibrium many body problems such as phase transitions in reaction-diffusion systems with absorbing states, or dynamical scaling in universal models such as the Kardar-Parisi-Zhang (KPZ) equation.

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Beyond networks: opinion formation in triplet-based social structures

The dynamics of social processes driven by the interaction of groups of agents may sensibly differ from those of populations whose members interact pair-wise, as represented by social networks. We propose a generalization of interaction patterns, where the role of a network's binary links is played by groups of agents. Differences in the collective dynamics of networks and group-based interaction patterns are illustrated by means of a model process of opinion formation in a population where agents are arranged forming triplets. They can be ascribed to the detailed structural connectivity of both types of patterns.

POSTERS

(Alphabetic Order)

1. **Jose Manuel Albornoz**, Postgrado en Física Fundamental, Universidad de los Andes, Venezuela
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A metabolic network simulation tool based on a discrete enzyme model

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RNA viruses: Quasispecies point of view

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Characterization of the dynamics of the heart rate prior to paroxysmal arrhythmias events type atrial fibrillation and ventricular tachycardia

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Soft wall effects on interacting particles in billiards

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One-dimensional Prisoner Dilemma: exhaustive exploration of parameter space for Darwinian and Pavlovian Evolutionary Strategies

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Hebbian plasticity and subharmonic locking

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First-order nonequilibrium phase transitions in an excitable lattice model

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A nonlinear model for sensorimotor synchronization

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Dynamic behavior of a Social Impact model for opinion formation

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Epidemics in the marriage problem

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Multidimensional Minimal Spanning Tree: The Dow Jones Case

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Superdiffusive intracellular actin-based transport of organelles mediated by molecular motors

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Swirling turbulent fountains in stratified media

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Scaling analysis and modeling of stride time in human gait

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Applications of non extensive q-Wavelets in the estimation of pathological t-wave alternans in human ECG by means of multifractal spectra

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Analysis of Australian stream flow rivers using quantifiers based on Information Theory

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A mathematical model for a freshwater ecosystem: the effect of environmental fluctuations

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Dissipation as a mechanism of energy gain

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Clustering transcriptional profiles into biological sensible groups

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Realistic Models for the study of the breather stability and the phase transitions in Klein-Gordon systems

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A layer model for intermittent turbulence in nocturnal stable atmospheric boundary layer

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Andreev reflection through a ferromagnetic metal - double quantum dot - superconductor syste

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Traveling Waves and Breader Solutions for the Complex Ginzburg-Landau Equation

24. **Mara Dávila**, Instituto de Física Aplicada, Universidad Nacional de San Luis, CONICET, Argentina
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Fractional statistical theory and use of quasi-chemical approximation for adsorption of interacting k-mers

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Anomalous diffusion in a trapping potential: mean square displacement and velocity autocorrelation function

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Analytical and computational model for quasispecies

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Time-frequency analysis combining wavelet packets and intrinsic mode functions

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Spatial models for catastrophic shifts in ecosystems

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Quenched disorder in epidemic processes

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Quantitative link between democratic motions and Adam-Gibbs theory in glassy relaxation

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Directional mode switching in semiconductor ring lasers: deterministic and stochastic effects

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The onset of Faraday waves at liquid/liquid interface containing an insoluble surfactant

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Event-driven simulations of grains in an electric field

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Relaxational dynamics of smectic pattern formation on a curved substrate

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Epidemic Scenarios in a Real Social Network

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Determination of the Polarizations Properties of Platinum Black Electrodes in Contact with Different Concentrations of Colloidal Suspensions of Polystyrene Particles

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Transition from pulses to fronts in the cubic quintic complex Ginzburg-Landau equation

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Steady-state molecular dynamics simulation of supersaturated vapor near the spinodal line

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Propagation analysis of noise-supported transmission

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One dimensional correlated Brownian motion: on characterizing red blood cells deformability

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Effects of epidemic threshold definition on disease spread statistics

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Dynamical behaviour of a ferromagnetic chain in a time dependent magnetic field

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Breaking down the Fermi acceleration with inelastic collisions

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Network analysis of exchange data: Interdependence drives crisis contagion

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Critical behavior of long linear k-mers on two-dimensional lattices

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A perturbative system for time series forecasting problem

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Dynamical properties of an Elliptical-Oval Billiard

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Effects of epidemic threshold definition on disease spread statistics

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Dynamics and synchronization of integrated sources for chaos based communications

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Characterizing synchronization in time series using information measures extracted from symbolic representations

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Strength through structure: visualization and local assessment of the trabecular bone structure

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Evaluating the significance of spike correlations in the neural code by means of analytically solvable models and of Information Theoretical Analysis

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Dynamics of Bernoulli maps on complex networks: exact results and simulations

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Atmospheric boundary layer instability and small scale intermittency

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