XIII Latin American Workshop on Nonlinear Phenomena

(LAWNP 2013)

Abstracts Book

Córdoba, October 2013

Contents

Plenary Talks

1.1. Active matter and granular systems

1.1.1. Presenting Author: Ernesto Altshuler

Extraterrestrial sink dynamics in granular matter

E. Altshuler[1], H. Torres[1], A. González-Pita[1], G. Sánchez-Colina[1], C. Pérez-Penichet[1], S.Waitukaitis[2], and R. C. Hidalgo[3]

[1] *Henri Poincaré* Group of Complex Systems and Superconductivity Laboratory, Physics Faculty- IMRE, University of Havana, 10400 Havana, Cuba

[2] The James Franck Institute and the Department of Physics, The University of Chicago, Chicago IL, U.S.A.

[3] Department of Physics and Applied Mathematics, University of Navarra, Pamplona, Spain

A loosely packed bed of sand sits precariously on the fence between mechanically stable and flowing states. This has especially strong implications for the exploration and development of extraterrestrial settings, such as planets or asteroids, whose geomorphology is predominantly granular owing to planetary formation processes and erosion. While the penetration dynamics of objects shot or sinking into granular media under Earth-like conditions is well-studied, there is no fundamental understanding of how the dynamics change in effective gravities, g_{eff} , different than that of Earth ($g = 9.8\ \mathrm{m/s^2}$). Here we describe the first systematic experiments of the sink dynamics of objects into granular media in different gravitational conditions. By conducting experiments in an accelerating frame, we explore g_{eff} ranging from $0.4g$ to $1.2g$. With the aid of discrete element modeling simulations, we reproduce these results and extend this range to include objects as small as asteroids and as large as Jupiter. We find that the final sink depth is independent of g_{eff}, an observation with immediate relevance to the design of future extraterrestrial structures and land-roving spacecraft. We explain the results quantitatively with phenomenological equation of motion that includes gravity-loaded friction.

1.2. Complex networks

1.2.1. Presenting Author: José Soares de Andrade Junior

Optimal transport and synchronization of complex networks

José Soares de Andrade Junior

Departamento de Física, Universidad Federal de Ceará, Fortaleza - Ceará, Brazil

What is the best way to add shortcuts to a transport system? Typically transport in disordered systems is dominated by a few channels. In fact, the concept of optimal path through a complex geometry plays an important role in physics, ranging from Laplacian flow to navigation. In the first part of the talk, we propose strategies for the optimal design of complex transport networks. Our network is built from a regular two-dimensional ($d = 2$) square lattice to be improved by adding long-range connections (shortcuts) with probability $P_{ij} \sim r_{ij}^{-\alpha}$, where r_{ij} is the Euclidean distance between sites i and j, and α is a variable exponent. We then introduce a cost constraint on the total length of the additional links and find optimal transport in the system for $\alpha = d + 1$. Remarkably, this condition remains optimal, regardless of the strategy used for navigation, being based on local or global knowledge of the network structure, in sharp contrast with results previously obtained for unconstrained navigation using global or local information, where the optimal conditions are $\alpha = 0$ and $\alpha = d$, respectively. In the second part of the talk, we start by introducing the concept of bearings. These are mechanical dissipative systems that, when perturbed, relax toward a synchronized (bearing) state. We then show that such structures can be perceived as physical realizations of complex networks of oscillators with asymmetrically weighted couplings. Accordingly, these networks can exhibit optimal synchronization properties through fine tuning of the local interaction strength as a function of node degree. In analogy, the synchronizability of bearings can be maximized by counterbalancing the number of contacts and the inertia of their constituting rotor disks through the mass-radius relation, $m \sim r^{\beta}$, with an optimal exponent $\beta = \beta_{\times}$ which converges to unity for a large number of rotors. Under this condition, and regardless of the presence of a long-tailed distribution of disk radii, our results show that the energy dissipation rate is homogeneously distributed among elementary rotors.

1.2.2. Presenting Author: Jürgen Kurths

How basin stability complements the linear-stability paradigm

J. Kurths[1,2,3], P. Menck[1,2], J. Heitzig[1], and N. Marwan[1]

[1]Research Domain on Transdisciplinary Concepts and Methods, Potsdam Institute for Climate Impact Research, PO Box 60 12 03, 14412 Potsdam, Germany

[2]Department of Physics, Humboldt University of Berlin, Newtonstraße 15, 12489 Berlin, Germany

[3]Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Aberdeen AB24 3UE, UK

The human brain, power grids, arrays of coupled lasers and the Amazon rainforest are all characterized by multistability. The likelihood that these systems will remain in the most desirable of their many stable states depends on their stability against significant perturbations, particularly in a state space populated by undesirable states. Here we claim that the traditional linearization-based approach to stability is too local to adequately assess how stable a state is. Instead, we quantify it in terms of basin stability, a new measure related to the volume of the basin of attraction. Basin stability is non-local, nonlinear and easily applicable, even to high-dimensional systems. It provides a long-sought-after explanation for the surprisingly regular topologies of neural networks and power grids, which have eluded theoretical description based solely on linear stability. We anticipate that basin stability will provide a powerful tool for complex systems studies, including the assessment of multistable climatic tipping elements.

1.3. Complex system dynamics

1.3.1. Presenting Author: Thierry Giamarchi

Pinning and non-linear phenomena

Thierry Giamarchi
University of Geneva

Many different physical systems undergo the phenomenon of pinning on an external potential. This is for example the case for domain walls in a magnetic or ferroelectric structure, which can pin either on a periodic potential or on external impurities.

This pinning leads to an extremely non-linear response to the application of an external force. I will review the recent on this subject to understand the various phenomena controlling this non-linear response, in particular for the velocity-force characteristics but also for the shape of the object.

One situation of special interest is when such systems have internal degrees of freedom. In that case the pinning can lead to bistable regimes for low forces, or even a succession of bistable transitions corresponding to different topological modes of the system evolution.

I will review this physics and its principal ingredients and discuss the recent results in this domain in connection with experiments performed on magnetic, ferroelectric or spintronic systems.

The recent works presented in this talk have been done in collaboration with: E. Agoritsas, S.E. Barnes, S. Bustingorry, J.P. Eckmann, A. Kolton, and V. Lecomte.

1.4. Non-equilibrium and fluctuation phenomena

1.4.1. Presenting Author: Jorge Kurchan

The evolution of a population with natural selection and glassy dynamics.

Jorge Kurchan

Laboratoire de Physique Statistique, Ecole Normale Superieure Paris, France

We have considered a system of individuals that may be in many metastable states, each with different lifetimes and different fitness properties, as defined by the number of children made per unit time. We show that under very mild assumptions, such a population exhibits a glass transition induced by selection. Thus, the population 'ages', in the sense that one may perform simple experiments to determine the time elapsed after the system was prepared, even if individuals are themselves not modified – exactly what happens with glassy systems. This problem has a surprising relation to the theory of large deviations.

1.5. Nonlinearities in social and biological systems

1.5.1. Presenting Author: Mogens Høgh Jensen

Vorticity Patterns in Tissues induced by Cell Divisions

Mogens Høgh Jensen

The Niels Bohr Institute, University of Copenhagen

In healthy blood vessels with a laminar blood flow, the endothelial cell division rate is low, only sufficient to replace apoptotic cells. The division rate significantly increases during embryonic development and under halted or turbulent flow. We study the long-range dynamics induced by cell division in an endothelial monolayer under non-flow conditions, mimicking the conditions during vessel formation or around blood clots [1]. Cell divisions induce long-range, well-ordered vortex patterns extending several cell diameters away from the division site, in spite of the system's low Reynolds number. We model these observations by a hydrodynamic continuum model simulating division as a local pressure increase in a non-nematic, meso-scale turbulent state [1]. In order to describe the injected energy by cell motion in the tissue we assume a negative local viscosity stabilized by a higher order term. We find a vorticity pattern very similar to the experimental observations with a similar order and periodicity of the patterns.

References

[1] N.S. Rossen, J.M. Tarp, J. Mathiesen, M.H. Jensen and L.B. Oddershede, Nature Physics, under review (2013)

1.5.2. Presenting Author: Andrea Cavagna

Superfluid transport of information in flocks of starlings

Andrea Cavagna

Institute for Complex Systems, National Research Council, Rome

Collective decision-making in biological systems requires all individuals in the group to go through a behavioural change of state. During this transition, efficient transport of information is crucial to prevent cohesion loss and preserve robustness. The precise mechanism by which living groups achieve such efficiency, though, is not fully understood. In my talk I will present an experimental study of starling flocks performing collective turns in the field. We find that the information to change direction propagates across the flock linearly in time with negligible attenuation, hence keeping group decoherence to a minimum. This result is not explained by current theoretical models of collective motion. We develop a new theory whose cornerstone is the existence of a conserved spin current generated by the gauge symmetry of the system. The theory turns out to be mathematically identical to that of superfluid flow in liquid helium and it explains the dissipationless propagating mode observed in turning flocks. The superfluid equations also provide a quantitative expression for the speed of propagation of the information, according to which transport must be swifter the stronger the group's orientational order. We check this theoretical prediction and find it to be verified by the data. We argue that the superfluid link between strong order and efficient decision-making is the adaptive drive for the high degree of behavioural polarization observed in many living groups. The mathematical equivalence between flocking and superfluidity is a compelling demonstration of the far-reaching consequences of symmetry and conservation laws across the most diverse natural systems.

1.6. Other nonlinear phenomena

1.6.1. Presenting Author: Hans Jürgen Herrmann

Packing of wires in cavities and growing surfaces

Hans J. Herrmann, N. Stoop, R. Vetter, and M. F. Wittel

ETH Zürich, Switzerland and UFC, Fortaleza, Brazil

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

1.6.2. Presenting Author: Giulio Casati

Coupled particle and heat transport: a dynamical system's perspective

Giulio Casati

Center for Complex Systems, University of Insubria, Como, Italy

The understanding of coupled particles and heat transport in complex systems is a fundamental problem, also of practical interest in connection with the challenging task of developing high-performance thermoelectric materials. Here we discuss how the combined effect of nonlinearity and symmetry breaking can lead to important consequences such as the possibility to control the heat current or wave propagation in nonlinear media. We will then discuss thermoelectric

transport phenomena from the perspective of dynamical nonlinear systems, focusing on stylized classical and quantum models, including the disordered hard-point gas.

References

[1] G. Casati, C. Mejia Monasterio, and T. Prosen: "Increasing thermoelectric efficiency towards the Carnot limit" Phys. Rev. Lett. **101**, 016601 (2008).

[2] G. Benenti, K. Saito and G. Casati, "Thermodynamic Bounds on efficiency for Systems with Broken Time-reversal Symmetry" . Phys. Rev. Lett. **106**, 230602 (2011).

[3] S.Lepri and G. Casati, ”Asymmetric wave propagation in Nonlinear systems”. Phys. Rev. Lett. **106**, 164101 (2011).

[4] G. Benenti, G. Casati and Jiao Wang ”Conservation laws and thermodynamic efficiencies” Phys. Rev. Lett. **110**, 070604 (2013)

1.7. Soft matter

1.7.1. Presenting Author: Paul Chaikin

Title not yet available

Paul Chaikin

New York University, New York, USA

Abstract not yet available....

1.7.2. Presenting Author: Cristian F. Moukarzel

Structural Rigidity Applications in Physics

Cristian F. Moukarzel

Appl. Phys. Dept. CINVESTAV Merida, Merida, Yucatan, Mexico

Graph Rigidity deals with the topological conditions for the propagation of vectorial information on a network whose links only partially transmit information. An example is the propagation of forces on structures made of rigid elements connected by rotatable bars. A bar joining two rigid elements still allows certain relative motions of these while forbidding others. The positional information transmitted by a bar is thus partial. The conditions under which such structures are able to transmit displacements or forces are nontrivial, but often can be reduced to statements about the topology of the underlying graph or multigraph representing the structure.

Graph Rigidity generalizes Graph Connectivity, obtained when links transmit complete information, as for example when rigid elements are welded to each other. Any motion of an element is thus fully transmitted to connected neighbors. Displacement or force transmission then follow from the existence of a connected path. Many physical phenomena are dictated by connectivity, and their study has been linked to the development of Percolation Theory.

Many physical phenomena instead depend on rigidity properties, and we will review some of them in this talk. A well known case is of course the studry of mechanical properties in composite or diluted systems. But there are less obvious examples in which rigidity concepts play a key role, as for example in relation with several aspects of glass physics.

Of particular interest are certain systems that self-organize onto minimally rigid, or isostatic, structures, thus giving rise to solids with unusual static and dynamic properties.

Invited Talks

2.1. Active matter and granular systems

2.1.1. Presenting Author: Irene Ippolito

Segregation by flow in quasi 2D piles

D. Rodríguez[1], J. Benito[2], I. Ippolito[1], J-P. Hulin[3], A. M. Vidales[2], and R. Uñac[2]

[1] Grupo de Medios Porosos y CONICET, Facultad de Ingeniería, Universidad de Buenos Aires, C. A. de Buenos Aires, Argentina.

[2] INFAP-CONICET, Departamento de Física, Facultad de Ciencias Físico Matemáticas y Naturales, Universidad Nacional de San Luis, San Luis, Argentina.

[3] Laboratoire Fluides Automatiques et Systemes Termiques, U. de Paris Sud, Orsay France.

Stratification, mixing and layering processes have been studied during the build-up of quasi-2D piles from two different mixtures of grains of different diameters (1mm glass beads and 3mm glass beads or coriander seeds). The domains of existence of the different flow regimes obtained for the two sets of beads as a function of the relative volume flow rates of the two species and of the fall heights have been compared and the influence of the flow regimes on the time dependence of the mean slope of the pile has been studied. The experiments, show in particular, that segregation may be complete when the larger grains are coriander seeds while some amount of mixing is always observed for glass beads, even though the ratio between the sizes of the particles is the same in both cases. The layering regime could be observed using glass beads of same spherical geometry and density but with two different diameters: it is is characterized by the large amplitude of the variations of the slope of the pile. No layering is observed when coriander seeds of same size replace glass beads as the large particles. The local processes involved in these regimes have been analyzed quantitatively : the characteristic velocities of the different types of displacements of the grains have in particular been determined from spatiotemporal diagrams of the variation with time of the profile of the free surface. Avalanches were only observed in the layering regime and play an important part in the development of the layers.

2.1.2. Presenting Author: Luis A. Pugnaloni

Nonlinear origins of universal responses in granular matter

Luis A. Pugnaloni[1,2]

[1]Dpto. Ingeniería Mecánica, Facultad Regional La Plata, Universidad Tecnológica Nacional, Av. 60 esq. 124, 1900 La Plata, Argentina.

[2]Consejo Nacional de Investigaciones Científicas y Técnicas

Despite the complex phenomenology of granular matter, there exist a number of conditions (of uppermost relevance in basic research and industrial applications) where the response of the system is insensitive to details of the grain–grain interactions. We will discuss two examples: (i) the flow rate of granular matter during silo discharge, and (ii) the frequency response function of a mechanical oscillator attached to a granular damper. These two observables follow “universal” scalings, under conditions of interest, that are independent of particle–particle interactions and other seemingly relevant variables of the problem. In the first example, the universal scaling is the well known Beverloo’s rule [1]; in the second, the frequency response function of the inelastic bouncing ball model [2]. We will argue that the origin of such universality is connected with a more fundamental, nonlinear phenomenon: *inelastic collapse* [3]. We will show that if the conditions for inelastic collapse are unmet, the universal response is lost in these examples. This conjecture, if found valid in other contexts, may help to build models that can explain a range of granular phenomena based on few simplifying hypothesis.

References

[1] W. A. Beverloo, H. A. Leniger, J. van de Velde, The flow of granular solids through orifices, Chem. Eng. Sci. **15**, 260 (1961).

[2] M. Sánchez, G.o Rosenthal, L. A. Pugnaloni, Universal response of optimal granular damping devices, J. Sound Vib. **331**, 4389 (2012).

[3] L. P. Kadanoff, Built upon sand: Theoretical ideas inspired by granular flows, Rev. Mod. Phys. **71**, 435 (1999).

2.1.3. Presenting Author: Rodrigo Soto

Active colloidal molecules

Rodrigo Soto[1] **and Ramin Golestanian**[2]

[1]Departamento de Fisica, Facultad de Ciencias Fisicas y Matematicas, Universidad de Chile, Santiago, Chile

[2]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, UK

Catalytically active colloids maintain non-equilibrium conditions in which they produce and deplete chemicals and hence effectively act as sources and sinks of molecules. The concentration fields resulting from the chemical activity decay as 1/r and produce gradients that attract or repel the colloids depending on their surface chemistry and ambient variables. This results in

a non-equilibrium analogue of ionic systems, but with the remarkable novel feature of action-reaction symmetry breaking. We study solutions of such chemically active colloids in dilute conditions when they join up to form molecules, and discuss the role of charge neutrality and valence with regards to making "ionic bonds". The molecules could be inert or have spontaneous activity in the form of net translational velocity and spin depending on their symmetry properties and their constituents. In contrast to equilibrium, the molecular stationary distribution is not given in terms of the relevant free energies but, rather, on the solution of Fokker-Planck equations that however do not admit potential solutions. We discuss appropriate methods to obtain the stationary distribution.

2.2. Classical and quantum chaos

2.2.1. Presenting Author: Marcus W. Beims

Ratchet currents in parameter space and temperature effects

A. Celestino, C. Manchein, H. A. Albuquerque, and M. W. Beims

Physics Department of UFPR Group of Chaos, disorded and complexity and classical and quantum systems
Albert-Ludwigs Universität Freiburg, Group of Theoretische Quantendynamik Centro Politécnico Curitiba, Brazil

In this talk we present results for the parameter space of a discrete ratchet model and show the direct connections between chaotic domains and a family of isoperiodic stable structures (ISSs) with the ratchet current. The ISSs appear along preferred direction in the parameter space giving a guide to follow the current, which usually increases inside the structures but is independent of the corresponding period. One of such structures has the shrimp-shaped form which is known to be a generic structure in the parameter space of dissipative systems. Temperature effects on the ISSs are discussed.

2.3. Complex system dynamics

2.3.1. Presenting Author: Thomas Dittrich

Classical information exchange and quantum entanglement between coupled dynamical systems

Thomas Dittrich

Departamento de Física, Universidad Nacional de Colombia, Bogotá D.C., Colombia

I present a study of the classical and quantum information exchange between coupled dynamical systems, beginning with a pair of linearly coupled harmonic oscillators. In this case, the time evolution of all relevant quantities can be solved analytically, in particular for the information contents (measured as Shannon information on the classical level and von Neumann entropy quantum mechanically) based on the classical and quantum phase-space densities, reps., for the total system as well as for the two subsystems. Starting from the conservation of total information under canonical as well as under unitary transformations, I compare classical and quantum information flows and identify relations between them. As initial conditions, I shall consider two complementary extremes, a classically large, incoherent Gaussian superposition of coherent states as closest quantum mechanical approximation to the corresponding classical initial distribution, and a highly excited pure state of the pair of coupled oscillators. I shall point out how periodic "sudden deaths of entanglement" on the quantum side coincide with and correspond to sign reversals of the correlation function between the two subsystems on the classical side: Both quantities oscillate periodically and in synchrony with the beats between the coupled oscillators.

The results elucidate the correspondence between classical and quantum information on a common footing, information flow in phase space. As immediate extensions, they suggest to increase the number of coupled oscillators and to include anharmonic potentials and complex nonlinear dynamics, in order to analyze in depth the relationships between entanglement, information flow, and decoherence.

2.4. Non-equilibrium and fluctuation phenomena

2.4.1. Presenting Author: Katja Lindenberg

Synchronization of coupled on-off units: Effects of fluctuations due to finite numbers

Katja Lindenberg[1], **Italo'Ivo Lima Dias Pinto**[2], **Upendra Harbola**[3], **and Daniel Escaff**[4]

[1] Department of Chemistry and Biochemistry and BioCircuits Institute, University of California San Diego, La Jolla, CA 92093-0340, USA

[2] Departamento de Física, CCEN, Universidade Federal da Paraíba, Caixa Postal 5008, 58059-900, João Pessoa, Brazil

[3] Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore, Karnataka 560012, India

[4] Complex Systems Group, Facultad de Ingeniería y Ciencias Aplicadas, Universidad de los Andes, Avenida San Carlos de Apoquindo 2200, Santiago, Chile

We consider Markovian coupled on-off units which in the mean field limit exhibit a second order transition to synchronization. When the number of units is finite instead of infinite, in addition to the fluctuations implicit in the distributions of switching times there are now fluctuations due to this finite number. These latter fluctuations profoundly affect the behavior of the system. We may also briefly discuss these behaviors when there is an inherent memory in the on-off transitions, that is, when the units are not Markovian.

2.5. Nonlinearities in social and biological systems

2.5.1. Presenting Author: Oreste Piro

Fluid dynamics in developmental biology: moving fluids that shape ontogeny

Oreste Piro

Departament of Physics, University of the Balearic Islands, Palma de Mallorca, Spain

Human conception, indeed fertilization in general, takes place in a fluid, but what role does fluid dynamics have during the subsequent development of an organism? It is becoming increasingly clear that the number of genes in the genome of a typical organism is not sufficient to specify the minutiae of all features of its ontogeny. Instead, genetics often acts as a choreographer, guiding development but leaving some aspects to be controlled by physical and chemical means. Fluids are ubiquitous in biological systems, so it is not surprising that fluid dynamics should play an important role in the physical and chemical processes shaping ontogeny. However, only in a few cases have the strands been teased apart to see exactly how fluid forces operate to guide development. In my talk, I will review instances in which the hand of fluid dynamics in developmental biology is acknowledged, both in human development and within a wider biological context, together with some in which fluid dynamics is notable but whose workings have yet to be understood, and we provide a fluid dynamicist's perspective on possible avenues for future research. In more details, I will expand on the particular case of the determination of left-right asymmetry in vertebrates. Experimental work in mice has shown unequivocally that fluid flow driven by rotating cilia in the node, a structure present in the early stages of growth of vertebrate embryos, is responsible for determining the normal development of the left–right axis, with the heart on the left of the body, the liver on the right, and so on. The theoretical elucidation of the way in which these cilia manage to generate deterministically a strongly asymmetric flow from an otherwise completely symmetric geometry and the consequent prediction of previously unknown facts confirmed later by new experiments, is a rare example in biology. It shows the power of abstract reasoning based on few physical principles and simple models, to understand complex biological processes and to use it as a guide for new experimental endeavors. I will put forward the need to follow more actively this type of strategies in system biology.

2.5.2. Presenting Author: Marcelo Kuperman

Room evacuation and game theory

Marcelo Kuperman[1,2]

[1]Centro Atómico Bariloche and Instituto Balseiro, 8400 – Bariloche, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

In this talk we present an agent based model for room evacuation by pedestrians. These pedestrians can be cooperative or non cooperative. The individuals are located on a square lattice and they can move only to empty spaces. There are multiple events of competition for the same chosen site to move. In those cases, the winner is chosen according to the strategies adopted by all the competitors. The payoff of each strategy depends on a parameter which value defines the characteristic of the game, that in one extreme can be associated to the prisoner dilemma and in the other to the stag hunt game. Interesting results arise that show a new and non trivial example of the emergence of collaboration.

2.5.3. Presenting Author: Luis G. Morelli

A pacemaker circuit in vertebrate development

Christian Schröter[7], Saúl Ares[8], Luis G. Morelli[1], Alina Isakova[4], Korneel Hens[4], Daniele Soroldoni[1], Martin Gajewski[9], Frank Jülicher[2], Sebastian J. Maerkl[4,6], Bart Deplancke[4], and Andrew C. Oates[1]

[1]Max Planck Institute of Molecular Cell Biology and Genetics, Pfotenhauerstr. 108, D-01307 Dresden, Germany

[2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str., 01187 Dresden, Germany

[3]Departamento de Física, FCEyN, UBA and IFIBA, Conicet, Pabellón 1, Ciudad Universitaria, 1428 Buenos Aires, Argentina

[4]École Polytechnique Fédérale de Lausanne, Institute of Bioengineering, Station 19, CH-1015 Lausanne, Switzerland

[5]Institute for Genetics, University of Cologne, Zülpicher Str. 47, 50674 Cologne, Germany

[6]École Polytechnique Fédérale de Lausanne, School of Engineering, Bldg. BM2111, Station 17, CH-1015 Lausanne, Switzerland

[7] University of Cambridge, Department of Genetics, Downing Street, Cambridge CB2 3EH, UK

[8]Logic of Genomic Systems Laboratory, Centro Nacional de Biotecnología - CSIC, Calle Darwin 3, 28049 Madrid, Spain

[9]Hamilton Bonaduz AG, Via Crusch 8, 7402 Bonaduz, Switzerland

During embryonic development, cells generate and process information to orchestrate the patterning of tissues and organs. Several fundamental patterning mechanisms have been identified. Among them, an interesting example is vertebrate segmentation. During vertebrate development, the axis that spans from head to tail is subdivided into regular segments that will later form the vertebrae and other tissues. Such segments form one by one, with a precise rhythm. The rhythm is controlled by a biological clock: at the cellular level, a gene regulatory circuit produces biochemical oscillations in the concentrations of some proteins. We use an interdisciplinary approach that brings together theory and experiment to unravel mechanisms that produce and control the rhythm of this biological pacemaker. **References**

[1] Schroeter C, Ares S, Morelli LG, Isakova A, Hens K, et al. (2012) *Topology and Dynamics of the Zebrafish Segmentation Clock Core Circuit.* PLoS Biol **10**: e1001364. doi:10.1371/journal.pbio.1001364

2.5.4. Presenting Author: Sebastián Bouzat

Models for cargo transport by molecular motors on microtubules

S. Bouzat

CONICET. Grupo de física estadística e interdisciplinaria, Centro Atómico Bariloche (CNEA), Bariloche, Argentina

Kinesin and dynein are molecular motors (also called motor proteins) which use the energy from

ATP hydrolysis to move big cargoes such as lipid droplets or mitochondria inside cells. These molecular motors perform directional walks along the microtubules, which act as long polymer highways for transport. Kinesins move to the plus end of the microtubules, i.e. preferably from the nucleus to the cell periphery, whereas dyneins move in the opposite direction. Usually, several motors of each type are linked to a single cargo, so that the transport is bidirectional. In this talk we discuss the problem of modeling transport by multiple-motors on microtubules. We introduce stochastic models which consider a Langevin equation for the position of the cargo and Montecarlo-like dynamics for motors. We analyze the influence of motor-motor interactions on transport, as well as the role of different system parameters including the cytoplasmic viscosity and the elasticity of the individual motors. We apply the models to the interpretation of data taken from in vivo experiments.

2.5.5. Presenting Author: Ana Amador

Using a low dimensional birdsong model to unveil motor control in zebra finches

A. Amador[1,2], Y. Sanz Perl[1,2], G. B. Mindlin[1,2], and D. Margoliash[3]

[1]Departamento de Fisica, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina
[2]IFIBA, CONICET, Argentina
[3]University of Chicago, Chicago, USA

Songbirds are a well studied example of vocal learning that allows to integrate neural and peripheral recordings with a precisely quantifiable behavior (song). Although neural activity has been related to song acoustics in auditory playback experiments, it remains unresolved whether neural activity is related to song spectral structure during singing. To address this issue, we worked with a minimal physical model for birdsong production, having as an output a synthetic song. Each syllable was coded in terms of parameters related to air sac pressure and tension of the syringeal labia, defining motor gestures. The model for birdsong production allowed to make predictions about motor control that were validated by developing a novel technique for dynamic control of subsyringeal pressure in zebra finches. To further validate this model, we assessed responses of the premotor forebrain nucleus HVC to song playback in sleeping birds, as HVC neurons exhibit highly selective responses to the bird's own song (BOS). Remarkably, the mathematical model was able to elicit responses strikingly similar to those for BOS, with the same phasic-tonic features. The analysis of the neural activity in terms of the model for song production allowed to propose a novel model for motor control in songbirds. We confirmed this result with HVC recordings in singing birds, showing the pertinence of working with a low dimensional model that represents an approximation of peripheral mechanics but captures relevant features of behavior.

2.5.6. Presenting Author: Enrique Hernandez-Lemus

The role of master regulators in gene regulatory networks

Enrique Hernandez-Lemus[1,2], Karol Baca-Lopez[1], Roselyn Lemus[1,3], and Rodrigo Garcia-Herrera[1]

[1]Computational Genomics Consortium, National Institute of Genomic Medicine, Mexico
[2]Complexity in Systems Biology, Center for Complexity Sciences, National Autonomous University of Mexico, Mexico
[3]Graduate Program in Molecular Oncology, National Center for Oncological Research, Spain

Gene regulatory networks present a wide variety of dynamical responses to intrinsic and extrinsic perturbations. Arguably, one of the most important of such coordinated responses is the one of amplification cascades, in which activation of a few key-responsive transcription factors (termed master regulators, MRs) lead to a large series of transcriptional activation events. This is so, since master regulators are transcription factors controlling the expression of other transcription factor molecules and so on. MRs hold a central position related to transcriptional dynamics and control of gene regulatory networks and are often involved in complex feed-back and feed-forward loops inducing non-trivial dynamics.

Recent studies have pointed out to the myocyte enhancing factor 2C (MEF2C, also known as MADS box transcription enhancer factor 2, polypeptide C) as being one of such master regulators involved in the pathogenesis of primary breast cancer. In this work, we perform an integrative genomic analysis of the transcriptional regulation activity of MEF2C and its target genes, to evaluate to what extent is this molecule inducing collective responses leading to gene expression deregulation and carcinogenesis. We also analyzed a number of induced dynamic responses, in particular those associated with transcriptional bursts, and nonlinear cascading to evaluate the influence they may have in malignant phenotypes and cancer.

2.5.7. Presenting Author: Federico Vazquez

Group decision making: opinion polarization versus consensus

Federico Vazquez[1], **Cristian La Rocca**[2], **and Lidia Braunstein**[2]
[1]Instituto de Fisica de Liquidos y Sistemas Biologicos, CONICET-UNLP
[2]Instituto de Investigaciones Fisicas de Mar del Plata, CONICET-UNMdP

Homophily (love of the same) and persuasive arguments are two social mechanisms that promote opinion polarization in human groups. We explore the dynamics of these mechanisms within two simple agent-based models for opinion formation. In the first model, each individual can take one of two opinions, for instance to decide whether a person suspected of a crime is guilty or not guilty. In a single step, an individual can either adopt the opinion of one of its interacting neighbors (imitation), or drop a connection with an opposite-opinion neighbor and form a new connection with another same-opinion person. In this way, homophily is implemented by promoting interactions between like-minded individuals that tend to group together. Depending on the relative rates associated to the imitation and reconnection processes, the group can either reach global consensus or split in two subgroups formed by people that share the same opinion. In the second model, we introduce an integer number k ($-M \leq k \leq M$) that measures the degree of extremism of an individual about its opinion, so that $k = -M$ (M) represent individuals who are totally convinced that the suspected person is guilty (not guilty). In a single step, a pair of individuals with convictions k and k' are chosen at random. If they have the same opinion [$\mathrm{sign}(k) = \mathrm{sign}(k')$], then they increase their convictions in one unit after they talk, by persuading each other using different arguments. If they have opposite opinions [$\mathrm{sign}(k) \neq \mathrm{sign}(k')$], then with the same probability 1/2 one individual becomes less convinced while the other becomes more convinced. The evolution of the system is characterized by two time scales, an initial transient polarized state where the opinion distribution is peaked at the two extreme values $k = M$ and $k = -M$, followed by a relaxation to the consensus in one of these two extreme opinions.

2.6. Other nonlinear phenomena

2.6.1. Presenting Author: Evaldo M. F. Curado

How general is the thermodynamical framework? A physical example

E. M. F. Curado[1,2], A. M. C. Souza[2], F. D. Nobre [1,2], and R. F. S. Andrade[2]

[1]Centro Brasileiro de Pesquisas Fisicas, Rua Xavier Sigaud 150, Urca 22290-180, Rio de Janeiro, Brazil

[2]National Institute of Science and Technology for Complex Systems, Rua Xavier Sigaud 150, Urca 22290-180, Rio de Janeiro, Brazil

A type of thermodynamical formalism can be introduced for a system of interacting particles under overdamped motion, in which thermal noise can be neglected ($T \simeq 0$). Heat and work terms (δQ and δW) can also be defined and, using the concept of an effective temperature θ, conjugated to a generalized entropy s, the first law in its infinitesimal form can be established. These definitions allow the construction of an unusual Carnot cycle, whose efficiency is $\eta = 1-(\theta_2/\theta_1)$, where θ_1 and θ_2 are the effective temperatures of the two isothermal transformations, with $\theta_1 > \theta_2$. These results support a generalized thermodynamical framework for this physical system.

2.7. Soft matter

2.7.1. Presenting Author: Gerhard Naegele

Dynamics in crowded solutions of globular charged proteins

Gerhard Naegele[1] **and Marco Heinen**[2]

[1]Institute of Complex Systems (ICS-3), Research Centre Juelich, Germany

[2]Dept. of Theoretical Physics, Heinrich-Heine-University Duesseldorf, Germany

We report on our recent work on the shear viscosity and collective diffusion in concentrated solutions of bovine serum albumin (BSA) proteins [1]. Data obtained from dynamic light scattering, neutron spin echo and rheometry measurements are compared to theoretical calculations based on an analytically treatable spheroid model of BSA with screened isotropic Coulomb interactions. For calculating dynamic properties, easy-to-implement theoretical methods are used which account for the solvent-mediated hydrodynamic interactions [2]. The only input required by these methods is the static structure factor, obtained from a consistent theoretical fit of small-angle x-ray scattering data using a newly developed analytic integral equation scheme [3]. All experimentally determined dynamic properties are reproduced theoretically with an at least semi-quantitative accuracy, including a peculiar maximum in the reduced viscosity as a function of concentration. We analyze the application range of a generalized Stokes-Einstein relation for proteins relating viscosity to collective diffusion and osmotic compressibility, and we discuss the dynamic influence of the microion electrokinetics and solvent permeability of the particles [4].

References

[1] M. Heinen, F. Zanini, F. Roosen-Runge, D. Fedunova, F. Zhang, M. Hennig, T. Seydel, R. Schweins, M. Sztucki, M. Antalik, F. Schreiber and G. Nägele, Soft Matter 8, 1404 (2012).

[2] M. Heinen, A. J. Banchio and G. Nägele, J. Chem. Phys. 135, 154504 (2011).

[3] M. Heinen and G. Nägele, J. Chem. Phys. 134, 044532 and 129901 (2011).

[4] G. Abade, B. Chichocki, M. L. Ekiel-Jezewska, G. Nägele and E. Wajnryb, J. Chem. Phys.136, 104902 (2012).

2.7.2. Presenting Author: Daniel Adrián Stariolo

Nematic and stripe glass phases in two dimensional systems with competing interactions

Daniel A. Stariolo

Departmento de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

Stripe phases are found in many different systems, from magnetic thin films to high Tc superconductors and block copolymers. The phase diagrams of these systems are very rich, showing many different kinds of positional and orientational order, often similar to liquid crystal phases, although of a different nature. We study stripe forming systems with nearly isotropic competing interactions at different scales in two spatial dimensions. We show that symmetry arguments lead naturally to the existence of nematic phases associated with orientational order of interfaces between stripes but absence of positional long range order [1]. At low temperatures a stripe phase with orientational and positional order may exist, depending on the effective range of the relevant interactions [2]. The equilibrium phase diagrams are described and experimental evidence of the different phases in ultrathin ferromagnetic films with perpendicular anisotropy is shown. A key characteristic of this kind of systems is frustration. We show that this class of two dimensional models may undergo an ergodicity breaking transition, leading to a glassy phase with persistent time dependent correlations [3]. Our results may be relevant to understand the low temperature physics of several mangetic, electronic and soft condensed matter systems.

References

[1] D. G. Barci and D. A. Stariolo, Phys. Rev. Lett. 98, 200604 (2007).

[2] D. G. Barci and D. A. Stariolo, Phys. Rev. B 84, 094439 (2011).

[3] A. C. Ribeiro Teixeira, D. A. Stariolo and D. G. Barci, Phys. Rev. E 87, 062121 (2013).

Contributed Talks

3.1. Active matter and granular systems

3.1.1. Presenting Author: José Daniel Muñoz

Objective Estimation of Edwards' Volumetric Entropy in Granular Media

W. F. Oquendo[1], **J. D. Muñoz**[1], **and F. Radjai**[2]
[1]Simulation of Physical Systems Group, CeiBA-Complejidad, Department of Physics, Universidad Nacional de Colombia, Ciudad Universitaria,Carrera 30 No. 45-03, Ed. 404, Of. 348, Bogota D.C., Colombia
[2]Université Montpellier 2, CNRS, LMGC, Place Eugeène Bataillon, F-34095 Montpellier cedex 05, France

On describing granular media within statistical mechanics, Edwards' volumetric entropy [Phys. A. **157**, 1080 (1989)] is a promising approach accounting for all grain configurations compatible with a given volume. This theory also defines a temperature-like variable, the *compactivity*, to describe its canonical ensemble. Nevertheless, the estimation of the compactivity and the entropy itself still seems hard to obtain and relying on the method used to compute them. By working out a recent proposal by Aste et. al.[Phys. Rev. E **77**, 021309 (2008)] to measure Edwards' compactivity from the volume distribution of Voronoï or Delaunay tessellations, we show that three related quantities: the compactivity χ, the entropy per elementary cell S/k and the total number C of elementary cells are tessellation-independent and can thus be used to objectively characterize the configurational state of a granular assembly. Furthermore, from these quantities we are also able to estimate Edwards' total volumetric entropy S_T and - even more - to derive analytic expressions for $S_T(\chi)$ and for the equation relating χ with the volume fraction ϕ (that is, the equivalent to the equipartition relation for this ensemble). These analytical results are well supported by extensive molecular dynamics simulations of both the limit state of isotropic compression and the limit state of uniform shear (i.e. the critical state of soil mechanics) for a 3D packings of mono-disperse spheres on a broad range of sliding and rolling friction coefficients. Indeed, the values for χ so obtained coincide between error bars with those from other methods to compute the compactivity, like the overlapping histogram technique [S.McNamara et.al., Phys. Rev. E **80**, 031301 (2009)] and the volume fluctuations method [E.R. Nowak et.al., Phys. Rev. E **57**, 1971 (1998); M. Schroter, D.I. Goldman and H.L. Swinney, Phys. Rev. E **71**, 030301(R) (2005)]. In addition, the same numerical results

also illustrate how the sliding and rolling friction coefficients and the particle stiffness change the compactivity and the total number of elementary cells in the sample. The simulations also show that two samples in contact with different sliding friction coefficients stabilizes to the same compactivity, when the isotropic compression is iterated many times. Our findings provide a reliable procedure to compute the volumetric entropy of granular states under mechanical stress and support Edwards' statistical description of granular media.

3.1.2. Presenting Author: Carlos Echeverria

Interface Mesoscopic Simulations in crowded environments

Carlos A. Echeverria[1] **and Kay Tucci**[1,2]

[1] CeSiMo, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.
[2] SUMA, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.

We propose a method to simulate a symmetric binary fluid inspired in the mesoscopic molecular simulation technique Multiparticle Collision (MPC) of Malevanets and Kapral that the space and state are continuous and the time is discrete. Also, this technique remains constant the energy and moment constant. We include a repulsion factor to MPC without making a calculation of interaction forces and results have a good agreement with a simple theory of Ising of interfase and a good behavior when the fixed obstacles are present. But, with this rule of repulsion we lost the local moment conservation and the global moment is conserved in zero. Aditionally, we include obstacles to show the mesoscopic character of the model.

3.1.3. Presenting Author: Iván Sánchez

Collective granular flow around a bend due to vertical tapping

Iván Sánchez[1], **José Ramón Darias**[2], **and Oliver Pozo**[3]

[1]Centro de Física, Instituto Venezolano de Investigaciones Científicas, Apartado Postal 21827, Caracas 1020, Venezuela
[2]Departamento de Física, Universidad Simón Bolívar, Apartado Postal 89000, Caracas 1080, Venezuela
[3]Institute for Polymers and Composites/I3N, University of Minho, 4800-058 Guimaraes, Portugal

The fl ow of granular materials around bends has been widely studied in the context of pneumatic transport. The case when the collective motion of grains through an elbow is triggered only by mechanical perturbations has received less attention, despite having important potential applications in vibratory conveying, mold lling and catalyst recirculation. We present results from experiments and computer simulations of the motion of a granular material inside an L-shaped container with an open outlet. The container is perturbed with single vertical taps of controlled intensity, until most of the granular material has left through the outlet. The net flow of grains during each tap depends on the intensity of the tap. Looking at the density and velocity profiles during a single tap, as well as at the pressure at the walls we gain insight on the dynamics of the collective flow. For low tapping intensities, an intermittent regime is observed

where not all taps induce a net flow through the bend. The main goal is to link the net flow and its internal dynamics with bulk and single grain properties of the flowing material.

3.1.4. Presenting Author: Patricio Cordero

Granular systems in shallow boxes

Patricio Cordero[1], Dino Risso[2], and Rodrigo Soto[1]
[1]Departamento de Física, FCFM, Universidad de Chile, Santiago, Chile
[2]Departamento de Física, Universidad del BioBio, Concepción,Chile

Fluidized granular media in a shallow geometry (i.e. a box with large horizontal dimensions and a height comparable to the particles' sizes) has attracted attention because it allows for detailed analysis of both the colletive behavior and the motion of individual grains. The box is vibrated with an amplitude A and an angular frequency ω. In general in granular systems there is no energy equipartition and in particular for these shallow systems the horizontal kinetic energy of the grains can be quite different from the kinetic energy associated to the vertical movement. When studying the transient dynamics of this separation it was shown that it was driven by negative compressibility of the effec we report a numerical study of a phenomenon that takes place in a vertically vibrated shallow system when two particle species, differing in their mass density, are put in the box. It has been known for decades that when a mixture of two types of granular particles are externally excited, grains of different size, shape, mass or mechanical properties can mix or segregate. In this geometry the two species also segregate. The focus of the present article will be mainly in a phenomenon segregation but also in the presence of explosions that take place once the species have segregated. The region in the A, ω space where segragation is observed is quite non trivial.

3.2. Classical and quantum chaos

3.2.1. Presenting Author: Alfredo M Ozorio de Almeida

Initial value for semiclassical evolution in the Weyl-Wigner representation

A. M. Ozorio de Almeida[1], R. O. Vallejos[1], and E. Zambrano[2]
[1]Centro Brasileiro de Pesquisas Físicas-CBPF, Rua Xavier Sigaud 150, 22290-180, Rio de Janeiro, RJ, Brasil
[2]Laboratory of Theoretical Chemistry, Institut des Sciences et Ingénierie Chimiques, École Polythechnique Fédéral de Lausanne-EPFL, CH-1015 Lausanne, Suissa

Initial Value Representations (IVR) are constructed to avoid the search for trajectories that are only defined in semiclassical approximations by their boundary conditions. We show how to incorporate these procedures within the full Weyl representation, so that quantum expectation values are given by phase space integrals over the evolving Wigner function. Spurious semiclassical singularities at caustics are cancelled, even though there is no increase in the number of trajectories, as compared to usual semiclassical formulae. The whole construction remains exact in the case of quadratic Hamiltonians. The evolution of (density) operators depends on either a forward and back trajectory, given by an initial value, or else on a pair of trajectories, propagating backwards from their final value. The general scheme also leads to analogous algorithms for evolving the quantum fidelity, which can be approximated perturbatively with a single trajectory, reducing to the 'dephasing representation' for small times.

3.2.2. Presenting Author: L. De Micco

Complexity in switching chaotic maps

L. De Micco[1,2], M. Antonelli[1], O. A. Rosso[3,4], and H. A. Larrondo[1,2]
[1] Facultad de Ingeniería, Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.
[2] CONICET.
[3] LaCCAN/CPMAT – Instituto de Computaçao, Universidade Federal de Alagoas, Maceió,Alagoas, Brazil.
[4] Laboratorio de Sistemas Complejos, Facultad de Ingeniería, Universidad de Buenos Aires, Ciudad Autónoma de Buenos Aires, Argentina.

In the last years digital measuring systems become the standard in all experimental sciences because new programable electronic devices, such as Digital Signal Processors (DSP) and Field Programmable Gate Arrays (FPGA) allow experimenters to design and modify their own experimental setup.

The implementation of chaotic maps in these new devices is interesting to create white and colored noises, pseudorandom number generators, etc. The effect of finite precision needs to be investigated. Due to roundoff, any digital implementation of a chaotic map will always become periodic with period T. This issue was considered by Grebogi and coworkers [1] and they shaw that the period T scales with roundoff ϵ as $T \sim \epsilon^{-d/2}$ where d is the correlation dimension of the chaotic attractor.

Nagaraj et al [2] shaw that the period T of a compound system obtained by switching between two chaotic maps is grater than the period of each map.

But the period length is not the only important property of a chaotic map: stochasticity and mixing are also relevant in many applications. To characterize these properties several quantifiers were evaluated [3]. Among them, the use of an entropy-complexity representation ($H - C$ plane) deserves special consideration [3-7].

In this paper we study the location on the $H - C$ plane of two well known chaotic maps: the tent map and the logistic map. The Bandt-Pompe procedure was used to assign a PDF to the time-series. Different numerical representations are considered, producing a quantization dynamical noise included in the dynamics of the system. In spite T is increased by switching between both maps, conmutation produces a non-monotonous evolution towards the floating point location on the $H - C$ plane. This result is relevant because it shows that increasing the precision is not always recommended, as the expression of T suggests.

References

[1] C. Grebogi, E. Ott, and J. A. Yorke, "Roundoff-induced periodicity and the correlation dimension of chaotic attractors," *Phys. Rev. A*, vol. 38, pp. 3688–3692, Oct 1988.

[2] N. Nagaraj, M. C. Shastry, and P. G. Vaidya, "Increasing average period lengths by switching of robust chaos maps in finite precision," *The European Physical Journal Special Topics*, vol. 165, pp. 73–83, 2008.

[3] L. De Micco, H. A. Larrondo, A. Plastino, and O. A. Rosso, "Quantifiers for randomness of chaotic pseudo random number generators," *Philosophical Transactions of the Royal Society A*, vol. 367, pp. 3281–3296, 2009.

[4] O. A. Rosso, H. A. Larrondo, M. T. Martin, A. Plastino, and M. A. Fuentes, "Distinguishing noise from chaos," *Phys. Rev. Lett.*, vol. 99, pp. 154 102–106, 2007.

[5] L. De Micco, C. M. González, H. A. Larrondo, M. T. Martin, A. Plastino, and O. A. Rosso, "Randomizing nonlinear maps via symbolic dynamics," *Physica A*, vol. 387, pp. 3373–3383, 2008.

[6] L. De Micco, J. G. Fernández, H. A. Larrondo, A. Plastino, and O. A. Rosso, "Sampling period, statistical complexity, and chaotic attractors," *Phys. A*,vol. 391, pp 2564-2575, 2012.

[7] O. A. Rosso, L. De Micco, H. A. Larrondo, M. T. Martin, and A. Plastino, "Generalized statistical complexity measure: a new tool for dynamical systems," *IJBC* , vol. 20, pp 187-192, 2010.

3.2.3. Presenting Author: Flavio M. de Aguiar

Freak oscillatory behavior in microwave driven nonlinear spin waves

F. M. de Aguiar[1], R. L. Rodríguez-Suárez[2], T. Araújo Lima[1], and J.R. Rios Leite, and S.M. Rezende[1]

[1]Departamento de Física, Universidade Federal de Pernambuco, Recife, PE 50670-901, Brazil

[2]Facultad de Física, Pontifícia Universidad Católica de Chile, Casilla 306, Santiago 22, Chile

Spin waves are collective excitations of the localized spins in a magnetic material. Critically driven by a microwave magnetic field, the populations of certain spin-wave modes can grow up to several orders of magnitude beyond the thermal level in high power ferromagnetic resonance experiments. Depending on the system parameters, higher-order bifurcations may occur above threshold, leading to low-frequency self-oscillations and eventually to a number of different routes to chaos. Here we numerically investigate the nonlinear dynamics of four excited modes, two of which are unidirectionally coupled in a master-slave scheme. A particular scenario was searched and found in which rare events of high-amplitude peaks are observed in low-frequency chaotic oscillations of the driven spin-wave modes. The distribution of such extreme events in this model is shown to be orders of magnitude above the Rayleigh law describing ordered linear bounded wave systems. In addition, it is shown that the intensity distribution in long wave trains can be fitted by a formula introduced by Mirlin, Pnini and Shapiro for monochromatic waves propagating in a quasi-one-dimensional random medium that supports a point source and a point detector. This work is supported by CNPq, CAPES and FACEPE (Brazil) and FONDECIT (Chile).

3.3. Complex fluid and plasma dynamics

3.3.1. Presenting Author: Gustavo Martinez-Mekler

Liesegang pattern formation in gases

Alfredo González[1], Fernando Montoya[2], Elizeth Ramírez[2], José Torres[2], and Gustavo Martinez-Mekler[1]

[1] Instituto de Ciencias Fisicas, UNAM, Cuernavaca, México
[2] Facultad de Ciencias, UAEM, México

A revealing pattern formation chemistry experiment consists of placing a cotton plug drenched in ammonia at one end of a long glass tube simultaneously with another one drenched in hydrochloric acid at the other end of the tube. After some time a white ring forms on the tube wall, the ring consists of amonium chloride, resulting from the gas reaction. Once one ring is formed, the reaction front moves, leaving more precipitate in the form of rings. This phenomenom is sometimes referred to as the formation of Liesegang rings. We present observations from our experiments on the propagation of the reaction front dynamics. We perform a statistical analysis of the ring distributions, focusing on the appearence of long range correlations, scaling regimes and their relation to extreme events. A cellular automata type model is put forth which captures some of the essential features of the chemical reaction. Films of the pattern formation process, as well as numerical simulations will be presented.

3.3.2. Presenting Author: R. Hilfer

Nonlinear partial differential equations for hysteresis in two-phase flow through porous media

R. Hilfer

Institute for Computational Physics, Universität Stuttgart, 70569 Stuttgart, Germany

The nonlinear relative permeability and capillary pressure as functions of saturation are crucial for the accepted traditional theory of two phase flow in porous media. A recent generalization of the traditional theory does not require these functions as input [1-3]. Instead it is based on the concept of hydraulic percolation of fluid phases. The novel approach allows to predict residual saturations and local spatiotemporal changes between imbibition and drainage during two phase immiscible displacement [1-6]. Recently, an analytically tractable hyperbolic limit of the generalized theory was investigated [7]. In this limit a fractional flow formulation exists, that resembles the traditional theory. The Riemann problem is solved analytically in one dimension by the method of characteristics. Initial and boundary value problems exhibit shocks and rarefaction waves similar to the traditional Buckley Leverett theory. However, contrary to the traditional theory, the generalized theory permits simultaneous drainage and imbibition processes. Displacement processes involving flow reversal are equally allowed. Shock fronts and rarefaction waves in both directions in the percolating and the nonpercolating fluids are found, which can be compared directly to experiment.

References

[1] R. Hilfer, *Capillary Pressure, Hysteresis and Residual Saturation in Porous Media* Physica A, vol. 359, pp. 119, (2006)

[2] R. Hilfer, *Macroscopic Capillarity and Hysteresis for Flow in Porous Media*, Physical Review E, vol. 73, pp. 016307, (2006).

[3] R. Hilfer, *Macroscopic capillarity without a constitutive capillary pressure function*, Physica A, vol. 371, pp. 209, (2006)

[4] R. Hilfer, *Modeling and Simulation of Macrocapillarity*, in: P. Garrido et al. (eds.) *Modeling and Simulation of Materials* vol. CP1091, pp. 141, American Institute of Physcis, New York, 2009.

[5] R. Hilfer and F. Doster, *Percolation as a basic concept for macroscopic capillarity*, Transport in Porous Media, vol. 82, pp. 507, (2010)

[6] F. Doster and P. Zegeling and R. Hilfer, *Numerical solutions of a generalized theory for macroscopic capillarity*, Physical Review E, vol. 82, pp. 036307, (2010)

[7] F. Doster and R. Hilfer, *Generalized Buckley-Leverett theory for two-phase flow in porous media*, New Journal of Physics, vol. 13, pp. 123030, (2011)

3.4. Complex networks

3.4.1. Presenting Author: Juan A. Almendral

Explosive synchronization in weighted complex networks

Juan A. Almendral[1,2], I. Leyva[1,2], I. Sendiña-Nadal[1,2], A. Navas[2], S. Olmi[3], and S. Boccaletti[3]

[1] Complex Systems Group, Univ. Rey Juan Carlos, 28933 Móstoles, Madrid, Spain
[2] Center for Biomedical Technology, Univ. Politécnica de Madrid, 28223 Pozuelo de Alarcón, Madrid, Spain
[3] CNR-Institute of Complex Systems, Via Madonna del Piano, 10, 50019 Sesto Fiorentino, Florence, Italy

The emergence of dynamical abrupt transitions in the macroscopic state of a system is currently a subject of the utmost interest. Given a set of phase oscillators networking with a generic wiring of connections and displaying a generic frequency distribution, we show how combining dynamical local information on frequency mismatches and global information on the graph topology suggests a judicious and yet practical weighting procedure which is able to induce and enhance explosive, irreversible, transitions to synchronization. We report extensive numerical and analytical evidence of the validity and scalability of such a procedure for different initial frequency distributions, for both homogeneous and heterogeneous networks, as well as for both linear and non linear weighting functions. We furthermore report on the possibility of parametrically controlling the width and extent of the hysteretic region of coexistence of the unsynchronized and synchronized states. Reference: "Explosive synchronization in weighted complex networks", submitted to Physical Review E.

3.4.2. Presenting Author: Sebastian Risau Gusman

Epidemic thresholds for bipartite networks

Sebastián Risau-Gusman[1] and Damián Hernández[1,2]

[1]CONICET-Centro Atómico Bariloche
[2]Instituto Balseiro

It is well known that sexually transmitted diseases (STD) spread across a network of human sexual contacts. This network is most often bipartite, as most STD are transmitted between men and women. Even though network models in epidemiology have quite a long history now, there are few general results about bipartite networks. One of them is the simple dependence, predicted using the mean field approximation, between the epidemic threshold and the average and variance of the degree distribution of the network. Here we show that going beyond this approximation can lead to qualitatively different results that are supported by numerical simulations. One of the new features, that can be relevant for applications, is the existence of a critical value for the infectivity of each population, below which no epidemics can arise,

regardless of the value of the infectivity of the other population.

3.4.3. Presenting Author: Ariel Chernomoretz

Topological characterization of disease-related annotations in high confidence proteinprotein interaction networks.

A. Berenstein[1], J. Piñeiro[2], L.Furlong[2], and A. Chernomoretz[1]

[1]Integrative Systems Biology Group, Fundación Instituto Leloir & IFIBA CONICET, Buenos Aires, Argentina.

[2]Research Programme on Biomedical Informatics (GRIB), Hospital del Mar Medical Research Institute (IMIM), Universitat Pompeu Fabra (UPF), C/Dr. Aiguader, 88, 08003 – Barcelona, Spain.

In recent years there has been a lot of interest in the application of complex network theory to human health related research programs. Taking advantage of the increasing availability of molecular interaction data, the network metaphor has appeared as an appealing framework to unveil patterns of biological relevance. In order to elucidate the molecular basis of human diseases a lot of attention has been paid to the analysis of potential biases in topological features - such us degree, clustering or betweenness - for diseases associated genes in the context of protein interaction networks. Following this line of research, we present a novel analysis based on the study of non-trivial associations between disease genes and the modular structure of the considered protein interaction network. We found that topological roles played by disease-associated genes were selectively enriched in different class of diseases. Our analysis also shows that cancer associated genes tend to populate high participation roles and recapitulates the idea that cancer genes present different topological features than genes associated to other disease classes.

3.5. Complex system dynamics

3.5.1. Presenting Author: Orlando Alvarez-Llamoza

Global interactions, information flow, and chaos synchronization

O. Alvarez-Llamoza, M. G. Cosenza and G. Paredes

Departamento de Física, Facultad Experimental de Ciencias y Tecnología (FACYT), Universidad de Carabobo, Valencia, Venezuela

We investigate the relationship between the emergence of chaos synchronization and the information flow in dynamical systems possessing homogeneous or heterogeneous global interactions whose origin can be external (driven systems) or internal (autonomous systems). By employing general models of coupled chaotic maps for such systems, we show that the presence of a homogeneous global field, either external or internal, for all times is not indispensable for achieving complete or generalized synchronization in a system of chaotic elements. Complete synchronization can also appear with heterogeneous global fields; it does not requires the simultaneous sharing of the field by all the elements in a system. We use the normalized mutual information and the information transfer between global and local variables to characterize complete and generalized synchronization. We show that these information measures can characterize both types of synchronized states and also allow to discern the origin of a global interaction field. A synchronization state emerges when a sufficient amount of information provided by a field is shared by all the elements in the system, on the average over long times. Thus, the maximum value of the top-down information transfer can be used as a predictor of synchronization in a system, as a parameter is varied.

3.5.2. Presenting Author: Alexandre Souto Martinez

Ergodic crossover in partially self-avoinding stochastic walks

Juliana M. Berbert[1], Rodrigo S. González[2], and Alexandre S. Martinez[3]

[1]Instituto de Física Teórica (IFT), Universidade Estadual Paulista (UNESP), Caixa Postal 70532-2 01156-970, São Paulo, SP Brazil

[2]Instituto de Ciências Exatas e Tecnológicas, Universidade Federal de Viçosa (UFV), Rodovia MG-230 Km 7, 38810-000 Rio Paranaíba, MG Brasil

[3]Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto (FFCLRP), Universidade de São Paulo (USP), Av. Bandeirantes 3900, 14040-901 Ribeirão Preto, SP Brazil

Consider a one-dimensional environment with N randomly distributed sites. An agent explores this random medium moving deterministically with a spatial memory μ. A crossover from local to global exploration occurs in one dimension at a well-defined memory value $\mu_1 = \log_2 N$. In its stochastic version, the dynamics is ruled by the memory and also by temperature T, which affects the hopping displacement. This dynamics also shows a crossover in one dimension, obtained computationally, between exploration schemes, characterized yet, by the trajectory size (N_p) (aging effect). In this paper, for an analytical approach, we consider the modified

stochastic version, where the parameter T plays the role of a maximum hopping distance. This modification allows us to obtain a general analytical expression for the crossover, as function of the parameters μ, T and N_p. Differently from previous work, we find the crossover occurs in any dimension d. These results have been validated by numerical experiments and may be of great use fixing optimal parameters in search algorithms.

3.5.3. Presenting Author: Pablo Balenzuela

The role of topology in collective behavior of excitable networks driven by noise

Pablo Balenzuela[1], **Pau Rué**[2], **Stefano Boccaletti**[3], **and Jordi Garcia-Ojalvo**[4]

[1] Departamento de Física, FCEyN, Universidad de Buenos Aires and IFIBA - Conicet
[2] Department of Genetics, University of Cambridge, Cambridge, England, UK
[3] Istituto Nazionale di Ottica Applicata, Firenze, Italia
[4] Department of Experimental and Health Science, University of Pompeu Fabra, Spain

In this work we analyze the collective behavior of excitable units driven by noise and coupled with different network's topologies in three different dynamical regimes.

An excitable element provides a nonlinear response under any given stimulus. It can be thought basically as a threshold device: if the stimulus is above the threshold, the unit responds, otherwise, it remains silent. This response is usually invariant under changes in the stimulus intensity. The best example of this behavior is the action potential (or spike) of a neuron. When they are coupled in networks, the interplay between individual dynamics and underlying topology gives raise to the emergence of collective properties, such as synchronization or coherent spiking response.

In the last years the synchronization of coupled chaotic oscillator and their dependence with the underlying network topology was extensively studied. It has been found that strongly heterogeneous networks (like scale free networks) synchronize worst than homogeneous ones, a phenomenon known as a the paradox of heterogeneity. However, if the links of heterogeneous networks are weighted with their betweenness, the synchronization improves notoriously.

An interesting behavior of excitable elements driven by noise is the phenomenon known as "coherence resonance", which happen when neurons respond in a quasi-periodic (coherent) way for an intermediate amount of noise. In networks of excitable units, it has been found that the degree of coherence is better than in individual neurons. It means that many neurons, driven by a purely stochastic stimulus, spike more regularly than an individual neuron driven by the same stimulus. This collective behavior, known as Array Enhanced Coherence Resonance (AECR) can be achieved only if there exist a balance between the degree of synchronization of the units of the networks and its coherent behavior.

In order to analyze the emergence of non-trivial collective properties related to the balance of coherence response and synchronization, we study the behavior of networks of excitable units coupled with different topologies of connections: Unweighted and Weighted Scale Free Networks (UWSFN and WSFN), Regular Networks (RN) and Random (ER) Networks in three different dynamical regimes: sub-threshold, spike driven and noise driven. The results shown in this work suggest than WSFN display an optimal balance between synchronization and coherence behavior given by the link's weighting procedure, which reduces the heterogeneity in the node's dynamics, improving the global response of the system.

3.5.4. Presenting Author: Osvaldo Anibal Rosso

Information Theory quantifiers based on Horizontal Visibility Graphs: distinction between stochastic and chaotic time series

Martín Gómez Ravetti[1], Laura C. Carpi[2], Bruna Amin Gonçalves[1], Alejandro Frery [2], and Osvaldo A. Rosso[3,4,5]

[1] Departamento de Engenharia de Produção, Universidade Federal de Minas Gerais. Av. Antônio Carlos 6627, Belo Horizonte. 31270-901 Belo Horizonte - MG, Brazil.
[2] LaCCAN/CPMAT - Instituto de Computação, Universidade Federal de Alagoas. BR 104 Norte km 97. 57072-970 Maceió, Alagoas – AL, Brazil.
[3] Instituto de Física, Universidade Federal de Alagoas. BR 104 Norte km 97. 57072-970 Maceió, Alagoas – AL. Brazil.
[4] Laboratorio de Sistemas Complejos, Facultad de Ingeniería, Universidad de Buenos Aires (UBA). (1063) Av. Paseo Colón 840, Ciudad Autónoma de Buenos Aires, Argentina.
[5] CONICET, Argentina.

A recently developed methodology for time series analysis, the Visibility Graph algorithm [Lacasa *et al.*, Proc. Natl. Sci. U.S.A. 105, 4972 (2008)], has been successfully used to study the distinction between deterministic and stochastic time series (TS). Specifically, a simplification of this method called the horizontal visibility graph (HVG), was used to distinguish between chaotic, correlated and uncorrelated noise time series [L. Lacasa and R. Toral, Phys. Rev. E., 82, 036120 (2010)]. To characterize the different nature of the systems, the degree distribution associated to the TS were fitted by using an exponential function $P(k)exp(-\lambda k)$ in a selected scaling region. By doing that, the λ parameter equal to $ln(3/2)$ for the uncorrelated noise situation, was found to be the central value that separates correlated noises ($\lambda > ln(3/2)$) from chaotic dynamics ($\lambda < ln(3/2)$). Nevertheless the methodology is well grounded; it cannot be applied to specific systems that posses laminar regions mixed with chaotic bursts, such as the Schuster map. In this case, it is not possible to found a representative scaling region due to the form of its corresponding degree distribution. In this work, we propose a methodology to characterize chaotic, correlated and uncorrelated noise time series by using the horizontal visibility graph methodology together with Information Theory quantifiers that does not require the choice of any scaling region, and consequently can be applied to any dynamical system. The chaotic systems considered in this analysis are the 27 chaotic maps described by Sprott [J.C. Sprott, *Chaos and Time Series Analysis* Oxford University Press, New York, (2003)] and the Schuster map. As correlated stochastic processes we use the fractional Brownian motion (fBm), the fractional Gaussian noise (fGn) and noises with power spectrum $f\hat{\ }-k\ PS$. Following, Olivares [Olivares *et al.*, Phys. Lett. A, 376, (2012) 1577-1583] we based our analysis on the so-called Shannon-Fisher Information plane that captures either, global and local features of the system's dynamics. By doing that, we were able to efficiently represent the different nature of the systems, as long as to distinguish between the degree of correlations structures.

3.5.5. Presenting Author: Mónica Jhoana Mesa Mazo

Complex behavior due to the effects of the cycle and phase of traffic light in a one dimensional traffic model.

Mónica J. Mesa[1], **Gerard Olivar**[1], **and Jhonny Valencia**[2]

[1] Dep. of Electrical, Electronic and Computer Sciences, Universidad Nacional de Colombia Manizales, Campus La Nubia

[2] Dept. of Computer Science and Decision, Universidad Nacional de Colombia,Medellín, School of Mines

Of every six human beings that inhabit the planet, three people live in cities and two live in developing countries. According to the UN, the urban population is currently estimated to be at 6000 million people in 2000 and 7000 million people in 2011. The population growth in cities increases the demand to build infrastructure which must meet the common needs of a growing populations. One of these important growing needs is accessible urban transport infrastructure that will enable people to have quick, inexpensive, and adequate transportation. Transportation is a problem that is shared by nearly all cities all around the world. This is due to the increase in the use of private vehicles. Private motorized vehicles also cause more accidents than public urban transportation. In addition, private motorized vehicles create more pollution, which causes environmental issues that can lead to health problems. For example, it is estimated that by 2015, urbanized areas will cause 80 percent of CO_2 emissions globally [1].

There are numerous researchers and different traffic studies devoted to creating a model that would help to control and analyze urban traffic [2-5].

In this paper we present an overview of the piecewise smooth model and simulation of a traffic model, characterized by a single vehicle traveling through a sequence of traffic lights that turn on and off with a specific change frequency ω and a phase $\varphi_n = -\sum_{m=1}^{n} \frac{L_m \omega}{v_{ola}}$. Also the separation between the nth and (n+1) traffic light is Ln. The nth light is green if $sin(\omega t + \varphi_n) > 0$, otherwise the light will be red.

We will show the description of the mathematical modeling used to simulate the system. The simulation was developed under an event driven strategy and implemented in Matlab. Regarding to the numerical analysis, we built a bifurcation diagram where the parameter under variation is the cycle of traffic light. As a principal result we evidence the effects of the cycle and phase of traffic light in the dynamical behavior of the system.

Piecewise smooth dynamical systems,vehicular traffic , non-linear numerical analysis, bifurcations, chaos.

References

[1] Lupano, J.A. Sánchez, R.J. *Políticas de movilidad urbana e infraestructura urbana de transporte*. Publicación de las Naciones Unidas, febrero 2009.

[2] Mesa, M.J. Olivar, G. *Bifurcaciones en un sistema de tráfico*.DDays 2012 South America, Noviembre 2012.

[3] Toledo B.A , J. Rogan, V. Muñoz, C. Tenreiro and J.A Valdivia. *Modeling traffic through a sequence of traffic lights.* Physical Review, E 70 016107, 2004.

[4] Valencia, J. Osorio, G. *Bifurcación por impacto con esquina en el sistema leva seguidor*: Universidad Nacional de Colombia, 2012.

[5] Villalobos, J. *Chaos in transit systems.* Universidad de los Andes. Departamento de Ingeniería Industrial. Ceiba Complejidad. August 2010.

3.5.6. Presenting Author: E.A. Jagla

A visco-elastic interface driven on a disordered landscape: modeling earthquake dynamics and friction phenomena

E. A. Jagla[1], F. Landes[2], and A. Rosso[2]

[1]Centro Atómico Bariloche and Instituto Balseiro, Comisión Nacional de Energía Atómica, (8400) Bariloche, Argentina

[2]CNRS - Université Paris-Sud, LPTMS, UMR8626, 91405 Orsay Cedex, France

When an elastic interface is pulled at constant average velocity on a quenched disorder potential, its advance occurs through abrupt instability events called avalanches, that display a broad distribution of sizes. Yet these avalanches are not temporally correlated, and the global dynamics is stationary: the pulling strength (the friction force) is constant in time up to statistical fluctuations. The introduction of viscoelastic effects in the interface deeply alters this phenomenology and provides a realistic description of friction phenomena, of which seismicity is just a large scale manifestation. The dynamics may become non-stationary, displaying a stick-slip behavior in time: the interface is blocked in the stick stage, and a system size avalanche advances the whole interface in the slip stage. In other cases we observe that the dynamics is stick-slip-like only on a local scale, with the phase of the stick-slip cycle depending on the spatial position. Numerical simulations in this case give a fairly realistic account of many characteristics of seismic phenomena.

3.5.7. Presenting Author: Sergio Roberto Lopes

Anomalous transport induced by nonhyperbolicity

S. R. Lopes[1], J. D. Szezech Jr[2], R. F. Pereira[3], and R. L. Viana[1]

[1]Departamento de Física, Universidade Federal do Paraná, Curitiba, PR, Brazil

[2]Programa de Pós-Graduação em Ciências/Física, Univ. Est. de Ponta Grossa, PR, Brazil

[3]Departamento de Matemática, Universidade Fedetral Tecnológica, Ponta Grossa, PR, Brazil

In this paper we study how deterministic features presented by a system can be used to perform direct transport in a *quasi*-symmetric potential and weak dissipative system. We show that the presence of nonhyperbolic regions around acceleration areas of the phase space plays an important role in the acceleration of particles giving rise to direct transport in the system. Such effect can be observed for a large interval of the weak asymmetric potential parameter

allowing the possibility to obtain useful work from unbiased nonequilibrium fluctuation in real systems even in a presence of a *quasi*-symmetric potential.

3.5.8. Presenting Author: Cristina Masoller

Inferring signatures of determinism in stochastic complex systems

A. Aragoneses, S. Perrone, T. Sorrentino, M. C. Torrent, and C. Masoller

Universitat Politècnica de Catalunya

I will present a method to infer signatures of determinism in the sequence of optical spikes emitted by a semiconductor laser with optical feedback, which resemble neuronal spikes. The method uses symbolic ordinal time-series analysis to classify inter-dropout-intervals (IDIs) in two categories that display statistically significant different features, one being consistent with waiting times in a resting state until noise triggers a dropout, and the other, with dropouts occurring during the return to the resting state, which has a clear deterministic component [1]. The method can be used for the analysis of real-world data, such as neuronal recordings of inter-spike intervals (ISIs), or data generated by complex systems such as inter-event times of user activity in social communities, where signatures of deterministic dynamics can be obscured by the presence of noise. The method is computationally simple to implement and the data requirements can be adapted for the analysis of small and large data sets.

References

[1] A. Aragoneses et al, Scientific Reports. 3, 1778; DOI:10.1038/srep01778 (2013).

3.6. Non-equilibrium and fluctuation phenomena

3.6.1. Presenting Author: Sebastian Bustingorry

The harmonic approximation to single-file diffusion and its two-dimensional generalization

Sebastian Bustingorry[1] **and Paulo M. Centres**[2]

[1]CONICET, Centro Atómico Bariloche, 8400 San Carlos de Bariloche, Río Negro, Argentina

[2]Departamento de Física, Instituto de Física Aplicada, Universidad Nacional de San Luis-CONICET, Chacabuco 917, D5700HHW, San Luis, Argentina

The single-file diffusion is a paradigmatic problem in statistical physics, aimed to model the strictly one-dimensional diffusion of particles with excluded volume interactions. It can be shown that, even in its simplest symmetric realization where forward and backward particle displacements occur with equal probability, the long time tagged particle diffusion is subdiffusive for infinite systems. Within an harmonic approximation to particle interactions, this behavior can be traced back to the interface growing exponent related to the well known Edwards-Wilkinson equation where the diffusion of the tagged particle is linked to the roughness of an interface model. Furthermore, it is well established that the asymmetric case can be associated to the Kardar-Parisi-Zhang equation. With this in mind, we take one step further and generalize this mapping to the two-dimensional case, where the single-file diffusion condition is generalized not only by the excluded volume interaction but through the more stringent cage effect. This can be of key relevance to diffusion models with constrained dynamics where the cage effect is an essential ingredient.

3.6.2. Presenting Author: Tarcísio Marciano da Rocha Filho

Scaling of the dynamics of homogeneous states of one-dimensional long-range interacting systems

Tarcísio Marciano da Rocha Filho[1,2], **Ademir Eugênio de Santana**[1,2], **Marco Antônio Amato**[1,2], **and Annibal Dias de Figueiredo Neto**[1,2]

[1]Instituto de Física - Universidade de Brasília

[2]International Center for Condensed Matter Physics

Quasi-Stationary States of long-range interacting systems have been studied at length over the last fifteen years. It is known that the collisional terms of the Balescu-Lenard and Landau equations vanish for one-dimensional systems in homogeneous states, thus requiring a new kinetic equation with a proper dependence on the number of particles. Here we show that previous scalings described in the literature are due either to small size effects or the use of improper variables to describe the dynamics. The correct scaling is proportional to the square of the number of particles and a new kinetic equation valid for the homogeneous regime is obtained. Numerical evidence is given for some typical models such as the Hamiltonian Mean Field and Ring models for different types of homogeneous initial conditions. The kinetic equation obtained

is also relevant for one-dimensional homogeneous models in plasmas, where the same dynamical scaling is observed.

3.6.3. Presenting Author: Horacio S. Wio

Noise Induced Phase Transitions and Coupled Brownian Motors: Non Standard Hysteretic Cycles

Horacio S. Wio

Instituto de Fisica de Cantabria, U.Cantabria & CSIC, Santander, Spain

Recent work [1,2,3] have shown the possibility, through a noise induced symmetry breaking leading to a nonequilibrium phase transition, of obtaining a set of coupled Brownian motors. It was also shown [4] that in some parameter region such a system could show negative mobility (that is motion opposed to the applied force) and anomalous hysteretic behavior (clockwise in opposition to the usual counter-clockwise). Using an explicit mean-field approximation and colored multiplicative noises, it was found a contraction of the ordered phase (and re-entrance as a function of the coupling) on one hand, and a shift from anomalous to normal hysteretic behavior on the other [5]. This behavior was obtained in systems presenting a noise induced phase transition that originates from a short time instability. Here we discuss a similar system, but where the noise induced phase transition is originated in an entropic mechanism [6]. Some preliminary studies that exploits such a mechanism indicate the possibility of obtaining no standard hysteretic cycles: anti-clockwise but showing a staircase-like structure. Depending on the parameter region, the hysteresis diagram could have one or more blocks, that can be explored as a whole or step by step, opening the possibility of exploiting it as a noise-controlled multipurpose logic gate[7].

References

[1] Sagués et al, Rev. Mod. Phys. 79, 829 (2007)

[2] van den Broeck et al, Phys. Rev. E 55, 4084 (1997)

[3] Mangioni et al, Phys. Rev. E 61, 223 (2000)]

[4] Reimann et al, Europhys.Lett. 45, 545 (1999)

[5] Mangioni et al, Phys. Rev. E 66, 051106 (2002)

[6] Carrillo et al, Phys. Rev. E 67, 04611 (2003)

[7] Wio, 22th ICNF-IEEE Proceedings (in press)

3.6.4. Presenting Author: Welles Morgado

Noise properties and thermostatistics for small systems

Welles A. M. Morgado[1] and Sílvio M. Duarte Queirós[2]

[1]Department of Physics, PUC-Rio and National Institute of Science and Technology for Complex Systems, Rua Marquês de São Vicente 225, 22453-900 Rio de Janeiro — RJ, Brazil

[2]Centro Brasileiro de Pesquisas Físicas and National Institute of Science and Technology for Complex Systems, Rua Dr Xavier Sigaud, 150, 22290-180 Rio de Janeiro — RJ, Brazil

Focusing on the long-term description of a thermodynamical system by means of time averaging of the noise, we first survey the problem of an anharmonicaly damped massive particle subjected to the standard Gaussian bath, namely the velocity-position joint probability density function and the cumulative injected and dissipated heat functions probability of heat transfer. We study the influence of the type of the noise on the heat injection and its statistics.

3.7. Nonlinear optics

3.7.1. Presenting Author: Vincent Odent

Photo-isomerization controlled optical pupil in dye-doped nematic liquid crystals

V. Odent[1], M. G. Clerc[1], C. Falcón[1], U. Bortolozzo[2], E. Louvergneaux[3], and S. Residori[1]

[1] Departamento de Física, Facultad de Ciencias Físicas y Matematicas, Universidad de Chile, Casilla 487-3, Santiago, Chile

[2] INLN, Université de Nice-Sophia Antipolis, CNRS, 1361 route des Lucioles 06560 Valbonne, France

[3] Université Lille1, Laboratoire de Physique des Lasers, Atomes et Molécules, CNRS UMR 8523, 59655 Villeneuve d'Ascq Cedex, France

Lately photoresponse of materials has become a very attractive research subject. It offers ways to develop many applications without using an electrical power supply [1]. Many studies have shown a particular interest on the photoisomerization transition (between an anisotropic state and an isotropic state) which is used like an optical switching [2]. However these studies consider a homogeneous optical forcing [2,3], while the optical external forcing is a laser beam with a Gaussian spatial profile. They have also showed that the temperature is an important factor for this transition.

We propose to study experimentally the front propagation in 2D submitted to a Gaussian profile corresponding to a photoisomerization. We will also compare also the front propagation with the spatio-temporal temperature evolution induced by the laser beam in the medium.

The setup is composed by a dye doped liquid crystal illuminated by a laser beam. The optical signal is recorded by a CDD camera. A polarizer is disposed in front of it to optimize the contrast between two states. In order to record the temperature evolution, a thermal camera is placed at a certain angle near the liquid crystal sample.

We determine experimentally that the transition is a first order with a hysteresis cycle. A bistable system submitted to a Gaussian forcing in 1D was studied theoretically by [4]. They find the front temporal evolution can be reproduced by a hyperbolic tangent. In the first place, to verify that the front propagation dynamics in 2D follows a hyperbolic tangente, we detect the circle radius in the time (the front position). The experimental result is in a very good agreement with the analytical trajectory. Later, we study experimentally and numerically the final front position with different laser intensities. The numerical simulations show a good quantitative correspondence with the analytical prediction and the experimental work also show a good qualitative correspondence with the analytical prediction.

Finally, we follow, in real time, the front propagation and the spatio-temporal evolution of the temperature in the dye doped liquid crystal. We show that there is a perfect correlation between the front and temperature propagations.

References

[1] H. Koerner, T. J. White, N. V. Tabiryan, T. J. Bunning, and R. A. Vaia1*materials today*, **11**, 34-42 (2008)

[2] A. Shishido, O. Tsutsumi, A. Kanazawa, T. Shiono, T. Ikeda, and N. Tamai. *J. Am. Chem. Soc.*, **119**, 7791–7796. (1997)

[3] I. C. Khoo. *Physics Reports* , **471** 221–267 (2009)

[4] V. Odent, S. Coulibaly, P. Glorieux, M. Taki, and E. Louvergneaux *unpublished*

3.7.2. Presenting Author: M.G. Clerc

Strong Nonlocal Coupling Stabilizes Localized Structures: An Analysis Based on Front Dynamics

M. G. Clerc

Lafer, Departamento de Física, FCFM, Universidad de Chile, Santiago, Chile

The existence, stability properties, and dynamical evolution of localized spatiotemporal chaos are studied. We provide evidence of spatiotemporal chaotic localized structures in a liquid crystal light valve experiment with optical feedback. The observations are supported by numerical simulations of the Lifshitz model describing the system. This model exhibits coexistence between a uniform state and a spatiotemporal chaotic pattern, which emerge as the necessary ingredients to obtain localized spatiotemporal chaos. In addition, we have derived a simplified model that allows us to unveil the front interaction mechanism at the origin of the localized spatiotemporal chaotic structures

3.8. Nonlinearities in social and biological systems

3.8.1. Presenting Author: Marcelo Lobato Martins

Boolean network model for cancer pathways: predicting carcinogenesis and targeted therapy outcomes

H. F. Fumiã and M. L. Martins

Departamento de Física, Universidade Federal de Viçosa, 36570-000, Viçosa, MG, Brazil

A Boolean dynamical system integrating the main signaling pathways involved in cancer is constructed based on the currently known protein-protein interaction network. This system exhibits stationary protein activation patterns — attractors — dependent on the cell's microenvironment. These dynamical attractors were determined through simulations and their stabilities against mutations were tested. In a higher hierarchical level, it was possible to group the network attractors into distinct cell phenotypes and determine driver mutations that promote phenotypic transitions. Such drivers are in agreement with those pointed out by diverse census of cancer genes recently performed for several human cancers. Furthermore, our results demonstrate that cell phenotypes can evolve towards full malignancy through distinct sequences of accumulated mutations. In particular, the network model supports routes of carcinogenesis known for some tumor types. Finally, the Boolean network model is employed to evaluate the outcome of molecularly targeted cancer therapies.

3.8.2. Presenting Author: Charles Novaes de Santana

Self-Organized Dynamic Predation-And-Migration Model: A Framework For Addressing The Complexity Of Species Interactions With Each Other And The Environment.

C. N. de Santana[1,2], Pablo A. Marquet[2,3,4], Carlos M. Duarte[2,5,6], and A. F. Rozenfeld[7,8]

[1] Department of Fish Ecology and Evolution / EAWAG, Kastanienbaum, Switzerland
[2]International Laboratory on Global Changes / IMEDEA-PUC-UFRJ, Palma, Spain
[3]Center of Advanced Studies in Ecology and Biodiversity (CASEB) / PUC-Chile, Santiago, Chile
[4]The Santa Fe Institute / Santa Fe, New Mexico, USA
[5]The UWA Oceans Institute / University of Western Australia, Perth, Australia
[6]Department of Global Change Research / IMEDEA, Esporles, Spain
[7]Engineering Department / Universidad del Centro, Buenos Aires, Argentina
[8]Rui Nabeiro Biodiversity Chair / University of Évora, Évora, Portugal

Understanding the structure and dynamics of ecological networks has become critical for understanding the persistence and stability of ecosystems. Recent works described topological properties and the robustness of food webs to the extinction of species at different trophic levels following different sequences and have revealed that ecosystems can respond differently to environmental disturbances. Such structural analyses are relatively fast and easy but their utility in capturing important information about functions and processes is often questioned.

Dynamical models in contrast provide essential information especially if one needs to understand changes in abundances, with the structure of the food web being almost constant. Here we present advances in the development of a framework to simulate dynamics undergoing ecosystem networks. We use a Monte Carlo (MC) approach to simulate the dynamics of predation and migration in an ecosystem for different timeline. We build networks of geographical spots (nodes) in which the links between each pair of spots mimic routes allowing species to move around geographically. At each spot it takes place simultaneously the interacting dynamics between individuals of different species lead by the architecture of a food web. We combine the dynamics of food webs together with spreading due to pursuit and evasion along the geography. The dynamic of the system depends on some parameters defined for the species and for the spots: Birth Probability (BP); Death by Predation Probability (DPP); Natural Death Probability (NDP); Mobility Probability (MP). Their values are defined automatically during run time, depending only on the availability of resources and on the pressure by consumers for the each species of the food web, defined by the density of individuals of each species and its preys and predators. By expressing the parameters that govern the dynamics as functions of densities, apparently, we introduce correlations between BP, DP P, NDP, MP, CC. As a result of that, the system self-organizes towards steady state, independently of the initial number of individuals of each species.

3.8.3. Presenting Author: Dante R. Chialvo

Exploration of the large-scale brain dynamics during the psychedelic state

Enzo Tagliazucchi [1], Robin Carhart-Harris[2], David Nutt[2], and Dante R. Chialvo [3,4]

[1] Neurology Department and Brain Imaging Center, Goethe University, Frankfurt am Main 60528, Germany
[2] Imperial College London, Centre for Neuropsychopharmacology, Division of Experimental Medicine, London, UK
[3] Concejo Nacional de Investigaciones Científicas y Tecnológicas, Buenos Aires, Argentina
[4] Facultad de Ciencias Médicas, Universidad Nacional de Rosario, Rosario, Argentina

Recent neuroimaging studies have demonstrated that the spontaneous brain activity reflects, to a large extent, the same activation patterns measured in response to cognitive and behavioral tasks. This correspondence has been explored with a large repertoire of computational methods, ranging from correlation measures to global brain networks yielded by independent component analysis. In this work we introduce a novel framework to study how different large scale brain connectivity states evolve and explore its use during the effect of psychedelic agents.

Psilocybin, a psychedelic substance found in 'magic mushrooms', is known to induce a state of unconstrained cognition, as well as to cause profound alterations in the perception of time, space and selfhood. Given the current interest in re-studing hallucinogen agents for the treatment of psychiatric conditions, the understanding of psilocybin mechanisms is of paramount importance. Here we analyze resting-state functional magnetic resonance data obtained from fifteen subjects before, during and after intravenous infusion of psilocybin and an inert placebo (saline).

Our analysis shows for the first time that psilocybin induces a different repertoire of limbic system connectivity states when compared to control conditions. In addition, the analysis shows changes in the brain signal spectral scaling exponents, affecting exclusively higher brain systems such as the default mode, executive control and bilateral dorsal attention networks.

Overall, the results demonstrate a displacement of the brain's normal dynamical operating point towards a more fluctuating regime and the feasibility to read the hallucinating mind dynamical states from neuroimaging data.

3.8.4. Presenting Author: Silvina Ponce Dawson

Fluctuations and transport inside cells

Emiliano Pérez Ipiña and Silvina Ponce Dawson

Departamento de Física, FCEN-UBA and IFIBA, CONICET

Imaging techniques are giving an ever deeper insight into the way in which the intracellular world functions. In particular, the expression of fluorescent proteins that behave as the native (non-fluorescent) ones has given researchers the opportunity to observe the spatio-temporal dynamics of various key cellular components. Imaging techniques are continuously improving thus, providing information of higher and higher spatial and temporal resolution. As the resolution increases fluctuations become more relevant. There are several techniques (*e.g.*, Fluorescence or Image Correlation Spectroscopy, FCS or ICS) that exploit the existence of fluctuations to estimate transport rates, particularly, diffusion coefficients, of different substances. The analysis of these experiments require the use of an underlying model. Most of these models make judicious assumptions on the ways in which number particle fluctuations behave. However, the volume that is available for diffusion is quite restricted inside cells due to the existence of numerous organelles and stores. On the other hand, the transport of key molecules usually involves diffusion and binding and unbinding to immobile or slowly moving sites. In this work we investigate to what extent these aspects affect fluctuations. In particular, we study the correlations between species that appear due to the limited available volume and the interaction with binding sites and discuss what implications they have on the interpretation of FCS experiments.

3.8.5. Presenting Author: Gastón L. Miño

Fast and slow swimmer: a consequence of nutrient source

Gastón L. Miño[1], Nicole King[3], Mimi A. R. Koehl[2], and Roman Stocker[1]

[1]Department of Civil and Environmental Engineering, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

[2]Integrative Biology, University of California, Berkeley, California 94720, USA

[3]Department of Molecular and Cell Biology, University of California, Berkeley, California 94720, USA

Protozoans play an important role in aquatic food webs. The ability to locate and exploit patches becomes particularly important in environments where background resource availability is low, such as in the ocean, where planktonic microorganisms regularly experience background concentrations of limiting nutrients and prey that are below the critical limits required for optimum growth. However, dissolved nutrients and bacteria are patchily distributed in the water column. To succeed within heterogeneous environments, organisms must possess movement and search behaviors that maximize exposure to limiting resources. To understand how

such environmental heterogeneity affects the ecology of populations, it is imperative to explore foraging behavior at environmentally relevant spatiotemporal scales.

The flagellated protozoan Salpingoeca rosetta is one of the closest relatives of multicellular animals. This cell uses a single flagellum to drive a flow of water and captures bacterial prey. This cell can produce colonies, fast and slow swimmer and theca cell depending on the environmental conditions. Fast and slow swimmers are morphological different. Slow swimmers have a long feeding collar and rounded cell body. Fast swimmers, in contrast, have a reduced or absent feeding collar. The transition on how a cell decides to become a fast swimmer it is not well understood.

In this work we try to elucidate on how the environment can produce a selection in the mode of swimming. Preliminary results suggest that the depletion of prey bacteria may activate certain mechanisms, showing the apparition of fast swimmers in the suspension.

3.8.6. Presenting Author: José Roberto Iglesias

Crimes against humanity: The role of global institutions

Eder M. Schneider[1], José Roberto Iglesias[1,2], Marcelo Kuperman[3], and Karen Hallberg[3]

[1]Instituto de Física, UFRGS, Porto Alegre, Brazil

[2]Instituto Nacional de Ciência e Tecnologia de Sistemas Complexos, Rio de Janeiro - Brazil

[3]Consejo Nacional de Investigaciones Científicas y Técnicas, Centro Atómico Bariloche and Instituto Balseiro - C.N.E.A., 8400 S. C. de Bariloche, Argentina

We discuss the role of international institutions, like the International Criminal Court (ICC), as an effective way of reducing the number and/or gravity of crimes against humanity. The action of the ICC is directed against leaders that authorize or promote these kinds of crimes, i.e. political authorities, army commanders, civil leaders, etc. In order to simulate the action of the ICC we build a hierarchical society where the most important leaders have the highest connectivity and can spread their points of view, or their orders, through a chain of less but still highly connected deputy chiefs or opinion chieftains. In this way, if they practice misconduct, corruption, or any kind of discriminatory or criminal actions against individuals or groups, it would very difficult and improbable that they will be prosecuted by the courts of their own country. It is to alleviate this situation that the ICC was created. Its mission is to process and condemn crimes against humanity though a supranational organism that can act on criminal leaders in any country. In this study, the action of the ICC is simulated by removing the corrupt leader and replacing it by a "decent" one. However, as the action of the corrupt leader could have spread among the population by the time the ICC acts, we try to determine if a unique action of the ICC is sufficient or if further actions are required, depending on the degree of deterioration of the human rights in the hypothetical country. The results evidence the positive effect of the ICC action with a relatively low number of interventions. The effect of the ICC is also compared with the action of the local national judiciary system.

3.9. Other nonlinear phenomena

3.9.1. Presenting Author: Hilda A. Cerdeira

Multistable behavior for a locally coupled rings of oscillators above synchronization

Hilda A. Cerdeira

Instituto de Física Teórica, UNESP, São Paulo, Brazil

A system of nearest neighbors Kuramoto-like coupled oscillators placed in a ring is studied above the critical synchronization transition. We find a richness of solutions when the coupling increases, which exists only within a solvability region (SR). They posses different characteristics, depending on the section of the boundary of the SR where the solutions appear. We study the birth of these solutions and how they evolve when the coupling strength increases, and determine the diagram of solutions in phase space.

3.9.2. Presenting Author: Santiago Gil

A genetic-epidemiological approach to cybersecurity

Santiago Gil and Albert-László Barabási

Center for Complex Network Research, Northeastern University, USA

Using threat-log data from an IDS/IPS in a University network, we study the patterns of threatening activity for individual hosts. Relating this information to the properties of each host as observed through large-scale network scans, we establish correlations between the individual ports and services and how they relate to specific kinds of threatening behavior. The methods applied are analogous to those successfully used in genetic epidemiology to associate genetic properties of patients to phenotypical expression of pathologies. This methods prove useful to uncover global patterns in the susceptibility of individual hosts to be compromised by malicious agents.

3.9.3. Presenting Author: Gabor Csernak

Round-off, non-smoothness and chaos

Gabor Csernak[1] and Gabor Stepan[2]

[1]HAS-BUTE Research Group on Dynamics of Machines and Vehicles, Budapest, Hungary

[2]Department of Applied Mechanics, Budapest University of Technology and Economics, Budapest, Hungary

The dynamics of non-smooth systems gained particular attention in the recent years [1,2]. There are several engineering problems that motivate the research of this topic, e.g. impacts or dry friction contacts between machine parts, abruptly changing stiffness parameters in oscillators, dynamics of so-called DC/DC buck converters, or digital control systems. Chaotic vibrations that are originated from the digital implementation of control are known for more than 20 years [3]. The consideration of the effects of sampling and processing delay is a routine procedure among control engineers, but the round-off in the analogue-digital converters is usually neglected. However, round-off frequently leads to deterministic but small scale chaotic behaviour – so-called micro-chaos [4] – which is often considered simply as stochastic noise in the practice.

In the present contribution, we rigorously prove the chaotic nature of a simple, but quite general PD-controlled system. It is also pointed out that systems with digital feedback control are typically sensitive to initial conditions and there exists a finite attracting domain in their phase-space. We also show that the oscillations, related to micro-chaos may have a considerable influence on the accuracy and settling time of control systems. Several possibilities are highlighted for the numerical determination of important characteristics of micro-chaotic oscillations. Finally, a bifurcation analysis is presented, based on a smoothed model of digital control.

ACKNOWLEDGMENTS This research was supported by the Hungarian National Science Foundation under grant no. OTKA K 83890.

References

[1] Leine, Remco I., Nijmeijer, Henk, *Dynamics and Bifurcations of Non-Smooth Mechanical Systems*, Lecture Notes in Applied and Computational Mechanics, Vol. 18, ISBN 978-3-540-44398-8, Springer, 2004.

[2] M. di Bernardo, C.J. Budd, A.R. Champneys. P. Kowalczyk, *Piecewise-smooth Dynamical Systems - Theory and Applications.* Applied Mathematical Sciences, Vol. 163, ISBN: 978-1-84628-039-9, Springer Verlag London, 2008.

[3] F.D. Delchamps, Stabilizing a linear system with quantized state feedback, *IEEE Trans. Autom. Contr.*, **35** pp. 916-924, 1990.

[4] G. Haller, G. Stépán, Micro-Chaos in Digital Control, *J. Nonlinear Sci.*, **6**, pp. 415-448, 1996.

[5] G. Csernák, G. Stépán, Digital Control as Source of Chaotic Behavior, *International Journal of Bifurcation and Chaos*, **20**(5), pp. 1365-1378, 2010.

3.10. Small systems

3.10.1. Presenting Author: Sílvio M. Duarte Queirós

Is the heat conduction a purely thermal property?

Sílvio M. Duarte Queirós[1] **and Welles A. M. Morgado**[2]

[1]Centro Brasileiro de Pesquisas Físicas and National Institute of Science and Technology for Complex Systems, Brasil

[2]Department of Physics, PUC-Rio and National Institute of Science and Technology for Complex Systems, Brasil

The law of heat conduction, or Fourier's law, i.e., the property by which the heat flux density is equal to the product of the conductance by the negative temperature gradient emerges as a paradigmatic manifestation of the laws of thermodynamics. Despite of the fact that anomalies were already found in the 1960s, the problem of heat conduction has kept on being regarded as purely thermodynamic. Inspired by a wide range of non-linear (small) systems, which span from surface diffusion and low vibrational motion with adsorbates to biological motors wherein the energy source is the stochastic hydrolysis of adenosine triphosphate (ATP), we will theoretically discuss to what extend the heat conduction is a simple manifestation of the physics of a system in contact with reservoirs at different temperatures, independently of their natures. In addition, we will introduce predictions about whether or not the mechanical features of the system can influence thermodynamical measurements in experiments.

3.11. Soft matter

3.11.1. Presenting Author: Leopoldo R. Gómez

Nucleation and Growth on Curved Space

Leopoldo R. Gómez, Nicolás A. García, and Daniel A. Vega

Department of Physics, Universidad Nacional del Sur - IFISUR - CONICET, 8000 Bahía Blanca, Argentina.

Nucleation and growth (NG) is by far the most common mechanism leading the dynamics of first order phase transitions. Between other examples, this process directs the formation of a crystal phase from an initial liquid (crystallization), and the dynamics of order-order phase transitions in a huge variety of hard and soft condensed matter systems [P. G. Debenedetti, Metastable Liquids: Concepts and Principles (Princeton University Press, Princeton, NJ, 1998).].

In its classical picture, NG starts with local structural fluctuations of the initial phase which lead to the formation of small nuclei of the new phase. In general, the formation of a nuclei involve changes in different free energy contributions, which are competing in nature, and control the dynamical evolution of the phase transition. On one hand, the birth of a nucleus of the new phase produces an interphase, leading to an increase of free energy due to surface tension. On the other hand, there is a decrease in the total free energy due to the local formation of the less energetic phase. Here the competition of these surface and volume terms produce an activated dynamics, such that the only nuclei which can propagate are the ones whose size overpass a critical value.

The aim of the present study is to provide a general physical description of NG in two-dimensional crystalline systems lying on curved surfaces. Such curved crystals are not only commonly found in nature in systems like viral capsids, insect eyes, pollen grains, and radiolaria, but also can be grown in the laboratory by using colloidal particles, liquid crystals, block copolymers, and possibly other self-assembled condensed matter systems [V. Vitelli et. al, Proc. Natl Acad. Sci. USA **103**, 12323 (2006); W. T. M. Irvine et. al, Nature (London) **468**, 947 (2010)]; [García et. al, Phys. Rev. E **88**, 012306 (2013)].

Here, by using theoretical calculations and simulations, we show how the curvature of the substrate affects the critical size of propagating nuclei and the minimum energy path towards the equilibrium crystal phase. The model is based on a coarse-grained Guinzburg-Landau free energy functional and a phase-field evolution equation. This approach can be combined with polar geodesic coordinates and conformal mapping to obtain analytical expressions for the size of the critical nuclei as a function of degree of undercooling and local substrate's curvature.

3.11.2. Presenting Author: Daniel A. Vega

Defect Induced Buckling in Free Standing Smectic Membranes

Daniel A. Vega[1], Aldo D. Pezzutti[1], Nicolas A. Garcia[1], Paul M. Chaikin[2], Elisabetta Matsumoto[3], Raleigh Davis[4], and Richard A. Register[4]

[1] Instituto de Fisica del Sur (IFISUR), Consejo Nacional de Investigaciones Cientıficas y Tecnicas (CONICET), Universidad Nacional del Sur. Av LN Alem 1253 8000 Bahia Blanca, Argentina

[2] Center for Soft Condensed Matter Research and Department of Physics, New York University, New York, NY 10003, USA
[3] Elisabetta Matsumoto Princeton Center for Theoretical Science, Princeton University, Princeton, NJ 08540, USA
[4] Raleigh Davis and Richard A. Register Department of Chemical and Biological Engineering, and Princeton Institute for the Science and Technology of Materials, Princeton University, Princeton, NJ 08540, USA

During the last years there has been an increasing interest in the study of two-dimensional (2D) textures on non-Euclidean space [Kamien, Rev. Mod. Phys. 74, 953 (2002); Irvine, Vitelli, and Chaikin, Nature 468, 947 (2010).]. One of the main differences between planar and curved 2D-modulated phases is related to the structure of topological defects. While in most flat systems the defects are nontrivial excitations of the ground state, in the case of curved crystals long-range interactions can lead to complex arrays of defects strongly coupled to the geometry. Here we study the coupling between geometry and defects in free standing membranes with smectic symmetry. We analyze experimentally the conformation of free standing cylinder forming block copolymer thin films and found that the geometry is linked with the elastic distortions produced by the disclinations present in the texture. The membrane configurations are compared with those resulting from a phase field model that combines a classical Brazovskii Hamiltonian for the liquid-crystalline phase and a Helfrich-Canham model for the fluid membrane.

3.11.3. Presenting Author: Tomás S. Grigera

Order-agnostic lengthscales in supercooled liquids through amorphous boundary conditions

Tomás S. Grigera

INIFTA, Universidad Nacional de La Plata, Argentina y CCT La Plata, Consejo Nacional de Investigaciones Cientificas y Técnicas, Argentina

Static correlation lengths that grow accompanying the well-known slowdown of supercooled liquids have been long sought. In the last few years growing correlations have been finally detected numerically through several different techniques. One of such techniques is based on confinement, of which several variants have been considered. After a brief discussion of similarities and differences with other approaches, I will focus on the use of amorphous boundary conditions. These allow to determine two lengthscales: a proper correlation length and a penetration length. I will show recent numerical results using cavity and sandwich geometries and discuss the behaviour of these lenghtscales, the observed nonexponential decay and the possible connection of these lengths with dynamics.

Posters

4.1. Active matter and granular systems

4.1.1. Presenting Author: María Alejandra Aguirre

Influence of the packing fraction on the flow rate of granular material through an aperture

Rosario De Schant[1], Jean-Christophe Géminard[2], and María Alejandra Aguirre[1]
[1]Grupo de Medios Porosos, Fac. de Ingeniería, Universidad de Buenos Aires. Paseo Colón 850, (C1063ACV) Buenos Aires, Argentina.
[2]Universitéde Lyon, Laboratoire de Physique, Ecole Normale Supérieure de Lyon, CNRS, 46 Allée d'Italie, 69364 Lyon cedex 07, France.

Over the last 50 years, granular flow through an aperture in vertical systems, e.g. silos and hoppers, has been studied by different disciplines (engineering, physics and chemistry). Nevertheless, in many industrial applications, granular material is horizontally transported at a constant velocity over conveyors belts or floating on the surface of a flowing liquid, therefore a thorough study is needed in horizontal configurations. In dense systems we have found that granular flow rate, different from how a liquid behaves, does not depend on the local pressure near the outlet but depends on the velocity and the high initial packing fraction. However, in contrast to what can be observed in vertical systems, in horizontal configurations the system might have a low compacity which should affect the flow rate. In this work, we study the influence of compacity over the granular flow rate. Therefore, for systems with different initial packing fractions, we analyze the discharge of a packing of monodisperse grains transported through an orifice by a conveyor belt driven at a constant velocity. We propose a model which describes how, during the discharge process, the packing fraction is modified by the presence of the aperture and how these variations influence the flow rate. However, the packing fraction fluctuations do not affect the velocity of the grains near the outlet and therefore we conclude that changes in the flow rate are independently related to variations of the packing fraction or to fluctuations of the velocity of the grains near the outlet.

4.1.2. Presenting Author: Paula A. Gago

Intermittent flow during the discharge of a two-dimensional vibrated silo: Connections with pedestrian dynamics.

Paula A. Gago[1], Juan Pablo Peralta[1], Luis A. Pugnaloni[1], and Daniel R. Parisi[2]
[1]Departamento de Ingeniería Mecánica, Facultad Regional La Plata, Universidad Tecnológica Nacional, Av. 60 esq. 124 s/n, 1900 La Plata, Argentina
[2]Instituto Tecnológico de Buenos Aires, 25 de Mayo 444, 1002 C. A. de Buenos Aires, Argentina.

We present results on the distribution of interruption times during the discharge of a two-dimensional silo. The experimental setup allows for a controlled effective acceleration of gravity through an incline of variable angle and controlled vibration intensity via a shaker. The bursts of grains that flow during a discharge for small outlets are registered with a microphone. We show that the dead times between two bursts follow a long-tail distribution as observed in similar studies. The control of the effective gravity allows us to investigate the effect that internal pressure has on the jamming-unjamming events. We compare this experimental results with simulations of panic scape of pedestrian with variable desired velocities and show that the dynamics of the two systems are remarkably similar with the effective gravity in the granular system playing the role of the desired velocity for pedestrians.

4.1.3. Presenting Author: Gago P.

Granular entropy in high intensity tapping

P. A. Gago and L. A. Pugnaloni

Depto. de Ingeniería Mecánica, UTN, Facultad Regional La Plata

Recently, McNamara et al. developed a method to calculate granular entropy in tapped systems in order to test Edwards theory of static granular packings. This method is based on the prediction that the ratio of two overlapping volume histograms should be exponential in volume. They use the distribution of Voronoi cell volumes since the distribution of the global volumes is nearly Gaussian. Gaussian distributions can yield false positive results for the test. McNamara's focus on a narrow range of tap intensities where the packing fraction is known to be monotonically decaying with tap intensity. However, recent works have reported that packing fraction is nonmonotonic and grows as a function of tap intensity for high intensities. We extend the test proposed by McNamara to this wider range of tap amplitudes and make an

analysis of the implications in relation with the Edwards theory.

4.1.4. Presenting Author: Dino E. Risso

Hydrodynamic behavior of 2D confined granular fluids

Dino Risso[1], Rodrigo Soto[2], and Ricardo Brito[3]

[1] Departamento de Física, Universidad del Bío-Bío, Concepción, Chile
[2] Departamento de Física, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Santiago, Chile
[3] Departamento de Física Aplicada I and GISC, Universidad Complutense de Madrid, Madris, Spain

The dynamics of a granular medium subject to a bulk energy injection mechanism method is studied. Making simple generic assumptions on the injection method the hydrodynamics equations are written. The fluctuations around the stationary state are analyzed and described in terms of the dynamic structure factor as it provides information of the fields that couple to the density fluctuations but also of the transport coefficients and some equilibrium properties like compressibility or specific heats. Two regimes are distinguished. A disipative one in which the heat mode is suppressed and a quasielastic regime in which the heat mode is visible. The two regimes and the crossover between the two regimes are fully characterized. The crossover between the two regimes takes place at a wavevector that is proportional to the inelasticity. To validate the model we propose a two dimensional hard disk model in which disipative collisions are characterized by a constant restitution coefficient and a collisional energy input mechanism. The model is simulated using the event driven algorithm for systems of different restitution coefficients and global density. An stationary granular temperature is reached that depends on the injection and disipation mechanism. The simulational results for the temperature and collision rate are compared with theoretical predictions founding very good agreement. From the simulational results for the dynamic structure factor of the density fluctuations the behaviour of transport coefficients and thermal properties is obtained and it is compared with the theoretical predictions founding also very good agreement.

4.1.5. Presenting Author: Ivan Berdakin

Stokesian dynamics optimization of a three linked spheres micro-swimmer

I. Berdakin, V. I. Marconi, and A. J. Banchio

GTMC, Facultad de Matemática Astronomía y Física, Universidad Nacional de Córdoba and IFEG-CONICET, Argentina

Self-propulsion of microorganisms and artificial swimmers is only possible through the generation of motility strategies that are able to overcome the absence of inertia. This condition, implied in every low Reynolds number regime, enables the success of only those strategies that are irreversible in phase space. One of the simplest swimmers meeting this requirement is the three-linked-spheres, a swimmer built upon three spheres linked by two arms that contracts asynchronously. This simple swimmer has received a lot of attention because it can be studied

both, analytically and numerically. In this work we use stokesian dynamics simulations to study in detail the forces acting on each of the swimmer's components and the power consumption during its motion. We define efficiency as the ratio between power dissipation and the work needed to produce the same motion by an external force. We find that the most efficient swimmer is that in which its arms contracts almost absolutely. Interestingly, under these optimum conditions, the analytical predictions based on first order approximations of the hydrodynamic equations divert significantly from those found in our simulations, in which near field interactions are taken into account. This highlights the importance of considering the finite size of the spheres, as it is done by the method implemented here. We believe that the results shown in this work would be very useful when designing an artificial swimmer of this kind with the intention to test it experimentally.

4.1.6. Presenting Author: Ivan Berdakin

Geometrical optimization for motility-based microorganisms concentrator and sorter devices

I. Berdakin[1], Y. Jeyaram[2], A. V. Silhanek[3], A. Guidobaldi[4], L. Giojalas[4], C. A. Condat[1], and V. I. Marconi[1]

[1] GTMC, Facultad de Matemática Astronomía y Física, Universidad Nacional de Córdoba and IFEG-CONICET, Argentina

[2] INPAC, Institute for Nanoscale Physics and Chemistry, Nanoscale Superconductivity and Magnetism Group, K.U. Leuven, Belgium

[3] Département de Physique, Université de Liege, Belgium

[4] CeBiCeM, Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Argentina

The use of soft lithography to build asymmetric micro-substrates makes it possible to control microorganisms motion and promises new and interesting applications in health industry and biotechnology. In this work, we investigate two ways in which these ratchet devices can be employed. First we show, experimentally and numerically, that it is possible to accumulate sperm cells in a region of space of our choice. Second, we study the most efficient way to sort out different subpopulations in a mixed culture of E. coli bacteria, that differ by their specific swimming strategies. In both cases, we develop models that incorporate the most relevant phenomenological aspects of the cellular motion using realistic parameters found in experiments, and integrate the equations of motion through molecular dynamics algorithms [1]. For E. coli, we study the diffusion properties of each subpopulation along the sorter and define a purity parameter for the extraction of each strain as a function of position. We obtain in this way a set of optimized parameters of the array geometry that maximizes the sorting efficiency of the device. Our results show remarkably that it is possible to sort bacteria with 100

References

[1] I. Berdakin, Y. Jeyaram, V.V. Moshchalkov, L. Venken, S. Dierckx, S.J. Vanderleyden, A.V. Silhanek, C.A. Condat, V.I. Marconi *Phys. Rev. E* **87** 052702 (2013).

4.1.7. Presenting Author: Ismael P. Cáceres

Drift of a subharmonic pattern in a pinned vertically vibrated quasi 2D shallow granular system

Ismael P. Cáceres and Dino E. Risso

Departamento de Física, Facultad de Ciencias, Universidad del Bío-Bío, Concepción, Chile.

When a 2D shallow vertical array of granular matter is vertically vibrated with some amplitud and frequency of oscillation, inside a range of the acceleration of the base it is possible to observe a subharmonic wave pattern [1]. In reference [2] the authors find that for a vertically air fluidized shallow bed of granular matter the same kind of behaviour can be obtained and they observe that if the base of the bed is tiled the pattern drift against gravity above a critical angle. A general model is proposed to describe this behavior.

In our work we simulate a vertical 2D shallow array of granular matter in the hard sphere inelastic model by event driven molecular dynamics. There is disipation between the grains and with the walls characterized by restitution coefficients. In the regime in which a subharmonic wave pattern is observed if we simulate a time long enough we could see from time to time some "jumps" in the wave-length, in that seems that a half wave-length enters into the system through a border and another half wave-lenght left out it by the other border. This jumps don't have a preferent direction. However, if we tiled the base more than a critical angle the jumps do show a preferent direction of movement with a mean average velocity like the behavior described in the air fluidized experiment. Also we could see lateral secondary oscilations of the oscillation's peaks, that seems to be the result of an over-excitation of the system.

References

[1] E. Clément, L. Vanel, J. Rajchenbach, and J. Durán, Phys. Rev. E **53**, 2972 (1996).

[2] J. Garay, I. Ortega, M. G. Clerc, and C. Falcón, Phys. Rev. E **85**, 035201 (2012).

4.1.8. Presenting Author: Evelyn B. Riveros

Simulational study of hydrodynamic modes in two dimensional models of quasi 2D horizontal granular systems.

Evelyn Riveros[1], Dino Risso[1], Rodrigo Soto[2], and Ricardo Brito[3]

[1] Departamento de Física, Universidad del Bío-Bío, Concepción, Chile.

[2] Departamento de Física, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Santiago, Chile.

[3] Departamento de Física Aplicada I and GISC, Universidad Complutense de Madrid, Madrid, Spain.

We make a simulational study of the hydrodynamics modes in a confined granular fluid in a 2D system. The system is fluidized by a local energy input in a way akin to reference Phys. Rev. E 87, 022209 (2013) in which the energy is injected to the system by kicks in each collision. In our model the mechanism of energy injection is a restitution coefficient which is grater or smaller than one depending on the relative velocity of grains involved in the collision. Results for the collisional rate, temperature and pressure in the stationary state are obtained and compared with the theoretical predictions when using Enskog aproximation. From these results it is posible to define a region in the density and inelasticity phase space in which the Enskog approximation applies. Next, in this phase space, we study the space-time density fluctuations to obtain the dynamic structure factor and from this the thermodynamic properties and transport coefficients for the model. The dependence of these properties in wave number space allow us to characterize the crossover between two regimes in which the system behaves inelastically and quasielastically. Our results are in good agreement with the $\mathbf{\Delta}$ model of reference Phys. Rev. E 87, 022209 (2013). A second model is also studied. In this 2D model there is an extra internal freedom degree that stores energy according to the flight time between collisions. For a given set of parameters the model show large density fluctuations and for some critical values of the parameters a phase separation between a solid and a fluid region develops. The dependence of the transition on the control parameters of the model and the density of the granular system is characterized. Some order parameters are studied to characterize the transition.

4.1.9. Presenting Author: Mónica A. García-Ñustes

Emergence of dislocation chains in patterns subject to a nonuniform drift

M. G. Clerc, C. Falcón, V. Odent, and I. Ortega

Departamento de Física, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Casilla 487-3, Santiago, Chile

Pattern formation far from equilibrium occurs in several domains of sciences through the spontaneous symmetry breaking of a ground state [1]. Generally, the transition from an homogeneous state to a patterned one can be observed by modifying a single bifurcation parameter. Structures, generated at this first threshold of spatial instability, are generally stationary and can be either of (i) localized or of (ii) extended-periodic type. In extended systems, if we continued increasing the bifurcation parameter above threshold, the pattern can exhibit secondary instabilities commonly related to a stationary-to-propagating transition. This transition can be induced by parity-breaking transitions, when motionless patterns are exposed to drift forces [4]. In such case, patterns are deformed and advected, which is usually related to convective instabilities [2]. In this regime, the physical properties under study can produce a non-uniform drift. Interesting experimental cases are particle-laden flows inside a partially fluid filled, horizontal, rotating cylinder [5] and a one-dimensional transverse Kerr-type slice subjected to optical feedback [6]. In both cases, a rich a complex dynamics as spatio-temporal dislocations chains are observed.

Theoretical works have proposed that the observed dynamical behavior obeys to a induce local Eckhaus instability, as a result of non-uniformities present in the system [6,7]. However, the complete scenario that can trigger this spatiotemporal complex dynamics of drifting patterns have not been described yet.

In the present work we study the spatiotemporal dynamics of drifting patterns. Based on a generic amplitude equation, we identify the mechanism of emergence of dislocations chains as a phase instability–Eckhaus instability–induced by an *inhomogeneous drift force*. This phenomenon is experimentally confirmed in a tilted quasi-one dimensional fluidized shallow granular bed mechanically driven by a harmonic vertical vibration.

References

[1] G. Nicolis and I. Prigogine, *Self-organization in Non Equilibrium Systems* (Wiley, New York, 1977).

[2] M. C. Cross, and P. C. Hohenberg, Rev. Mod. Phys. **65**, 851, (1993).

[3] R. E. Goldstein, G.H. Gunaratne, L. Gil and P. Coullet, Phys. Rev. A **43**, 6700 (1991).

[4] M.G. Clerc, C. Fernandez-Oto, M. A. Garcia-Ñustes, and E. Louvergneaux, Phys. Rev. Lett. **109**, 104101 (2012).

[5] E. Guyez and P. J. Thomas, Phys. Rev. Lett. **100**, 074501 (2008); G. Seiden, and P. Thomas, Rev. Mod. Phys. **83**, 1323 (2011).

[6] E. Louvergneaux, Phys. Rev. Lett. **87**, 244501 (2001).

[7] H. Riecke, and H.G. Paap, Phys. Rev. A **59**, 2570 (1987).

4.1.10. Presenting Author: J. R. Darias

Relation between stress and flow rate in a two-dimensional silo during gravity discharge

J. R. Darias[1] and L. A. Pugnaloni[2]

[1]Laboratorio de Óptica y Fluidos, Universidad Simón Bolívar, Apartado Postal 89000,Caracas 1080-A,Venezuela.

[2]Departamento de Ingeniería Mecánica, Facultad Regional La Plata, Universidad Tecnológica Nacional, Av. 60 esq. 124 s/n, 1900 La Plata, Argentina.

We present results obtained from simulations using the Molecular Dynamics method for the stress on the walls and flow rate of particles in a two-dimensional silo discharged by gravity. The flow rate of particles was calculated as a function of the outlet diameter of the silo. We find that results are consistent with the two-dimensional Beverloo's scaling in an interval between six and twenty particles diameters. Moreover, we found that the data set for the flow rate over a wider range of orifice sizes is well fitted by the modified expression proposed by Mankoc et al. [1]. Interestingly, only for the region where the particle flow rate is predicted by the Beverloo's scaling, the quotient between the stress on the walls and base of the silo is constant. This result agrees with the hypotheses behind the Janssen's law [2] for the variation of the stress with the silo depth, where the quotient between the horizontal and vertical stress is constant.

References

[1] C. Mankoc, A. Janda, R. Arévalo, J. M. Pastor, I. Zuriguel, A. Garcimartín and D. Maza, "The flow rate of granular materials through an orifice", Gran. Matt. 9 (2007), 407-414.

[2] M. Sperl, "Experiments on corn pressure in silo cells – translation and comment of Janssen's paper from 1895", Gran. Matt. 8 (2006), 59-65.

4.1.11. Presenting Author: Benito Jesica Gisele

Arching in the segregation process of a tapped column of bi-disperse disks

R. O. Uñac[1], L. A. Pugnaloni[2], J. G. Benito[1], and A. M. Vidales[1]
[1]Instituto de Física Aplicada CONICET, UNSL, San Luis, Argentina
[2]Instituto de Física de Líquidos y Sistemas Biológicos CONICET, UNLP, La Plata, Argentina

We study numerically the evolution of the segregation patterns obtained when tapping a column of disks of a given size where the presence of one bigger disk (the intruder) or a set of them (mixture of big and small disks) is allowed. The size ratio between large and small disks can be varied. Simulations are performed using a pseudo-dynamic model that only takes into account the excluded volume restriction during the collision of disks. The disks are initially deposited in a rectangular die. For the case of one intruder, it is placed at the center of the base of the column. For the case of a set of intruders, they are randomly distributed inside the column. The tapping procedure is achieved by expanding the particles with an intensity A, and then, by allowing them to fall down due to gravity. The height and the velocity of the one-intruder case are measured as a function of the tapping number, size ratio and tapping intensity. For the case of a mixture of disks, tapped column is followed by measuring a set of segregation indices as a function of concentration and intensity A. The behavior of the arches of particles present during the setting up of segregation is followed. The incidence that arch distributions have on the segregation process is analysed. A comparison with the one-intruder case is performed. Arches seem to be the key for segregation when just geometrical features are present.

4.1.12. Presenting Author: Iván Sánchez

A granular fountain

Iván Sánchez, Ruddy Urbina, Katiuska Díaz, and Werner Brämer-Escamilla
Centro de Física, Instituto Venezolano de Investigaciones Científicas, Apartado Postal 21827, Caracas 1020, Venezuela

We present an interesting and eye-catching experiment, with potential for introductory level educational and public outreach applications: a granular fountain. It is an example of the rich and sometimes counterintuitive phenomena that takes place when fine sand is vertically vibrated at low frequencies. We offer guidelines for reproducing the experiment and also a short

discussion on the physics behind the effect.

4.1.13. Presenting Author: Claudio Falcón

Surface Kinks in shallow granular layers

J. E. Elías, M. G. Clerc, C. Falcón, and M. García-Ñustes

Departamento de Física, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Casilla 487-3, Santiago, Chile

We report on the experimental observation of spatially modulated kinks in a shallow one-dimensional fluidized granular layer subjected to a periodic air flow. We show the appearance of these solutions as the layer undergoes a parametric instability. Due to the inherent fluctuations of the granular layer, the kink profile exhibits an effective wavelength, a precursor, which modulates spatially the homogeneous states and drastically modifies the kink dynamics. We characterize the average and fluctuating properties of this solution. Finally, we show that the temporal evolution of these kinks is dominated by a hoping dynamics, related directly to the underlying spatial structure.

4.2. Classical and quantum chaos

4.2.1. Presenting Author: Carlos A. Briozzo

Experimental synchronization of two bilaterally coupled fourth-order electronic circuits: Characterizing their interaction by means of Symbolic Entropy.

C. A. Briozzo, C. Cabeza, and A. C. Martí

Instituto de Física, Facultad de Ciencias, Universidad de la República, Iguá 4225, Montevideo, Uruguay

The degree of complexity of the interaction between two RC coupled autonomous fourth-order Chua-like electronic circuits is analyzed using tools from nonlinear time series analysis.The method presented proves to be especially suited for examining experimental or noisy systems as shown by comparison with numerical simulations. It performance is contrasted to other approaches to analyze regular and chaotic synchronization, like cross correlation, Shannon entropy, synchronization error and phase analysis techniques.

4.2.2. Presenting Author: Marla Heckler

Exit time in open chaotic maps

Marla Heckler[1,2], Sandra Denise Prado[1], and Fernando Kokubun[3]

[1]Universidade Federal do Rio Grande do Sul, UFRGS
[2]Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, IFRS
[3]Universidade Federal do Rio Grande, FURG

In this work we study transport properties of generic quantum open maps. We simulate situations where electrons can enter and leave a cavity through contact points or leads. Particles are injected into the system and evolve accordingly to the system evolution operator. Some of the particles will escape rapidly while others can remain for longer times depending either on the size of the openings or a parameter k which runs from integrable to chaotic regimes. The main characteristics of the dynamics in generic systems are bifurcations of periodic orbits which are events in which periodic orbits are created or destroyed as a parameter is varied. We show here numerical evidences of how diffusion, conductance, average exit time and bifurcations are strong correlated.

4.2.3. Presenting Author: Ivan Luiz Bolorino

Effects of temperature on molecular dissociation through a semiclassical approach

I. L. Bolorino and E. F.de Lima

Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP)

In this work, we investigate the control of dissociation of heteronuclear diatomic molecules subjected to laser pulses. This phenomenon is modeled by the classical forced one-dimensional Morse Oscillator. On the classical point of view, this system presents chaotic dynamics associated with the anharmonicity of the internuclear potential and with the coupling of of permanent dipole of the molecule with the electric field of laser. Is studied the dissociation for some values of temperature, allowing to verify the behavior of the amplitude threshold with temperatur. Finally, we compare the classical results with quantum results. This system represents a diatomic molecule in an electronic state subjected to a laser. We consider the potentials and dipole functions for the NO, CO and IBr molecules. The states that belong to contínuum of energies can represent a dissociated molecule or a pair of atoms in collision. The photodissociation corresponds to transition between the bound states to states of the continuum. We investigate the dynamics through the study of classical trajectories's system, solving the Hamilton equations to the trajectories ensemble. To solve the problem on quantum point of view, we apply the methods based on expansion in autofunctions basis of quantum Morse oscillator. We analyze the dissociation probability a molecule as a function of intensity and frequency of laser for some values of temperatures.

4.2.4. Presenting Author: Flavio M. de Aguiar

Analogies between liquid 4He and the elliptical stadium

F.M. de Aguiar and T. Araújo Lima

Departamento de Física, Universidade Federal de Pernambuco, Recife, PE 50670-901, Brazil

A stadium is a plane region comprised of two half-circles or two half-ellipses that bracket a rectangular sector of width $2h$ and height $2b$, where $b = 1$ is the radius of the circle or the minor axis of the ellipse. The circular or Bunimovich stadium exhibits the K-property for any arbitrarily small h. Here we focus on elliptical stadia with half major axis a in the interval [1, 1.08]. In this case, the corresponding billiards are surely chaotic if $h > c(a) = 2a^2\sqrt{a^2 ˘ 1}$, and exhibit a mixed phase if $h < h_0(a) = \sqrt{a^2 ˘ 1}$. [2] Whether or not there is a lower bound for chaos between these two curves is still an open problem. Numerical evidences indicate that if it exists it must be close to h_0. Here, for a given a, we have numerically calculated the mean separation d of nearby trajectories as a function of h in the vicinity of h_0. Let $s =< logd >$ be a peculiar time average that takes into account both the initial transient and the steady state regions up to some discrete time t 100. We will present numerical evidences that $c = h(ds/dh)$ exhibits a pronounced peak at $h = h_0$, bearing resemblance to the lambda transition of the heat capacity of liquid 4He as a function of the temperature at saturated vapor pressure. The mixed phase space for $h < h_0$ sets further the thermodynamic analogy, with the two-fluid model, the irregular portion of the billiard phase space playing the role of the normal fluid component, and the regular one playing the role of the zero-entropy superfluid component.

4.2.5. Presenting Author: Flavio M. de Aguiar

Classical and quantum properties of irrational triangular billiards

T. Araújo Lima, S. Rodríguez-Pérez, and F. M. de Aguiar

Departamento de Física, Universidade Federal de Pernambuco, Recife, PE 50670-901, Brazil

Classical billiards in polygons are not chaotic, yet there are numerical evidences they might be ergodic. Here we use numerical and microwave techniques to investigate a number of particle and wave features in triangles whose sides are consecutive integers (N, $N+1$, $N+2$). All angles in a triangle belonging to this one-parameter family are irrational with π if $3 < N < \infty$. For the classical dynamics, we calculate the relative measure $r(t)$ of the occupied cells in a discretized surface of section as a function of the discrete time t, as well as position correlation functions, for varying N. Results are compared with the ones from the universal random model (RM). For small N, the calculated $r(t)$ is very close to the analytic result of the RM, and the correlation functions decay with an exponent close to -1. A slow departure from the thus characterized ergodicity is observed for $N > 20$. For the quantum dynamics, we numerically solve the Schrödinger equation with a boundary method. Short range (nearest neighbor spacing distribution) and long range (Dyson-Metha) statistics are calculated for the first 145,000 energy eigenvalues beyond the first 5,000 ones in the unfolded spectra. A departure from Random Matrix Theory is observed for $N > 20$, so that intermediate statistics are observed when the classical geometry is not strongly mixing. Scars were searched and not found in high-lying wavefunctions for $N < 20$, in qualitative agreement with the so called quantum unique ergodicity. Ghosts of classical periodic orbits could be found for quasidoublets which appear in the spectra for $N > 50$. These results fill a gap in the classical-quantum correspondence in regards to the ergodic hierarchy. (Ref.: T. Araújo Lima, S. Rodríguez-Pérez, and F.M. de Aguiar, Phys. Rev. E 87, 062902 (2013).)

4.2.6. Presenting Author: Emanuel F de Lima

The role of the permanent dipole in molecular dissociation

Emanuel F. de Lima

Instituto de Geociencias e Ciencias Exatas, UNESP-Univ Estadual Paulista, Rio Claro, Sao Paulo, 13506-900, Brazil

The role of the permanent dipole function in the dissociation of heteronuclear diatomic molecules by laser pulses is investigated. The system is modeled by a driven Morse oscillator where the interaction between the molecule and the laser radiation is given by the product of a position-dependent dipole function with a time-dependent external field. Several non-linear forms of the dipole function with adjustable parameters are considered. Quantum and classical results are compared through direct numerical calculations. Additionally, quantum matrix elements and

Fourier components related, respectively, to the quantum and classical dissociation mechanisms are studied in search for correspondence between the two approaches.

References

[1] de Lima, E. F., Ramos, T. N. and de Carvalho, R. E. , Phys. Rev. E **87**, 014901 (2013).

[2] de Lima E. F., de Carvalho R. E., Physica D, **241**, 1753 (2012).

[3] de Lima E. F., de Aguiar, M. A. M., Phys. Rev. A, **77**, 033406 (2008).

4.2.7. Presenting Author: Pablo R. Zangara

Interaction-disorder competition in a spin system evaluated by the Loschmidt Echo

Pablo R. Zangara[1], Axel D. Dente[1], Aníbal Iucci[2], Patricia R. Levstein[1], and Horacio M. Pastawski[1]

[1] Instituto de Física Enrique Gaviola (CONICET) and Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, 5000 Córdoba, Argentina.

[2] Departamento de Física, Facultad de Ciencias Exactas, Universidad Nacional de La Plata and IFLP-CONICET, CC 67, 1900 La Plata, Argentina.

The interplay between interactions and disorder in closed quantum many-body systems is nowadays relevant for thermalization phenomena. We address this competition in an infinite-temperature spin system, by means of the Loschmidt Echo (LE), which is based on a partial time reversal procedure. This quantity has been formerly employed to connect quantum and classical chaos, and here we use it to filter out an irrelevant part of the Hamiltonian. The scaling of the LE decay rates is analyzed as function of the interactions and disorder strengths. The natural bound for these rates is found to be the time-scale of the Survival Probability under the reversed (unperturbed) Hamiltonian. Moreover, the strategy enables a phase diagram that shows the regions of ergodic and non-ergodic behavior of the polarization under the echo dynamics.

4.2.8. Presenting Author: Rodrigo Frehse Pereira

Perturbations in systems with transversal unstable dimension variability

R. F. Pereira[1,2,3], S. Ely de S. Pinto[2,3], and M. S. Baptista[3]

[1]Departamento Acadêmico de Matemática, Universidade Tecnológica Federal do Paraná, Ponta Grossa-PR 84016-210, Brasil.

[2]Departamento de Física, Universidade Estadual de Ponta Grossa, Ponta Grossa-PR 84030-600, Brasil.

[3]Institute for Complex Systems and Mathematical Biology, King's College, University of Aberdeen, Aberdeen AB24 3UE, United Kingdom.

Unstable dimension variability (UDV) is an extreme form of nonhyperbolicity. It is a structurally stable phenomenon, typical for high dimensional chaotic systems, which implies severe

restrictions to shadowing of perturbed solutions. Perturbations are unavoidable in modelling Physical phenomena, since no system can be made completely isolated, states and parameters cannot be determined without uncertainties and any numeric approach to such models is affected by truncation and/or roundoff errors. Thus, the lack of shadowability in systems exhibiting UDV presents a challenge for modelling. Aiming to unveil the effect of perturbations a class of nonhyperbolic systems is studied. These systems present transversal unstable dimension variability (TUDV), which means the dynamics can be split in a skew direct product form, *i. e.* the phase space is decomposed in two components: a hyperbolic chaotic one, called longitudinal, and a nonhyperbolic transversal one. Moreover, in the absence of perturbations, the longitudinal component is a global attractor of the system. A prototype composed of two coupled piecewise-linear chaotic maps is presented in order to study the TUDV effects. This system has an invariant subspace $\boldsymbol{\mathcal{S}}$ which characterizes the complete chaos synchronization and UDV, when present, is transversal to it. Taking advantage of (piecewise) linearity of the equations, an analytical method for unstable periodic orbits' computation is presented. The set of all unstable periodic orbits (UPOs) is one of the building block of chaotic dynamics and its properties provide valuable informations about the asymptotic behaviour of the system as, for instance, the invariant natural measure. Therefore, the TUDV's intensity is analytically studied by computing the contrast measure, which quantifies the difference between the statistical weights associated to UPOs with different unstable dimension. The effect of perturbations is modelled by the introduction of a small parameter mismatch, instead of noise addition, in order to keep the model's determinism. Consequently, the characterization of dynamics by means of UPOs is still possible. It is shown the existence of a dense set $\boldsymbol{\mathcal{G}}$ of UPOs outside the invariant subspace consistent with a chaotic repeller. When perturbation takes place, $\boldsymbol{\mathcal{G}}$ merges with the set $\boldsymbol{\mathcal{H}}$ of UPOs previously in $\boldsymbol{\mathcal{S}}$, given rise to a new nonhyperbolic stationary state. The analysis of $\boldsymbol{\mathcal{G}} \cup \boldsymbol{\mathcal{H}}$ provides a topological explanation to the behaviour of systems with TUDV under perturbations. Moreover, the relation between the set of UPOs embedded in a chaotic attractor and its natural measure, proven only for hyperbolic systems, is successfully applied to this system: the error between the natural measure estimated both numerically and by means of UPOs is shown to be decreasing with $\boldsymbol{p}$, the considered UPOs' period. It is conjectured the coincidence between both in $\boldsymbol{p} \to \infty$ limit. Hence, a positive answer to reliability of numerical estimation to natural measure in nonhyperbolic systems *via* unstable dimension variability is presented.

4.2.9. Presenting Author: José Pablo Salas Ilarraza

Nonlinear Dynamics of a Neutral Atom in a Magnetic Trap

José Pablo Salas Ilarraza

Área de Física, Universidad de la Rioja, 26006 Logroño, Spain

In the frame work of the nonlinear mechanics, we study the dynamics of a neutral atom confined in a magnetic quadrupolar trap. Owing to the axial symmetry of the system, the z-component of the angular momentum is an integral of motion and, in cylindrical coordinates, the dynamics of the atom is modeled by a two-degree of freedom Hamiltonian. The structure and evolution of the phase space as a function of the energy is explored extensively by means of numerical techniques of continuation of families of periodic orbits and Poincaré surfaces of section.

4.3. Complex fluid and plasma dynamics

4.3.1. Presenting Author: Juan Manuel Rosselló

Stability map and energy focusing of sonoluminescent bubbles in sulphuric acid for different static pressures

J. M. Rosselló[1,2], D. Dellavale[1,2], and F. J. Bonetto[1,2]
[1]Laboratorio de Cavitación y Biotecnología, Comisión Nacional de Energía Atómica (CNEA) - Instituto Balseiro
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

Single bubble sonoluminescence (SBSL) is a two-phase phenomenon in which a gas bubble is forced to have a strong spherically converging inertial collapse. The sudden pressure and density rise within the bubble content is sufficiently rapid to almost adiabatically heat the gas until a hot plasma is formed and a very short duration light pulse is emitted. In the present research we report several experimental and numerical results on the influence of static pressure (P_0) over the main parameters in SBSL, using a sulphuric acid aqueous solution (SA) with low concentrations of argon gas dissolved. Bi-frequency driving was used in the experiments to enhance spatial stability of the bubbles. Measurements of the temporal evolution of the bubble radius were compared with simulations provided by a state of the art numerical code that models the radial dynamics of the bubbles. The results showed that an increase on the static pressure of the system shifts the Bjerknes instability threshold, allowing the bubble to access higher acoustic pressures (P_{Ac}^{LF}). Furthermore, a decrease in the measured ambient radius R_0 and the calculated relative gas concentration c_∞/c_0 were observed. A notorious increment in the bubble collapse violence and energy focusing for P_0 above 1 bar was achieved. These were mainly indicated by the growth of the bubble expansion ratio (R_{max}/R_0) and the bubble mechanical energy density. In agreement with the previous statement, the maximum temperature during the bubble collapse predicted by the model is augmented as well. The effectiveness of different harmonics used in the ultrasound pressure field, regarding to energy focusing are also discussed. Finally, we analyzed the stability regions of the R_0-P_{Ac}^{LF} parameter space for P_0 above the measured via numerical predictions, identifying the shape instabilities as the main limiting agent to obtain further energy concentration in SA systems at high static pressures.

4.3.2. Presenting Author: Daniel Dourado

Quasi-linear approach for plasma oscillations in the presence of an external field

D. D. A. Santos, B. V. Ribeiro, and M. A. Amato

Instituto de Física, Universidade de Brasília, Distrito Federal, Brazil.

The small-amplitude waves in a collisionless unmagnetized electronic plasma in the presence of an external radiation field are discussed. In a semiclassical approximation it was shown that both the strength and the number of photons of the external field appear explicitly in the expression of the dielectric function. This approach allows a detailed description about the influence of the radiation on the collective plasma oscillations.

Along the same lines discussed in Valentini et al. (2012), we introduce the effect of the particle trapping on the wave potential well through a flattening on the electron equilibrium distribution function near the wave phase velocity. The preliminary results show that despite the flattening on the distribution function occurs in a small velocity range, it can significantly change the dispersion relation of the plasma waves. In this picture, the propagation of the collective oscillations is analyzed for different densities and temperatures of the plasma and for different number of photons and external field strength.

4.3.3. Presenting Author: Nicolas Perinet

Quasi-hexagon and beaded stripe patterns in Faraday waves

Nicolas Perinet[1], **Damir Juric**[2], **and Laurette S. Tuckerman**[3]

[1]Departamento de física, FCFM, Universidad de Chile
[2]LIMSI-CNRS
[3]PMMH-ESPCI

Faraday waves are standing wave patterns produced by the vertical oscillation of a fluid layer. Stripes, squares and hexagons are the most common patterns, but quasipatterns, superlattices, and solitons can also occur. We have recently carried out the first numerical simulation of three-dimensional Faraday waves. Our simulations lead to a hexagonal pattern, which is not permanent, but gives way to a pattern we have called "beaded stripes". This is succeeded by a regular alternation between two other sets of patterns which we call quasi-hexagons and asymmetric beaded stripes and which are related by spatio-temporal symmetries. We analyze this sequence of patterns via their Fourier coefficients.

4.3.4. Presenting Author: Daniel Freire

Recognition of coherent structures in turbulent fountains in stratified media

Daniel Freire, Sandra Kahan, Cecilia Cabeza, Gustavo Sarasúa, and Arturo C. Martí

Instituto de Física, Universidad de la República, Montevideo, Uruguay

In the present work it is studied the interaction between a turbulent fountain and its stratified environment using laboratory experiments. A jet of heavy fluid was injected vertically upwards into a linearly stratified medium. The jet reaches a maximum height before it begins to fall due to the effect of gravity. At the same time, because of the effects of friction and mixing, the vertical momentum and the density of the jet fluid decrease and it submerges up to an intermediate height of zero buoyancy known as spreading height. Proper Orthogonal Decomposition (POD) on Digital Particle Image Velocimetry (DPIV) realizations was used to identify large coherent structures. Frequency spectra on temporal eigenvectors (or amplitudes) and spatial eigenfunctions (or modes) can be partially explained like instability threshold on simplified (first order) Navier-Stokes and heat transfer equations. Energy analysis along with temporal and spatial analysis led to the recognition of some periodic behaviors, needing some of them a more detailed explanation in the context of non linear convection theory.

4.3.5. Presenting Author: Juan Manuel Rosselló

Multi-bubble clusters in sonoluminescence for a cylindrical resonator and harmonic driving

J. M. Rosselló[1,2], D. Dellavale[1,2], and F. J. Bonetto[1,2]
[1]Laboratorio de Cavitación y Biotecnología, Comisión Nacional de Energía Atómica (CNEA) - Instituto Balseiro
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

In the present work, bubble clusters formed of multiple sonoluminescent bubbles were experimentally and theoretically studied. Argon bubbles were acoustically generated and trapped using bi-frequency driving, within a cylindrical acoustic chamber filled with a sulphuric acid aqueous solution (SA85w/w). The bi-harmonic signal used to generate the acoustic pressure field was composed of a low frequency component (given by the resonance frequency of the vessel f_0) plus the eleventh or the tenth harmonic of f_0. This acoustic pressure field was strong enough to sustain, for long periods of time, a large number of spatially fixed sonoluminescent bubbles over an ellipsoid shaped tridimensional cluster. In order to explain the size and shape of the bubble clusters, we performed a series of numerical simulations of the hydrodynamic forces acting over the bubbles, where bubble-bubble interaction has been neglected. The results revealed that the positional stable region, mainly determined by the null Bjerknes force (F_{Bj}), is defined as an axisymmetric ellipsoidal surface centered in the acoustic field antinode. The dimensions of the ellipsoids were studied as a function of the applied low frequency acoustic pressure amplitude (P_{Ac}^{LF}) and the static pressure of the fluid (P_0). In both cases the observed experimental behavior was in agreement with the simulation results. As the applied acoustic pressure is increased, the surface expands in order to preserve the conditions were the net force acting on the bubble is zero (e.g., the pressure gradient acting over the bubble and the ambient radius R_0). With respect to the effect of static pressure over the bubble surface, we found a significant reduction of the ellipsoidal cluster as P0 was augmented. The later could be explained analyzing the changes occurring in the R_0-P_{Ac}^{LF} parameters space for elevated static pressures. The numerical model predicted a shift in the positional stability frontier to regions where higher acoustic pressures can be applied over the bubbles. As a consequence, the sonoluminescent bubbles can reach positions closer to the pressure antinode in the cylindrical flask. Finally, the role of the high frequency component of the pressure field in the phenomenon is qualitatively discussed.

4.3.6. Presenting Author: Arturo Olvera

Periodic solutions in self-consistent chaotic transport in fluid and plasmas

Arturo Olvera[1], **David Martinez del Rio**[2], **and Diego del-Castillo-Negrete**[3]

[1]IIMAS-UNAM, Mexico.
[2]Posgrado de Ciencias Matematicas, UNAM. Mexico.
[3]Oak Ridge National Laboratory, USA.

We study self-consistent chaotic transport in two-dimensional incompressible shear flows like the Vlasov–Poisson equation.

We consider a self-consistent models of a simple but limited kinematic chaotic advection models. The model is an area preserving self-consistent map obtained from a space-time discretization of the single wave model.

These model provides relatively simple self-consistent Hamiltonians (streamfunctions) for the Lagrangian advection problem. The models shows the phenomenology of shear flow instability, vortex formation and relaxation which is observed in numerical simulation of the the Navier–Stokes equation.

This dynamical system is defined as a set of N twist maps which are coupled by the phase and the perturbation parameter. We study the existence of periodic orbits by the construction of normal forms for arbitrary number of coupled twist maps. Numerical methods are used to find periodic solutions, this solutions agrees with the asymptotic solutions.

4.3.7. Presenting Author: Caroline G. L. Martins

Stickiness, collisions and escape patterns in a wire-model to simulate the magnetic surfaces of the tokamak ITER

Caroline G. L. Martins[1], **T. Kroetz**[2], **M. Roberto**[1], **and I. L. Caldas**[3]

[1]Departamento de Física, Instituto Tecnológico de Aeronáutica, São José dos Campos, São Paulo, 12228-900, Brasil
[2]Universidade Tecnológica Federal do Paraná, Pato Branco, Paraná, 85503-390, Brasil
[3]Instituto de Física, Universidade de São Paulo, 05315-970, São Paulo, Brasil

Tokamaks with poloidal divertors improve substantially the magnetic confinement of plasmas for controlled thermonuclear fusion, and this good performance will be tested in the future tokamak ITER, which is under construction in Cadarache (France) [1]. In this work we use a set of five parallel wires conducting electric current, to describe equilibrium magnetic surfaces for tokamaks with divertors. We show the versatility of the model creating surfaces with similar topology of the surfaces of ITER, capturing some aspects of the dynamics of magnetic field lines near the divertor. To study the escape patterns of the field lines near the divertor, we

introduce magnetic resonant perturbations generated by error fields due to asymmetry in the equilibrium coils [2], and an additional noise to simulate the colisional diffusion of particles [3]. The deposition patterns at the divertor plates were analyzed, and our results agree with results obtained with sophisticated computer codes [4]. We solve numerically the differential equations of the perturbed magnetic field to investigate the stickiness effect caused by special island chains near the divertor plates, which trap magnetic field lines for many toroidal turns, interfering at the diffusivity of the system.

References

[1] G. Janeschitz, The Status of ITER; The ITER Design Review (presented to APS-DPP Town Meeting on ITER Design Review, Orlando, FL, (2007).

[2] N. Pomphrey and A. Reiman, Phys. Fluids B **4**, 938 (1992).

[3] P. Beaufume, M. A. Dubois, and M. S. Mohamed Benkadda, Phys. Lett. A **147**, 87 (1990).

[4] T. Kroetz, Caroline G. L. Martins, M. Roberto and I. L. Caldas, Set of Wires to Simulate Tokamaks with Poloidal Divertor. Accepted for publication at Journal of Plasma Physics, 2013.

4.4. Complex networks

4.4.1. Presenting Author: Jesús Espinal

Analysis of Mexicoś Narco War Network

Jesús Espinal and Hernán Larralde

Instituto de Ciencias Físicas, Universidad Nacional Autónoma de México

Since December 2006, more than a thousand cities in Mexico have suffered the effects of a battle among several drug cartels and Mexico's army. Sources are not in agreement in terms of the number of casualties, it varies between 30 and a 100 thousand, the economic and social ravages of this war are impossible to quantify. In this work, we constructed a narco-network based on the correlations in the number of casualties due to the organized-crime between different cities. We analyze those networks in terms of several parameters and attempt to determine a correlation-threshold value at which violence bursts. This kind of studies may help to understand the starting and propagation of gang-related violence waves.

4.4.2. Presenting Author: Berenstein Ariel José

Multipartite network-based approach to prioritize target proteins in neglected tropical diseases.

A. J. Berenstein[2], M. P. Magariños[3], F. Agüero[3], and A. Chernomoretz[1,2]

[1]Laboratorio de Bioinformática, Instituto Leloir, Buenos Aires, Argentina.
[2]Departamento de Física, Universidad de Buenos Aires, Bs As, Argentina.
[3]Laboratorio de Genómica y Bioinformática, Instituto de Investigaciones Biotecnológicas, Universidad de San Martin, San Martín, B 1650 HMP, Buenos Aires, Argentina.

Background Neglected tropical diseases (NTDs) are human infectious diseases that occur in tropical or subtropical regions and are often associated with poverty. Historically, lack of interest from the pharmaceutical industry, resulted in the lack of good drugs to combat the majority of the pathogens that cause these diseases. Recently, the availability of open chemical information has increased with the advent of public domain chemical resources and the release of data from high throughput screening assays. In our laboratory, our goal is to prioritize and identify candidate drug targets, and candidate drug-like molecules to foster drug development in Trypanosoma cruzi (causative agent of Chagas disease). For this we use comparative genomics, and chemogenomics approaches, taking advantage of the availability of drug-target data from other model organisms that have been extensively studied, like human, yeast, and mouse.

Materials and Methods Chemical datasets, including bioactivity data against pathogen and non pathogen targets were obtained from open databases and high throughput screenings. Starting from these data, we built a tripartite network considering three disjoint set of vertexes with approximately $\mathbf{1.710^5}$ drugs and $\mathbf{1.710^5}$ proteins across more than 150 species and several biological relations (orthology, sharing of Pfam domains, participation in defined metabolic pathways), organized in three different planes. Three different classes of target similarity criteria were considered: sharing of PFAM domains present in the same protein, clustering in the same ortholog group (OrthoMCL algorithm), and belonging to the same metabolic pathway. Only statistically significant terms (in context of drug-target predictions) were taken into account. A bipartite projection was made using a modified version of the Zhou method [2] over the protein plane. In the resulting monopartite protein-protein network, proteins are linked if and only if, they share at least one relevant biological entity. Finally, in order to get a prioritization list of potential targets, a voting scheme was performed using all known sets of drug-targets associations.

Results We performed a cross validation procedure by splitting drug-target evidences in two sets: an evaluation set (target proteins of a given organism) and a training set (all drug-target evidences in the remaining organisms). In preliminary tests, we aimed to retrieve (recall) known/validated E. coli and M. musculus targets after omitting all links from these species. The information contained in the network (derived from other organisms) allowed us to identify several drug-targets from these with AUCs of 0.89 and 0.73 respectively. These results suggests that is possible to identify candidate drug targets, even in the absence of species-specific inhibition data. This is particularly important in the case of neglected diseases, as this means we can leverage data from model organisms (or from other tropical diseases) to guide drug repositioning exercises in an organism/disease of interest.

References

[1] TDR Targets: a chemogenomics resource for neglected diseases. Magariños et al. (2012) 40 (D1): D1118 D1127. DOI: 10.1093/nar/gkr1053

[2] Bipartite network projection and personal recommendation. Zhou et al. Phys Rev E (2007) Oct;76(4 Pt 2)v:046115. DOI: 10.1103/PhysRevE.76.046115

4.4.3. Presenting Author: Leonardo Ermann

Google matrix analysis of directed networks

Leonardo Ermann[1] and Dima L. Shepelyansky[2]

[1]Departamento de Fsica Teorica, GIyA, Comision Nacional de Energa Atomica, Buenos Aires, Argentina

[2]Laboratoire de Physique Theorique du CNRS, IRSAMC, Universite de Toulouse, UPS, 31062 Toulouse, France

On a scale of the past ten years, modern societies have developed enormous communication and social networks. Their classification and information retrieval processing become a formidable task for the society. Due to the rapid growth of World Wide Web, social and communication networks, new mathematical methods have been invented to characterize the properties of these networks on a more detailed and precise level. Various search engines are essentially using such methods. It is highly important to develop new tools to classify and rank enormous amount of network information in a way adapted to internal network structures and characteristics. This poster describes the Google matrix analysis of directed complex networks demonstrating its eficiency on various examples including World Wide Web, Wikipedia, world trade and Ulam networks. The analytical and numerical matrix methods used in this analysis originate from the fields of Markov chains, quantum chaos and Random Matrix theory.

4.4.4. Presenting Author: Fabiane de Fatima Carvalho

Comparison of Control Schemes in Neural Bursting Synchronization

R.L. Viana and C.A.S Batista

Universidade Federal do Paraná

The study of synchronization of complex networks has revealed interesting features, as a special case, the bursting synchronization of neuronal networks have been associated with diseases, like the rest tremor caused by Parkinson's disease. Since the synchronization of neuronal networks is related with diseases, to control such undesirable rhythms is a goal of great interest. In recent years techniques were developed to suppress bursting synchronization of neuronal networks, like Deep Brain Stimulation – DBS and the Delayed feedback signal control. In this work we computationally simulated a network with 10.000 sites, each site representing a neuron. The dynamic behavior of a neuron was simulated with Rulkov's map, and the synchronization of the network is reached by coupling the neurons. The coupling used was the global coupling, in which each neuron is connected with each other. This coupling is obtained by adding a term in the map, proportional to the mean field produced by all neurons. Once the synchronization is warranted we are now interested in suppressing this synchronized state. Two different ways were tested to suppress the bursting synchronization, the first one is the most conventional method, a time-periodic external signal current, and the second one is the delayed feedback signal current. This work consisted in the comparison of the effectiveness of both methods employed. This procedure was repeated for a network that exhibits the small-world topology.

4.4.5. Presenting Author: Fernando da Silva Borges

Dynamic range in a neuron network with electrical and chemical synapses

Fernando S. Borges[1], Kelly C. Iarosz[2], Ricardo L. Viana[3], Sergio R. Lopes[3], and Antonio M. Batista[4]

[1] Pós-Graduação em Ciências, Universidade Estadual de Ponta Grossa, Ponta Grossa, PR, Brazil
[2] Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Aberdeen, United Kingdom
[3] Departamento de Física, Universidade Federal do Paraná, Curitiba, PR, Brazil
[4] Departamento de Matemática e Estatística, Universidade Estadual de Ponta Grossa, Ponta Grossa, PR, Brazil

The dynamic range is the logarithmic difference between maximum and minimum levels of sensation produced by known stimuli. In the human sensory systems the dynamic ranges are typically larger than for single neurons, this amplification being essentially a collective effect of the neural network. We investigated the dynamic range exhibited by a cellular automaton network with electrical and chemical synapses, when the stimuli are modelled by a Poisson process of suprathreshold events of stereotyped unit amplitude and the neuron response is its average firing rate.

4.4.6. Presenting Author: Rodrigo Frehse Pereira

Synchronization between replicas of coupled map lattices

Romeu M. Szmoski [1,3], Rodrigo F. Pereira [2,3], Sandro Ely de S. Pinto [3,4], and Murilo da S. Baptista [4]

[1] Departamento Acadêmico de Física, Universidade Tecnológica Federal do Paraná, Ponta Grossa-PR 84016-210, Brasil

[2] Departamento Acadêmico de Matemática, Universidade Tecnológica Federal do Paraná, Ponta Grossa-PR 84016-210, Brasil

[3] Departamento de Física, Universidade Estadual de Ponta Grossa, Ponta Grossa-PR 84030-600, Brasil

[4] Institute for Complex Systems and Mathematical Biology, King's College, University of Aberdeen, Aberdeen AB24 3UE, United Kingdom

The synchronization between spatially extended systems is becoming a growing field of research recently. The interest in this area ranges from theories of phase transition up to application in social networks and information flow in the brain. However, there is a lack of analytical results to define the critical parameters for synchronization. The purpose of this work is to consider the synchronization schemes using replicas of coupled map lattices interconnected. Upon the study of the stability of the subspace synchronization, we find exact expressions for the parameters of the system and the synchronization time. We extend the results to the case in which the links vary over time, and we applied this extension for an example of encryption. The system studied here is about homogeneous networks, but the results may contribute to the study of complex networks coupled.

4.4.7. Presenting Author: Luis Carlos Tapia Herrera

Resting state networks from mesoscale to macroscale

L.C. Tapia, A. Alessio, H. Ozelo, G. Beltramini, B.P. Damasceno, R.J.M. Covolan, and G. Castellano

Universidade Estadual de Campinas

Neuronal elements in the brain are not isolated, they work together and they work in an organized way. The functional magnetic resonance imaging (fMRI) technique allows identifying cortical networks when the brain develops a task. But even in the absence of any task, cortical brain networks are present. These networks increase their activity in the absence of a task - this is the so called resting state of the brain. A consistent finding is that some brain regions with similar functionality are time correlated in resting state. So far there isn't a clear interpretation of the meaning of the resting state of the brain. One theory suggests that this state is involved in introspection and mind wandering, this includes any thoughts that are not associated with the external environment. Other theory suggests that this state is the baseline of the brain processing and information maintenance. Recent studies have modeled the brain networks

architecture with aid of graph theory. The advantage of such approaches is that this theory may quantify the structure and functionality of the brain. For example, in resting state fMRI analysis, functional connectivity is a measure of how strongly any two brain regions are time correlated. From a graph theory point of view regions are considered as nodes, and time correlations are considered as links between nodes of the graph. This work presents a graph analysis of resting state data sets. Twelve healthy subjects (mean age 35.5 ± 10.4 , 6 men) participated on this study. We divided the brain in 90 regions using the AAL (Automated Anatomical Labeling) atlas, and extracted the mean time course of each region. We compared the strength of these time course correlations between brain regions using Pearson's correlation. Defining a threshold we can classify any two time courses as correlated or not correlated. We thus obtained an undirected graph that allows us to make measures of the network. We studied the connectivity of each graph with the aid of the degree distribution function.

4.4.8. Presenting Author: Alejandro J. Alvarez S.

Coupling circle maps on networks to detect communities via hierarchical clustering

A. J. Alvarez[1,2] and J. L. Cabrera[1]

[1]Venezuelan Institute for Scientific Research (IVIC), Center for Physics, Stochastic Dynamics Lab., Caracas 1020A, Venezuela.

[2]Venezuelan Institute for Scientific Research (IVIC), Mathematics Department, Caracas 1020A, Venezuela.

In this work we propose a method for community detection in complex networks driven by a renormalization process based on cross-correlations between the time series of pairs of nodes subjected to coupled circle map dynamics. Two methods of renormalization are used in order to obtain exclusive or inclusive communities respectively. Additionally we test our method with a set of benchmark networks and compare it with other methods reported in the literature in order to show its effectiveness and performance.

4.4.9. Presenting Author: Alejandro J. Alvarez S.

New distance measures for hierarchical clustering processes and community detection in complex networks.

A. J. Alvarez[1,2] and J. L. Cabrera[1]

[1]Venezuelan Institute for Scientific Research (IVIC), Center for Physics, Stochastic Dynamics Lab., Caracas 1020A, Venezuela.

[2]Venezuelan Institute for Scientific Research (IVIC), Mathematics Department, Caracas 1020A, Venezuela.

In recent years we have witnessed an explosion of results related to community detection in complex networks. A main way to address the problem of community detection is based on the use of renormalization or hierarchical clustering processes. This approach make use of distances that tend to capture only a topological or a statistical aspect relevant for community detection, e.g., intermediation between nodes or fraction of common neighbors. This fact reduce

the quality of detected communities. In this work we propose a family of distances able to expand the measuring of properties to effectively characterize the community structure of a network. The method results in significant communities with higher values of modularity and considerable improved performance on sparse networks. Furthermore, it behaves quite well in the classification of satellite nodes.

4.4.10. Presenting Author: Igor Tauscher Martynetz

One-dimensional chemical coupling for Rulkov neurons

R.L. Viana and I.T. Martynetz

Departamento de Física, Universidade Federal do Paraná, 81531-990 Curitiba, Paraná, Brazil

The Rulkov model for neurons is widely used to describe behavior of neurons. When we have a network of one-dimensional neurons, they interact with others trough of synapses electrics and chemical. This work will show how neurons synchronize from a coupling of a given chemical substance. And how can determinated the phase of bursting neurons, and what their critical value for the transition from synchronized to non- synchronized, using the order parameter.

4.4.11. Presenting Author: Andrés D. Medus

Impact of social heterogeneities on the recurrence of infectious diseases

A. D. Medus[1] and C. O. Dorso[1,2]

[1]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón 1, Ciudad Universitaria, Ciudad Autónoma de Buenos Aires (1428), Argentina and IFIBA

[2]CONICET

The periodical recurrence and persistence of some infectious diseases has been widely studied through different modeling tools. Deterministic compartmental approach is a very successful modeling paradigm when all involved populations are large enough. However, the stochastic nature of the disease spread dynamic become relevant under close to extinction conditions, as is usually the case for the study of infectious diseases persistence threshold.

Different mechanisms contributing to explain the origin of persistence patterns have been studied and captured by theoretical mean field models. These models generally adopt the totally mixed population hypothesis in the form of a mass action law for the infectious rate. However, experimental evidence support the presence of heterogeneities on individuals contact patterns that has been proven to impact on the dynamic of disease spread.

In this work we present an epidemiological individual based model with heteregeneous contact pattern based on a complex network substrate. Our model allows to follow the time evolution of disease incidence on an explicitly stochastic framework. We introduce some details of the implemented discrete time stochastic algorithm.

Finally, we use our model to study the impact of contacts heterogeneities on the stochastic persistence threshold for perhaps the best documented disease in last century: measles.

4.4.12. Presenting Author: Lucas Damian Catalano

Evolution of commodity relationship using cross-correlation complex networks

L. D. Catalano and M. A. Figliola

Universidad Nacional de General Sarmiento

A field study of interest are the forms of interaction between the different systems that are close together. An example of such systems are the different groups of commodities. The interest of this work is to study the temporal evolution of the interactions between commodity prices over recent years. Commodities are grouped according to their origins (soft, grain, cattle, etc.).

We propose a network to correlate the price index of the different commodities. We constructed networks for different periods between 1991 and 2012. The nodes represents the commodities prices and the cross-correlation are represented by the links. In order to get the cross-correlation we used a novel method: Detrended Cross-Correlation Analysis proposed by Podobnik and Stanley in 2008. This estimator, MFDFA based method, is effective for self-similar signals with characteristics such as we analyzed. We studied the evolution of the networks over all the period. In all cases we calculated average degree, number of disconnected nodes and cross-correlation intensity.

The results showed that since 2007 the cross-correlation increase in all cases. We conjecture that it is consequence of the cash flow from the subprime mortgage crisis to the commodity market.

4.4.13. Presenting Author: Mauricio Aparecido Ribeiro

Theory of complex networks applied to proteins

Mauricio A. Ribeiro[1], Sandro Ely de Souza Pinto[1], Vanessa Leifeld[2],Mariza B. Marques[2], and Rodrigo Frehse Pereira[3]

[1] Programa de Pós-Graduação em Ciências-Física, Universidade Estadual de Ponta Grossa, Paraná, Brasil
[2] Programa de Pós-Graduação em Química Aplicada, Universidade Estadual de Ponta Grossa, Paraná, Brasil
[3] Departamento de Matemática, Universidade Tecnológica Federal do Paraná, Paraná, Brasil

Recent advances in science have brought important studies on complex networks in many different phenomena, such as sociology (social networks, collaboration networks), biology (metabolic networks, gene networks) or computer science (internet, P2P networks and etc). Thus, the theory of complex networks is an interdisciplinary topic that covers many areas of knowledge [1]. A complex network can be represented by a graph, which is a set of vertices $(\boldsymbol{V})$ and set of edges $(\boldsymbol{E})$, which can be directed or undirected [1-3]. Several biological phenomena are described by complex networks, such as interactions of insects, plants, neural networks and etc.

Another example of application of complex networks are proteins. Proteins are the most abundant molecules in the cells and perform several functions essential to biological processes. They present on their monomer composition **20** amino acids which bind covalently through peptide bonds in various sequences and combinations to form its primary structure. Each protein has a particular primary structure, which results in property, function and spatial arrangement unique to the different existing types. Among the main functions of proteins include cell repair, energy source, immunity, transport, regulation of metabolic processes, among others [4]. Three proteins of great importance and are found in milk $\boldsymbol{\alpha}$-lactalbumin, $\boldsymbol{\beta}$-lactoglobulin and Bovine Serum Albumin (BSA). They contain all the essential amino acids (not synthesized by the human body) and high amount compared to other protein sources, such as vegetable and so have been studied under different aspects [5]. The $\boldsymbol{\alpha}$-lactalbumin, $\boldsymbol{\beta}$-lactoglobulin and BSA present in the primary structure **123**, **162** and **582** amino acids, respectively [5,6]. Knowing the primary sequence of each of these proteins and utilizing graph theory, it is possible that each amino acid of a protein is taken as a vertex of a complex network and its edges are links formed between amino acids for the formation of this protein. In this sense, the formation of complex networks allows the study of proteins, improving the understanding of functions and behaviors of these molecules. Thus, the aim of this work was to build networks with the proteins of interest and calculate the betweeness centrality vertex and betweeness centrality edges, observing the behavior of the distributions of these measures and relating to the properties of proteins. Significant correlations were obtained between the distributions and functions of milk protein, supporting the study of proteins in the form of complex network.

References

[1] NEWMAN, M. E. J. Networks, An Introduction. Oxford University Press, New York 2010.

[2] ALBERT, R., BARABASI, A.L. Statistical mechanics of complex networks. Rev. Mod. Phys.,74 (2002) 47.

[3] BRANDES, U.; A Faster Algorithm for Betweenness Centrality. Journal of Mathematical Sociology 25(2):$\mathbf{163-177}$, 2001.

[4] MURRAY, R. K.; GRANNER, D. K.; MAYES, P. A.; RODWELL, V. W. Harper's Biochemistry. 23a ed. Prentice-Hall international Inc. 1993. 806 p.

[5] HOZ, L.;NETTO, F.M. Structural modification of $\boldsymbol{beta}-$Lactoglobulin subjected to gamma radiation. International Daity Journal, 18, $\mathbf{1126-1132}$, 2008.

[6] OHNO, S. Original domain for the serum albumin family arose from repeated sequence, Proc.Natl. Acad. Sci. USA, vol. 78, 12, $\mathbf{7657-7661}$.

4.4.14. Presenting Author: Eleonora Catsigeras

Dynamics of large cooperative pulse-coupled networks

Eleonora Catsigeras

Instituto de Matemática y Estadística "Rafael Laguardia", Universidad de la República, Uruguay

We study the deterministic dynamics of networks composed by m non identical, mutually pulse-coupled cells. We assume weighted, asymmetric and positive (cooperative) interactions among the cells, and arbitrarily large values of m. We consider two cases of the network's graph: the complete graph, and the existence of a large core (i.e. a large complete subgraph). We prove that the system periodically eventually synchronizes with a natural spiking period p >= 1, and that if the cells are mutually structurally identical or similar, then the synchronization is complete (p = 1)

4.4.15. Presenting Author: Ewandson Luiz Lameu

Synchronization analysis in a scale-free clustered network.

Ewandson L. Lameu[1], Carlos A. S. Batista[2], Kelly Iarosz[3], Antonio M. Batista[4], Ricardo L. Viana[2], and Sergio R. Lopes[2]

[1] Programa de Pós Graduação em Ciências/Física, Universidade Estadual de Ponta Grossa, Paraná, Brasil
[2] Departamento de Física, Universidade Federal do Paraná, Paraná, Brasil
[3]University of Aberdeen, Scotland
[4]Departamento de Matemática e Estatística, Universidade Estadual de Ponta Grossa, Paraná, Brasil

Functional brain networks are composed of cortical areas that are anatomically and functionally connected. One of the cortical networks for which more information is available in the literature is the cat cerebral cortex. Statistical analyses of the latter suggest that its structure can be described as a clustered network, in which each cluster is a scale-free network possessing highly connected hubs. Those hubs are strongly connected together. We have built a clustered scale-free network inspired in the cat and human cortex structure so as to study their dynamical properties. We focus on the synchronization of bursting activity of the cortical areas and how it can be suppressed by means of neuron deactivation through suitably applied light pulses. We show that is possible to effectively suppress bursting synchronization by acting on a single hub, because it is highly connected and have a strong influence over the network.

4.4.16. Presenting Author: Cristina Masoller

Global climate networks constructed from symbolic time series analysis of monthly atmospheric data.

Cristina Masoller

Universitat Politècnica de Catalunya

In recent years the application of complex networks to climatological data analysis lead to the development of the field of climate networks, where the nodes (or vertices) represent geographical coordinates over the Earth, and the links (or edges) quantify the degree of statistical similarity of the climate in pairs of nodes: when the similarity is significant, the nodes are interconnected with a link. Since in our climate there are features and patterns that recur at various times scales (short periods of a few days for weather patterns, intra-season phenomena recurring within 1-3 months, El Niño phenomenon recurring in inter-annual scale of 4-6 years, etc.), we have tried to analyze how these features modify the climate network, by using a symbolic method of time-series analysis that allows selecting different time-scales. Specifically, we have used ordinal analysis and quantified climate similarity by computing the mutual information of ordinal sequences of atmospheric data (monthly surface air temperature anomalies, where each month average is removed). By tuning the time scale of the ordinal pattern and performing a

statistical significance analysis (i.e., eliminating links that are consistent with noise), we construct climate networks that uncover climate phenomena with short and long term memory [1]. We have also consider the influence of the annual solar forcing on the climate network and computed a lag-time associated to each link, that allows, when two nodes are located different hemispheres, to compute the similarity of temperature anomalies during the same season [2]. Our results show that, while the network topology is modified by the inclusion of lag-times, the average connectivity of the network nodes remains almost unaffected. This result is interpreted as due to the fact that, in monthly temperature data, the influence of the annual solar forcing is removed from the anomaly values.

References

[1] J. I. Deza, M. Barreiro and C. Masoller, "Inferring interdependencies in climate networks constructed at inter-annual, intra-season and longer time scales", Eur. Phys. J. Special Topics 222, 511–523 (2013).

[2] G. Tirabassi and C. Masoller, "On the effects of lag-times in networks constructed from similarities of monthly fluctuations of climate fields", EPL 102, 59003 (2013).

4.4.17. Presenting Author: Francisco W. S. LIMA

Analysing and controlling the tax evasion dynamics via nonequilibrium SLR model.

Francisco W. S. LIMA

Dietrich Stauffer Computational Physics Lab, Departamento de Física, Universidade Federal do Piau, Teresina, Piau 64049-550, Brazil

Within the context of agent-based Monte-Carlo simulations, we study the problem of the fluctuations of tax evasion in a community of honest citizens and tax evaders by using the version of the nonequilibrium Zaklan model proposed by Lima (2010). The studied evolutionary dynamics of tax evasion are driven by a non-equilibrium SLR model. This SLR model display a first-second order social phase transition, with the objective to attempt to control the fluctuations of the tax evasion in the observed community in which citizens are localized on the nodes of directed Small-World networks proposed in the SLR model in two regime: first and second order social phase transition.

4.5. Complex system dynamics

4.5.1. Presenting Author: Rosa Mujica

An efficient control scheme for coupled maps lattices

R. Mujica

Laboratorio de Fenomenos No Lineales, Escuela de Fisica, Facultad de Ciencias, Universidad Central de Venezuela.

In this work a strategy to control extended systems, that minimizes the number of sites that are perturbed in the network, is proposed.

The idea behind the method is based approximation of the asymptotic dynamics of the system by a manifold of smaller dimension than the system but contains the global attractor.

By using a model-based control scheme, we obtain results that may be useful in designing control methods in the case of complex extended systems.

4.5.2. Presenting Author: Pedro Garcia

Information transfer and inertial manifold theory

P. Garcia

Laboratorio de Sistemas Complejos, Departamento de Fisica Aplicada, Facultad de Ingenieria, Universidad Central de Venezuela.

Inertial manifolds are objects that represent the long term behavior of dissipative systems. When they exist, they are finite dimensional invariant smooth manifolds with dimension minor than the original system but containing it global attractor.

In this work, the relation between the information transfer between sets of nodes in a network and the inertial manifold associated to the network, is explored.

Results that can be useful in the design of control or synchronization schemes of complex extended systems are

4.5.3. Presenting Author: María Florencia Carusela

Purely non-linear collective effects behind the current reversal phenomena of superconducting vortices at high frustration

María Florencia Carusela[1] and Verónica I. Marconi[2]

[1]Instituto de Ciencias, UNGSarmiento, J.M. Gutierrez 1150, 1613 Los Polvorines, Argentina - CONICET.

[2] Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba and IFEG-CONICET, X5000HUA, Córdoba, Argentina.

Numerical studies on the directed motion of ac-driven vortices in asymmetrically modulated 2D Josephson Junction Arrays (JJA) [1] has shown that this non-linear effect is possible both at low and high vortex density. Interestingly dc-voltage rectification reveals a strong dependence on vortex density as well as an *inversion of the vortex flow direction vs the ac amplitude for a wide range of magnetic field applied, around* $f=1/2$ ($f=Ha^2/\Phi_0$), in good agreement with experiments [2]. In this work we analize deeply this rocking ratchet effect, the inverted current response at high f and the influence of vortex-antivortex pairs dynamics. We focus our attention on the temporal response, spatial and temporal correlations, vortex structures, and vortex-antivortex pairs formation which let us give a more microscopic understanding of the underlying non-equilibrium vortex dynamics. We show that the vortex dynamics underlying the current inversion effects in JJA is clearly different for the one explained and/or observed in other 2D vortex ratchet systems such as superconducting films with arrays of dots or antidots, superconducting fluxon pumps, etc, and can not be understood in the framework of diluted vortex lattices (London limit) neither can be easily reduced to the dynamics of a few effective degrees of freedom. Our study of the full JJA superconducting phases dynamics shows indeed a complex collective phenomena arising from the interplay of strong vortex interactions, *asymmetric pinning potentials and its effective modifications at high vortex densities*, ac-drive, and vortex-antivortex dynamics and gives insight into a *purely collective* mechanism behind the current reversal effect.

References

[1] *Verónica I. Marconi, Phys. Rev. Lett.*, **98**, *047006 (2007).*

[2] *D. Shalom and H. Pastoriza, Phys. Rev. Lett.* **94**, *177001 (2005).*

4.5.4. Presenting Author: Alejandra C. Ventura

Regulatory mechanisms for input-output curves in cell signaling

Laila Kazimierski, Alejandro Colman-Lerner, and Alejandra C Ventura

Instituto de Fisiología, Biología Molecular y Neurociencias, Facultad de Ciencias Exactas y Naturales, UBA, Buenos Aires, Argentina

An important characteristic of every living cell is its ability to communicate with the surrounding environment. This exchange of information is called cellular signaling and is based on the capacity of the cell to give proper responses to environmental signals. Mathematical/computational modeling based on biological information can be used to improve our understanding of cellular signaling, thereby enhancing predictive accuracy. Intracellular signaling networks have sensing mechanisms such as membrane receptors, responsible for converting extracellular stimuli in receptor activation. This generates network activity, which is composed of different steps of transduction, and generates a response to the stimulus. It is commonly accepted that stimulation levels that cause maximum receptor occupancy cannot be distinguished from each other; all produce the same saturated response. However, it has been experimentally observed that, in many cases and, despite this apparent saturation of the sensors, the system can generate distinguishable responses for apparently undistinguishable signals. In previous work we have presented a mechanism, pre-equilibrium signaling (PES) that enables cells to discriminate levels of signals that saturate receptors at equilibrium. The mechanism is based on the coupling of a slow sensing process compared to the time scale of the downstream processes. The immediate consequence of this coupling is to cause an expansion of the system's dynamic range (range of stimuli to which the system can respond in a dose-dependent manner). Despite the diversity of possible biochemical networks, it may be common to find that only a finite set of core topologies can execute a particular function. In this work we study biochemical networks with minimum number of components and minimum number of connections, to identify which of them are capable of using the PES mechanism. Our main goal with this study is to extract general design principles, meaning the rules that underlie what networks can achieve PES. These design rules provide a framework for functionally classifying complex natural networks and a manual for engineering networks.

4.5.5. Presenting Author: R. Salgado-Garcia

Symbolic Complexity for Nucleotide Sequences: A Sign of the Genome Structure

Raúl Salgado-Garcia

Facultad de Ciencias, Universidad Autónoma del Estado de Morelos. Avenida Universidad 1001, Colonia Chamilpa, 62209, Cuernavaca Morelos, Mexico

We introduce a method to estimate the complexity function of symbolic dynamical systems from a finite sequence of symbols. We test such complexity estimator on several symbolic dynamical systems whose complexity functions are known exactly. We use this technique to estimate the complexity function for genomes of several organisms under the assumption that a genome is a sequence produced by a (unknown) dynamical system. We show that the genome of several organisms share the property that their complexity functions behaves exponentially for words of small length l ($\mathbf{0 \leq \boldsymbol{l} \leq 10}$) and linearly for word lengths in the range $\mathbf{11 \leq \boldsymbol{l} \leq 50}$. It is also found that the species which are phylogenetically close each other have similar complexity functions calculated from a sample of their corresponding coding regions.

4.5.6. Presenting Author: Alejandro Seif, Tomás S. Grigera

Numerical Studies of the phenomenology of the Pica Ciamarra-Tarzia-de Candia-Coniglio liquid model

Alejandro Seif and Tomás Sebastián Grigera

Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas (INIFTA), Universidad Nacional de La Plata, Argentina y CONICET La Plata, Consejo Nacional de Investigaciones Cientícas y Técnicas, Argentina

Given the recent theoretical proposals conecting the dynamical behaviour of supercooled liquids with their thermodynamical propierties (case in point the growth of relaxation time with the decrease of entropy), it is interesting to possess a *toy model* that can show the supercooled

liquids phenomena, but can also be studied numerically for temperatures as low as possible. This is why in the present work, we have studied and tested the model proposed by Pica Ciamarra-Tarzia-de Candia-Coniglio as such toy model. We have compared Monte Carlo and Kinetic Monte Carlo simulations, showing the latter is orders of magnitude more efficient for systems whose temperatures are below the melting point. We have also studied the behaviour of the density, the formation of crystals and time correlation functions with respect to variations in time, size and temperature of the system. The model is able to reproduce a large part of the phenomenology of supercooled liquids close to the glass transition, particularly the two-step relaxation, the non exponential relaxation and the super-Ahrrenius increase of relaxation times. However, we have found two limitations: Studying the crystal formation, we can estimate the metaestability limit (kinetic spinodal) for a value of $\mathbf{1/T \simeq 12}$ (compared to a value of the Kauzmann temperature of $\mathbf{1/T_K \simeq 25}$. This means that it is not possible to study the system in an equilibrium state, for temperatures under $\mathbf{1/T = 12}$. On the other hand, after performing a study of ageing through the time correlation functions, we can establish that although the model exhibits ageing, the scaling laws which are observed experimentally cannot be found.

4.5.7. Presenting Author: David Hansmann

A new linkage between discrete interface motion models and continuous stochastic differential equations.

D. Hansmann[1] and R. C. Buceta[1,2]

[1]Departamento de Física, Facultad de Ciencias Exactas y Naturales - Universidad de Mar del Plata, Funes 3350, B7602AYL Mar del Plata, Argentina

[2]Instituto de Investigaciones Físicas de Mar del Plata (UNMdP and CONICET), Funes 3350, B7602AYL Mar del Plata, Argentina

Models of interface motion in disordered media are usually grouped into universality classes according to the scaling exponents of their observables (e.g. interface width, correlations, or power spectrum) and the continuous stochastic differential equations (SDE) of these universality classes describe distinctive mesoscopic properties of their underlying discrete models. But apart from these mesoscopic aspects it is not trivial to show the linkage between a discrete model and its continuous SDE. An approach to this problem is to derive a continuous SDE directly from a discrete model, taking advantage of symmetries and coarse-grained contributions. A practice, which is based on analytical functions, was introduced by Vvedensky et al. in 1993 (PhyRev, 42,852), using regularization techniques of Heaviside functions derived from the first and second transition moments. A different approach, which is based on the direct calculation of the continuous SDE coefficients, has been introduced by us in 2012 (JPhyA, 45, 435202). To this end our approach employs the probability distributions of height-differences between neighbor sites at the surface of a modeled system and generalized functions derived from the evolution rules of the model. So far, the approach has been successfully applied to both restrictive and non-restrictive growth models within KPZ universality class and to volume conserving surface models with symmetrical and asymmetrical jump rates. The present work discusses the principles of the formalism on the basis of some examples and gives an outlook for future applications.

4.5.8. Presenting Author: Germán Dima

Average dynamics of a finite set of coupled phase oscillators presenting excitability

G. C. Dima and G. B. Mindlin

Departamento de Física, Universidad de Buenos Aires.

Large systems consisting of many coupled excitable units occur in a wide variety of fields. Recently, it has been shown that in arrays of all-to all coupled units, the dynamics of the average activity of the network is ruled (in the limit of $N \to \infty$) by a low dimensional dynamical system. In this work we investigate the actual size of a finite array whose dynamics can be represented by the behavior of the infinitely large one. We compare those two cases studying the topological organization of periodic orbits found in their average dynamics.

4.5.9. Presenting Author: Vanesa Avalos Gaytán

Synchronization and modularity in adaptive networks

Vanesa Ávalos Gaytán[1], Juan A. Almendral[2], Satu Elisa Schaeffer[3], and Stefano Boccaletti[4]

[1] Facultad de Sistemas, Universidad Autónoma de Coahuila, Saltillo, Coahuila, México
[2] Dept. Tecnología Electrónica, Universidad Rey Juan Carlos, Móstoles, Madrid, Spain
[3] Dept. of Mechanical and Electrical Engineering, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, NL, Mexico
[4] Group of Computational Systems Biology, Center for Biomedical Technology, Pozuelo de Alarcón, Madrid, Spain

An important open problem in complex networks is the role of mesoscales in the production of a collective and coordinated dynamics. It is evident that the existence of communities in a task-performing network is closely related to the coexistence of two seemingly but not fundamentally opposite phenomena: the establishment of collective subtasks in the network (*segregation* of the network) and the coordination of those subtasks at a global scale (*integration*). The hierarchical nature of the function of complex systems is not yet fully elucidated; a thorough treatment of the relation between network structure and its dynamics at mesoscale level is also of interest. In this talk, we present a model for complex networks in which the formation of the mesoscale is dynamically driven by a simple adaptive rule. More precisely, we consider a network formed by Kuramoto oscillators, coupled through evolving links. The links are defined to be bistable; those coupling nodes with similar dynamics are reinforced, while those linking non-synchronous nodes are weakened. Our main finding is that modularity, a global feature, can naturally emerge in a network when evolving links are considered, that is, by means of dynamical properties at the local scale.

4.5.10. Presenting Author: Natalia Gulko

The Dynamics of a Coast and Tsunami Mitigation

N. G. Gulko[1] and R.I. Volinski[2]

[1]Ben -Gurion University of the Negev

[2]Ben -Gurion University of the Negev

The aim of our work is to elaborate an engineering approach to mitigate tsunami. The model consists of hydrodynamic and hydrogeological blocks. The kernel of hydrodynamic block is the shallow water equations with initial and boundary conditions. The hydrogeological block is constructed on the basis of the phasic theory of originating coasts of ocean, sea, man-made lake through the stages youth, second youth, maturity and old age. At that, young coasts undergo to catastrophic destruction, while the old age coast zone is stable. The theory of ageing of coastal zone allows a quantitative description by using maturity coefficient depending on parameters of sediments and waves. The model was used successfully at solving the questions of ecological safety on parts Black and Azov seas where underwater extraction of sand and grave from a sea bottom was realized. It was shown that unsuccessful arrange underwater sand pit rejuvenates the coast and its further development from youth to old age excites terrible scoars [1,2]. Similarly, the model can be used also in connection with the problem of terrible impact of tsunami waves on coasts and all on that. An example is given for using the model to ground of engineering applications for softening of hypothetical tsunami run-up on one of the parts of East Mediterranian. Impossibility to predict the time of the tsunami wave generation was noted in [3]. The main reason of such a current state is indeterminancy of triggering mechanism of underwater earthquake as a main source of tsunami wave generation. As a result, corresponding initial boundary value problem is undeterminable also due to it is unknown exactly the initial moment of generation.

4.5.11. Presenting Author: Osame Kinouchi

Complex Automata, Fine-Tuning, and the Stability of the Standard Model Vacuum

Osame Kinouchi[1,2] and Sandro Martinelli Reia[1]

[1]Departamento de Física - FFCLRP - USP

[2]Center for Natural and Artificial Information Processing Systems

We show, in contrast to common wisdom, that the single-site mean field calculations gives a good description for most of the d = 2 totalistic cellular automata (CAs) with Moore neighbourhood. The mean-field result is also useful for detecting the non-trivial CAs where spatial correlations are strong. We devise a control parameter calculable a priori from the rule table that reveals the presence of a first order absorbing phase transition. The famous Game of LIFE reveals itself as a metastable system where bubbles of true vacuum grows as a critical nucleation

process. Complex automata, similar to LIFE, occur only at the metastable coexistence region of the absorbing state phase transition. This contrast to previous ideas that Wolfram class IV complex automata lie at the border of a second order phase transition. This kind of absorbing phase transition is the same of that obtained from mean-field calculations for the standard model vacuum stability. Also, the recent determination of the Higgs boson mass indicates that our vacuum is metastable and lies in a region similar to the metastable region where LIFE is located in CAs rule space. Following a heuristic analogy, already done in the literature, between the space of possible CAs and the space of possible universes (the multiverse) we obtain that complex behaviour is not generic, that is, fine-tuning is needed since the critical region is a P-1 surface in a P dimensional parameter space. Finally we discuss the recent proposals of Degrassi et al. (2012) and Giudice (2008) that Self-Organized Criticality could be an explanation for the fine tuning of our universe to the critical region. We show that, by analogy with the CAs rule space, these authors present no mechanism to dynamically tune universes to the complex-critical region, so that the fine tuning of the Higgs mass continues to be an open problem. Finally, we propose that a evolutionary Smolin process could be the dynamical self-tuning mechanism toward criticality desired by Degrassi et al (2012) and Giudice (2008).

4.5.12. Presenting Author: Lucía Lopez

A strong Ca2+ mediated coupling of Ca2+ release sites gives rise to stereotyped Ca2+ signals.

Lucía Lopez[1,2], Estefanía Piegari[1,2], Lorena Sigaut[1,2], and Silvina Ponce Dawson[1,2]

[1]IFIBA (CONICET)

[2]DF, FCEyN, UBA

Intracellular Ca2+ signals usually involve Ca2+ release from the endoplasmic reticulum through IP3 receptors (IP3R's). IP3R's are typically organized in clusters. Their open probability depends on both the concentrations of IP3 and of cytosolic Ca2+. In the presence of a fixed IP3 concentration (a situation achieved in experiments), signal propagation is strongly dependent on cytosolic Ca2+ via the phenomenon known as Ca2+-Induced-Ca2+-Release (CICR). Once an IP3R becomes open and starts to release Ca2+, the ions released act upon other IP3R's and can eventually induce their opening. This process occurs both at the intra and the inter-cluster level. Namely, depending on the amount of Ca2+ that is released from a cluster and the mechanisms of Ca2+ buffering, the opening of IP3R's in a cluster can induce the opening of IP3R's on others. In this way either localized signals (puffs) or waves that propagate throughout the cell can be evoked. In this work we investigate the ways in which the signal size (or spatial spread) is modulated by the various processes involved in their production. Using a simple model that is based in experimental observations we show that the signals sizes can span a wide range of values or can be stereotyped depending on the strength of Ca2+ intracluster coupling. In particular we show that if the clearance rate of Ca2+ is decreased the size distribution is almost Gaussian about a mean while it approximately follows a power law for larger values of this rate.

4.5.13. Presenting Author: Mateos Diego

Some proposal method originated in Information Theory for Electrophysiologics register analysis

Diego Mateos[1], Walter Lamberti[1], and Steeve Zozor[2,3]

[1] FaMAF, National University of Córdoba, Córdoba, Argentina.
[2] Department of Physics, National University of La Plata, La Plata, Argentina.
[3] GIPSA-Lav, Glenoble, France.

The physiological signal like EEG , ECG and blood pressure has been analysed using statistical technique develop for time series . Recently this set of tools has expanded including physical concept like chaos ,complexity , ect [1,3]. The use of this analysis method has allow a grater comprehension of this physiologic phenomenon enabling a better clinical diagnosis. One example very significant is the characterization of a chaotic behaviour associate with some kind of cardiac disease [4],or the application of "wavelet entropies " for the studies in EEG epileptic patient [5]. In this work shown different method of analysis in physiologic register, based fundamentally in Jensen-Shannon divergence associate with wavelet, The Band-Pompe permutation [6] and the Lempel-Ziv complexity [7]. This method have been applied in EEG, Blood pressure continues register and respiration register. Even though the result are preliminary may conclude ,that the studies made give information potentially useful from the clinical point of view.

4.5.14. Presenting Author: Carlos Adalberto Schnaider Batista

CONTROL OF BURSTING SYNCHRONIZATION IN NETWORKS OF THERMALLY SENSITIVE NEURONS WITH CHEMICAL SYNAPSES

C. A. S. Batista[2], R. L. Viana[2], S. R. Lopes[2], and A. M. Batista[1]

[1]Universidade Estadual de Ponta Grossa - Ponta Grossa - Paraná - Brasil
[2]Universidade Federal do Paraná - Curitiba - Paraná - Brasil
[3]Universidade Tecnológica Federal do Paraná - Curitiba - Paraná - Brasil

Thermally sensitive neurons present bursting activity for certain temperature ranges, characterized by fast repetitive spiking of action potential followed by a short quiescent period. Synchronization of bursting activity is possible in networks of coupled neurons, and it is sometimes an undesirable feature. Control procedures can suppress totally or partially this collective behavior, with potential applications in deep brain stimulation techniques. We investigate the control of bursting synchronization in small-world networks of Hodgkin-Huxley type thermally sensitive neurons with chemical synapses through two different strategies. One is the application of an external time-periodic electrical signal and another consists of a time-delayed feedback

signal. We consider the effectiveness of both strategies in terms of protocols of applications suitable to be applied by pacemakers.

4.5.15. Presenting Author: Pablo Amil

Experimental multistability in Mackey-Glass delayed differential equation

P. Amil[1], C. Cabeza[1], A. C. Martí[1], and C. Masoller[2]

[1]Instituto de Física, Facultad de Ciencias, Universidad de la República, Uruguay

[2]Departament de Física i Enginyeria Nuclear, Escola Tècnica Superior d"Enginyeries Industrial i Aeronàutica de Terrassa, Universitat Politècnica de Catalunya, Barcelona, Spain

Multistability in Mackey-Glass delayed differential was found in simulations, and experimental work in an electronic implementation of such equation. Characterization of different solutions corresponding to the same set of control parameters was made, making possible to compare occurrences of each solution between computer simulations and experimental data.

4.5.16. Presenting Author: Rodrigo García

Light Controlled Oscillators (LCO): Synchronization and other emergent properties.

R. García[1], C. Cabeza[1], Arturo C. Martí[1], and N. Rubido[2]

[1]Instituto de Física, Facultad de Ciencias, Universidad de la República, Uruguay.

[2]Institute For complex systems and mathematical biology, King's college, University of Aberdeen, AB24 3UE, United Kingdom

In the framework of nonlinear phenomena, light controlled oscillators make interesting components presenting some advantages like having a simple electronic implementation and other advantages for numerical modeling. Couplings between two LCO are also easily implemented with a system of IR LEDs and photosensors. In this work, a complete characterization of the dynamics of a free LCO is shown, as well as a complete characterization of the possible interactions of two coupled LCOs, and emergent dynamics are studied. In particular, synchronization properties are studied and a peculiar phenomenon called 'oscilation death' is shown.

4.5.17. Presenting Author: Tatiana Alonso Amor; Dante R. Chialvo

Average coherence versus extreme events in the large scale brain resting-state functional magnetic resonance imaging

Tatiana Alonso Amor[1] and Dante R. Chialvo[2]

[1]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Buenos Aires, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Tecnológicas, Buenos Aires, Argentina

Recent work in our lab has shown how the brain fMRI dynamics at resting-state can be captured by inspecting only the relatively large amplitude in the brain blood oxygenated level dependent (BOLD) signal peaks. These results suggest that relevant information can be condensed in a few discrete events. In this work we use a related approach to estimate higher moments of the resting-state BOLD signal as a measure of the functional activity of the time series. We analyze the relationship between the average cross-correlation of the BOLD signals, a time average measure which estimate the mean synchronization, with other measures that reflect the existence of extreme events of high synchronization and moment-to-moment variations. The approach is able to investigate the two sides of the collective brain dynamics, one taking into account the entire length of the signal, and the other condensing the information about instantaneous changes in the brain collective activity.

4.5.18. Presenting Author: Inés Caridi

The Minority Game with a deterministic choosing rule of the strategy to play

Gabriel Acosta[1], Inés Caridi[2], Sebastián Guala[3], and Javier Marenco[3]

[1] Departamento de Matemática, FCEN, Universidad de Buenos Aires, Buenos Aires, Argentina

[2] Instituto de Cálculo, FCEN, Universidad de Buenos Aires, Buenos aires, Argentina [3] Instituto de Ciencias, Universidad Nacional de General Sarmiento, Buenos Aires, Argentina

In this work we propose the MG^{prior}, namely an MG with a new *choosing rule* of the strategy to play, which takes into account both prior preferences and game information [1]. MG^{prior} clarifies the quasi-periods observed in the sequence of minority sides of the MG [2]. In this new model, agents use their favourite strategy in case of tie, thus generating a deterministic execution. We have shown that in the Strict Period Two Dynamics (SPTD) regime for even occurrences of the states, the outcomes of the MG^{prior} are a periodic sequence and, moreover, the decisions of the agents are also periodic (strong periodicity). Furthermore, we propose the *FSMG*^{prior}, a maximal instance of the MG^{prior} in which all the potential agents are present (in the same way that the FSMG was defined in [3]). By exploiting the symmetry of the $FSMG^{prior}$, we show that the $FSMG^{prior}$ necessarily verifies the Stricted Period Two Dynamics.

We prove some general theorems applicable for sequences which meet periodicity and SPTD for even and/or odd occurrences of the states (i.e., not necessarily coming from a minority game). These theorems imply that in the regime in which SPTD is met for even occurences of the states, the sequence of minority sides of the MG^{prior} results periodic with length $L = 2k\mathcal{H}$, and $k = 1$ when the SPTD is met for both even and odd occurrences. In these cases, we showed that the periodic sequences for the MG^{prior} with parameter m are obtained as the eulerian cycles in the De Bruijn graph of order m. For example, when $m = 2$ there are two eulerian cycles associated with the periodic sequences **11100010** and **00011101**. We have characterized the quasi-periods of the MG for $m = 2$ as deviations from these eulerian cycles. These deviations sometimes generate inner paths which end in the same eulerian cycle, and sometimes generate outer paths which end in the other eulerian cycle.

Finally, we conclude that the fact that the sequence of outcomes is not periodic in the MG is generated by the random breaking of tied strategies, following the original choosing rule of strategies of the MG.

References

[1] G. Acosta, I. Caridi, S. Guala, J. Marenco, Physica A 392, 4450-4465 (2013).

[2] S. Liaw, C.Liu, Physica A 351, 571 (2005).

[3] G. Acosta, I. Caridi, S. Guala, J. Marenco, Physica A 391, 217-230 (2012).

4.5.19. Presenting Author: Inés Caridi

Characterizing the underlying static complex network of the Minority Game

Inés Caridi[1,2]

[1]Instituto de Cálculo, FCEN, UBA

[2]CONICET

The Minority Game (MG) is a well known agent-based model with no explicit interaction among its agents [1]. However, it is known that they interact through the global magnitudes of the model and through their strategies. In this work we intend to formalize the implicit interactions among MG agents as if they were links on a complex network. We have defined the link between two agents by quantifying the similarity among them. This link definition is based on the information of the *instance* of the game (the set of strategies asSigned to each agent at the beginning) and it brings about a static, unweighted, and undirected network. This link definition only captures the underlying network of connections at the strategies level, without dynamic information. We have analyzed the structure of the resulting network for different MG parameters, such as the number of agents (N) and the capacity of information processing of the agents (m), always taking into account games with two strategies per agent. In the region of crowd-effects of the model, the resulting networks structure is a small-world network, whereas in the region where the behavior of the MG is the same as in a game of random decisions, MG networks become a random network of Erdos-Renyi. The transition between these two networks is slow. We cannot say anything characteristic about the network in the region of the coordination among agents. Perhaps the instance (static) network may not be sufficient to offer information about this region, and it might be necessary to consider the dynamic network, which should be obtained using information related with the strategies which the agents actually used. Finally, we have studied the resulting static networks for the *Full Strategy Minority Game* (FSMG) model, a maximal instance of the MG in which all possible agents take part in the game [2-3]. We have explicitly calculated the degree distribution of the FSMG network and, from this exact result, we have estimated the degree distribution of the MG network, which is in accordance with computational results.

References

[1] D. Challet and Y. C. Zhang, Physica A, 246, 407, 1997; D. Challet and Y. C. Zhang, Physica A, 256, 514, (1998).

[2] I. Caridi, H.Ceva, Physica A, 317, 247, (2003).

[3] G. Acosta, I. Caridi, S. Guala, J. Marenco, Physica A 391, 217-230 (2012).

4.5.20. Presenting Author: Everton Cortez Rosado

Quantum-classical correspondence of the effects of the dipole range in molecular dissociation

E. C. Rosado and E. F. de Lima

UNESP - Rio Claro

The quantum and classical dissociation dynamics of heteronuclear diatomic molecules induced by infrared laser pulses are investigated. The dissociation is modeled by a Morse oscillator interacting with a classical electric field through a permanent dipole coupling. We treat this problem, of two atoms, like the movement of a single particle subject to the interaction potential between the atoms. Thus, we can control the dynamics of the system controlling the in- teraction between the external field and the dipole moment of this imaginary particle. We present a method to solve the time dependent Schrodinger and use the Split-time operator to study the behavior of several populations of the system. The main focus of the work is the effect caused in the dissociation by changing the spatial range of the dipole interaction. In agreement with classical calculations, the quantum results show an inhibition of the dissociation proba- bility for certain frequencies which are related to the finite range of the dipole. The concordance between quantum and classical dynamics is explained through the examination of classical Fourier components and quantum matrix elements of the dipole function.

4.5.21. Presenting Author: Larissa de Oliveira Figueira

Optimal Control of Chaotic Photoassociation of the Diatomic Molecules

Larissa de Oliveira Figueira and Emanuel Fernandes de Lima

Universidade Estadual Paulista- Julio de Mesquita Filho - Campus de Rio Claro

The photoassociation process control, process in which two colliding atoms absorb a photon to create a molecule, is a topic of great scientific interest. One reason for this interest is that photoassociation is a essential phenomenon for the control of chemical reactions with interference with the laser photodissociation process. To describe this process we use the model of the Morse potential which is a fundamental analysis for the study of molecular dynamics, reproduces realistically the Anharmonicity of molecular vibrations and has a continuous energy that allows the study of addition photoassociation to be a paradigm in quantum-classical compare. The appropriate identification of the external field and related physical mechanisms is essential to the efficiency of photoassociation, on the other hand, the classical dynamics associated with atoms and molecules subject to actions of external fields is generally not integrable which enables the application of control techniques coherent molecular systems classically chaotic,in this case, the techniques used are genetic algorithm and local control. The modeling of time-dependent external fields using control theory is important both for fundamental studies and

applications. A particle subject to the Morse potential similarly describes the relative motion of a pair of atoms in collision, so we can determine the Hamiltonian of our problem based on this potential

$$H = \frac{p^2}{2m} + D[e^{-2\alpha(r-r_e)} - 2e^{-\alpha(r-r_e)}] - Are^{-\chi r^4}.\epsilon(t) \tag{4.1}$$

where m_r the reduced mass of two atoms, r is the internuclear distance,D is the classical dissociation energy, α is the range of the potential, r_e is the equilibrium position ,r is the internuclear distance, A and χ are fixed parameters and $\epsilon(t)$ is the electric field of the laser,is given by a two-color pulse with frequencies w and $2w$.

$$\epsilon(t) = f(t)[sin(wt) + \lambda sin(2w + \phi)] \tag{4.2}$$

where λ give the ratio between the amplitude of the pulse components, ϕ is relative phase and $f(t)$ is a square envelope function. A gaussian wave packet was chosen as distribution of the initial phase space. Points are chosen by a Monte Carlo algorithm to be distributed according to the projection wavepacket. When calculated of the number of particles fotoassociadas, the classical photoassociation probability calculated as the fraction of trajectories trapped in the potential, well is investigaded as a function of the external field parameters, with special emphasis given to the role of the relative phase of the field components. Thus we can apply the techniques mentioned control and make comparisons of the results.

4.5.22. Presenting Author: Felipe Olivares

Information quantifiers and the fine structure of chaotic attractors

Felipe Olivares[1,4], Angel Plastino[2], and Osvaldo A. Rosso[3,4]

[1] Departamento de Física, Universidad Nacional de La Plata, La Plata.Argentina
[2] Instituto de Física, Universidad Nacional de La Plata, La Plata. Argentina
[3] LaCCAN-CPMAT, Universidade Federal de Alagoas, Maceió. Brasil
[4] Laboratorio de Sistemas Complejos, Universidad de Buenos Aires, Capital Federal. Argentina.

We highlight the potentiality of a special Information Theory approach in order to unravel the intrincates of nonlinear dynamics. Information quantifiers as the Shannon entropy, statistical complexity and Fisher information are functionals that characterizes the probability distribution P associated to the time series generated by a given dynamical system. The adequate way of picking up such distribution is achieved by the Bandt and pompe metodology, which is one of the most simple symbolization techniques available and takes into account time – causality in the concomitant process. In this communication we introduce two representation spaces called causality entropy-complexity information plane ($\mathcal{H} \times \mathcal{C}$), which quantifies global features, as the presence of correlational structures and, the causality entropy-Fisher information plane ($\mathcal{H} \times \mathcal{F}$) that measures local features. These two informational planes become a new tool to characterize a time series generated by a dynamical systems or experimental measurements.

We studied 3 routes to chaos namely period doubling, tangent bifurcation and hopf bifurcation as a funtion of a control parameter, simulated by time series obtained from two discrete chaotic systems: logistic map and delayed logistic map. The analysis in both causality planes $\mathcal{H} \times \mathcal{C}$ and $\mathcal{H} \times \mathcal{F}$ provide a characterization of the intrinsic information of the maps, independently from the control parameter. The $\mathcal{H} \times \mathcal{F}$ plane shows a specific behavior for each kind of routes to chaos. At this point we are able to differentiate between a period doubling tree; intermittency behavior ocurring before the tangent bifurcation; periodic attractos; and quasiperiodic orbits generated by the delayed logisctic map after a critical value r_H of the parameter (Hopf bifurcation). This characterization comes in what we call a dynamic feature plane-topography map, $\mathcal{H} \times \mathcal{F}$, because the local sentitivity of the Fisher information quantifier. On the other hand, the characterization given by the plane $\mathcal{H} \times \mathcal{C}$ locates all the dynamics on the curve of maximum complexity, independely of the underlying phenomenon in the time series. Thus we are not able to identificate the differences between the dynamics under analysis. This last characterization is consistent with the quantification given by the Lyapunov exponents. Finally a study of the evolution of the information quantifiers as a function of the sampling time τ used when we construct the PDF, allows us to infer usefull information about the characteristic temporal scales of the underlying dynamics of the temporal series. More precisely, we are able to identify between periodic and quasiperiodic orbits. A quasiperiodic motion can be thought as a mixture of periodic orbits with different fundamental frecuencies. We are able to characterize qualitative and quantitative the period of these movements.

4.5.23. Presenting Author: Taline Suellen Krüger

The effect of non hyperbolic areas of phase space in the stickiness of island

Taline S. Krüger[1], Paulo P. Galúzio[1], and Sergio R. Lopes[1]

[1] Department of Physics, Federal University of Paraná, Paraná, Brazil

In this work we investigate how properties of the phase space can be related to the phenomenon of stickiness. In particular we show that the stickiness of a particular resonance island of the phase space is strongly related to the presence of hyperbolic channels that occur in the neighbourhood of the island. We show that inside theses channels an unstable variable make possible to the trajectory to be ejected of the stickiness region. The stickness of the channel is related to the time the trajectory stays near the island (neighbourhood of the island) before being ejected from the stickiness area. Using the standard map dynamics, we perform an analysis for various K values (the nonlinear parameter).

4.5.24. Presenting Author: T. L. Prado

Synchronization and Clusterization studies on Network of Networks using Modified Hodgkin-Huxley Equations

T. L. Prado and S. R. Lopes

Departament of Physics, Federal University of Paraná, Curitiba, Paraná, Brazil

The study of complex networks are fundamental for the comprehension of neuronal behaviour. Dynamical effects emerge from the interaction of individual dynamics from each neuron, for example, synchronization phenomena, self-organized criticality, chaotic bursts and many others.

In this work we study the synchronization phenomena that arises from network of networks. We use the experimental obtained cat neural network. Each macroscopic area of the cat brain is simulated using sub-networks, composed by hundreds of individual neurons, each has local dynamics based on modified Hodgkin-Huxley equations, namely the Huber-Braun set of equations. Each sub-network has a small world scheme of coupling. All sub-networks are coupled using the external adjacency matrix, obtained by experimental data of real cats. We analyse the evolution of the system using Kuramoto order parameter, synchronization as well as phase synchronization are studied. We show that the system presents regimes of phase synchronization and anti-synchronization. Network clustering effects are also reported.
Keywords: Complex Networks, Small-World, adjacency matrix, non-local connections, synchronization, order parameter.

4.5.25. Presenting Author: Damián G. Hernández

Cooperation within triplets in the rock-paper-scissors game

D. G. Hernández and D. H. Zanette

Consejo Nacional de Investigaciones Científicas y Técnicas, Centro Atómico Bariloche and Instituto Balseiro

We study a population involved in a cyclic game of three strategies, known as rock-paper-scissors game, whose agents interact through groups of three individuals (triplets) considering the possibility that two weak agents cooperate and beat a strong one. In a wide range of parameters the system present a stable heteroclinic cycle, which implies that in a finite population some of the strategies become extinct and other survive. We found that the cooperation within triplets only benefit the survival of the strategy if it is above a threshold. We study the survival probabilities of the different strategies as a function of the cooperation parameters through a analytic approximation and compare with simulations, obtaining a good agreement. Results are generalizable to other systems with heteroclinic cycles.

4.5.26. Presenting Author: Alejandra Figliola

Quantifiers of information: Entropy and Complexity

Alejandra Figliola[1], Osvaldo Rosso[2,3], Mariel Rosenblatt[1], and Eduardo Serrano[4]

[1] Instituto del Desarrollo Humano, Un. Nac. General Sarmiento, Los Polvorines, Pcia. de Buenos Aires, Argentina.
[2] Universidade Federal de Alagoas - UFAL Lab. Computaçao Científica e Análise Numérca LaCCAN, Maceió, AL, Brasil.
[3] Lab. Sistemas Complejos, Fac. Ingeniería, Un. Buenos Aires. Argentina
[4] Escuela de Ciencia y Tecnología, Un. de San Martín, San Martín, Pcia. de Buenos Aires, Argentina.

The focus of this work is the comparison between quantifiers of information: *Shannon Entropy, Generalized Statistical Complexity, Wavelet Leader Entropy* and *Wavelet Leader Complexity.* Besides the well-known Shannon entropy, we highlight the application of Statistical Complexity, made by López Ruiz, Mancini and Calvet, which is based on a measure of complexity that is

constructed from the output signal of a system and is widely used by a wide range of scientific communities from physics and biology to economics and physiology, within the framework of the study of complex systems. It has the functional form of a product between the entropy of the system and their distance from the equilibrium. If $\boldsymbol{P}$ is the probability distribution of the system and $\boldsymbol{H(P)}$ a measure of the entropy, then the complexity $\boldsymbol{C(P)}$ is $\boldsymbol{C(P) = H(P)D(P, P_e)}$, when $\boldsymbol{D(P, P_e)}$ is the distance of the equilibrium of the system. The different ways of choosing a distribution will result in different distributions "qualities" of quantifiers of information. Bandt and Pompe proposed a simple technique of symbolization and that is also capable of considering the temporal causality process under analysis.
Moreover, the local regularity analysis is useful in many fields, such as financial analysis, fluid mechanics, PDE theory, signal and image processing. Different quantifiers have been proposed to measure the local regularity of a function. The Wavelet Leaders Entropy and the Wavelet Leaders Complexity are two new measure of regularity by combining the concept of entropy and complexity coming from the information theory and statistical mechanics, with the wavelet leaders coefficients coming from the wavelet theory.
In addition to the proposed comparison between these quantifiers, we apply this methodology to the financial data series of the Dow Jones Industrial Average index, registered in the period $\boldsymbol{1928 - 2011}$, in order to compare both formulations.

4.5.27. Presenting Author: Daniel H. Barmak

Modeling interventions during a dengue outbreak

D. H. Barmak, C. O. Dorso, M. Otero, and H. G. Solari

Departamento de Física, FCEN-UBA and IFIBA-CONICET, Pabellón I, Ciudad Universitaria, Buenos Aires, Argentina

We present a stochastic dynamical model for the transmission of dengue that considers the co-evolution of the spatial dynamics of the vectors (*Aedes aegypti*) and hosts, human population, allowing the simulation of control strategies adapted to the actual evolution of an epidemic outbreak. We observed that imposing restrictions to the movement of infected humans is not a highly effective strategy. In contrast, isolating infected individuals with high observance by the human population is efficient even when implemented with delays to an ongoing outbreak. We studied insecticide spraying strategies as well assuming different (hypothetical) efficiencies. We observed that highly efficient fumigation strategies seem to be effective during an outbreak. Nevertheless, taking into account the controversial results on the use of spraying as a single control strategy, we suggest that carrying out combined strategies of fumigation and isolation during an epidemic outbreak should account for a suitable strategy for the attenuation of epidemic outbreaks.

Taking advantage of the versatility of the model, we also analyze more real non-control strategies situations such as inhomogeneities on the distribution of humans(greater concentrations of people due to workplace, residential or commercial areas) and the effect of the concentration of dengue infected humans at hospitals where might be people going for reasons not related to dengue.

4.5.28. Presenting Author: Daniel Escaff

Synchronization of globally coupled two-state stochastic oscillators with a state-dependent refractory period

Daniel Escaff[1], Upendra Harbola[2,3], and Katja Lindenberg[2]

[1]Complex Systems Group, Facultad de Ingeniería y Ciencias Aplicadas, Universidad de los Andes, Avenida San Carlos de Apoquindo 2200, Santiago, Chile

[2]Department of Chemistry and Biochemistry and BioCircuits Institute, University of California San Diego, 9500 Gilman Drive, La Jolla, California 92093-0340

[3]Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore 560012, India

We present a model of identical coupled two-state stochastic units, each of which in isolation is governed by a fixed refractory period. The nonlinear coupling between units directly affects the refractory period, which now depends on the global state of the system and can therefore itself become time dependent. At weak coupling the array settles into a quiescent stationary state. Increasing coupling strength leads to a saddle node bifurcation, beyond which the quiescent state coexists with a stable limit cycle of nonlinear coherent oscillations. We explicitly determine the critical coupling constant for this transition.

4.5.29. Presenting Author: L. A. Gonzalez - Diaz

Sojourn times for heteroclinic attractors described by coupled Lotka-Volterra maps

L. A. González - Díaz and J. L. Cabrera.

Lab. de Dinámica Estocástica - Centro de Física, Instituto Venezolano de Investigaciones Científicas.

We show that, if the saddle points are hyperbolic, the sojourn times increase exponentially. Asymptotically, these times are those that the orbit spends within the neighbourhood of one fixed point given. We consider N - dimensional coupled Lotka - Volterra maps.

4.5.30. Presenting Author: Pasquale Miguel Angel or Marcos Carballido

Dynamics of tumor cell colony spreading stimulated by epidermal growth factor

N.E. Muzzio[1], M. Carballido[1], M.A. Pasquale[1], P.H. González[2], and A.J. Arvia[1]

[1]Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas (INIFTA), UNLP, CONICET, Sucursal 4, Casilla de Correo 16, (1900) La Plata, Argentina

[2]Cátedra de Patología, Facultad de Ciencias Médicas, UNLP, Calle 60 y 120

It is well established that cell motility in colonies play a relevant role in many biological processes. Cells often migrate collectively in groups maintaining cell-cell junctions, and this type of movement has been observed in cancer explants in vitro. The characterization of individual cell motility and its influence on the colony border roughness behavior can give new insight about the colony spreading. In this contribution, Hela (cervix cancer) cell colonies with different geometries and under different growth regimes, i.e., initially q-radial or q-linear, and diverse cell populations ($\boldsymbol{N}$) were analyzed. After colonies formation the standard culture medium (S medium) was replaced by fresh media supplemented with different epidermal growth factor (EGF) concentrations ($\boldsymbol{c_{EGF}}$), and the follow up was started after cells adaptation. Cultures were followed for about 12 day and individual cell displacements were recorded by a time-lapse system at time intervals in the range 5-45 min over 2-4 days. Dynamic scaling analysis ($\boldsymbol{dsa}$) was applied to the q-linear colony fronts to determine critical exponents, and cell coordinates at different times were used to evaluate individual cell displacement velocities, trajectories, their directionality and persistence, and their mean square displacement ($\boldsymbol{msd}$). The EGF produced the decrease in the average size of cells, the number of focal contacts per unit area and the prolongation of pseudopodia connecting distant cells, and consequently a decrease in the local cell density. This effect depends on the initial cell population and $\boldsymbol{c_{EGF}}$. The kinetics of q-radial colonies with low $\boldsymbol{N}$ fulfilled a first order exponential law in terms of $\boldsymbol{N}$ with a kinetic constant ($\boldsymbol{k}$) that increased with $\boldsymbol{c_{EGF}}$. For $\boldsymbol{t} < 9000$ min, the same kinetic law was observed for the average colony radius ($< \boldsymbol{R} >$) versus $\boldsymbol{t}$ data for both S and EGF media, whereas, for longer $\boldsymbol{t}$ (larger $\boldsymbol{N}$) a constant front displacement velocity regime set in only for the colony spreading in S medium; this is, no transition from the exponential law to constant velocity regime was distinguished in EGF media, at least for the experimental conditions used in this contribution. It is worth noting that specific N-dependent features appeared in the $< \boldsymbol{R} >$ versus $\boldsymbol{t}$ plots, depending on $\boldsymbol{c_{EGF}}$. The kinetic transition was associated to the formation of an active ring at the colony border region where cell proliferation and cell motility contributed to the 2D front propagation. Cell motility was guided by local crowding constrains, depending on $\boldsymbol{N}$ and the colony geometry. Cells moved from higher to lower density regions and the larger value of N the greater the cell velocity. The analysis of msd data of individual cells suggested collective movements of living and new born cells searching for cell free space. Two transport mechanisms contributed to cell displacement: a conventional diffusion at low $\boldsymbol{N}$, and a ballistic-like one at large $\boldsymbol{N}$ and particularly for q-linear colonies. The presence of EGF increased individual cell and colony front velocities as well as the contribution of the ballistic mechanism. The critical exponents obtained from the $\boldsymbol{dsa}$ applied to the q-linear colony fronts grew either in the S or EGF containing media, were compatible with a Kardar-Pasisi-Zhang (KPZ) continuous equation for a certain range of time and front length. The influence of the EGF is manifested in the faster roughness saturation. Cells redistribute at the border region determining the velocity components that appear to be related to the curvature dependent non linear term in the KPZ equation.

4.5.31. Presenting Author: Reale, Marcela

Interaction effects in two-dimensional ratchets

A. J. Fendrik and L. Romanelli

Instituto de Ciencias, Universidad Nacional de General Sarmiento

We have studied the effect of the interaction between particles (Lenard-Jones type) in the transport properties of a system composed of two species of particles in a bidimensional potential ratchet. By controlling the system parameters, we analyze the possibility of designing a device capable of segregating the particles according to their masses.

4.5.32. Presenting Author: Maurício Girardi-Schappo

Synchronization Patterns in Regular and Complex Networks of Map-based Neurons

Maurício Girardi-Schappo, Luciano R. Prado, and Marcelo H. R. Tragtenberg

Departamento de Física, Universidade Federal de Santa Catarina, 88040-900, Florianópolis, Santa Catarina, Brazil

A few maps have been proposed to describe neurons. Among them, KTz is a neuron model described by a 3D map representing the action potential, a recovery variable and a slow variable, and exhibits many excitable cells behaviors (fast and regular spiking, bursting, etc). We utilize a Chemical Synapse Map to couple KTz's units into regular and complex networks. We study the synchronization limit and the transient behavior of the networks. Many different patterns of synchronization appear in the network, from phase and antiphase synchrony to completely chaotic states in infinite regular networks. These synchronous regimes are related with the bifurcation undergone by the coupled maps. We also study the role of synaptic noise in the synchronization patterns and identify the relevant synaptic parameters for each case.

4.5.33. Presenting Author: Mauricio J. A. Bolzan

On multifractality of low-latitude geomagnetic fluctuations

M. J. A. Bolzan and R. R. Rosa

Laboratório de Física, Campus Jatai, Universidade Federal de Goiás (UFG).

We analyze the complex solar wind-magnetosphere interactions based on the scaling properties of low-latitude nonstationary geomagnetic fluctuations measured through the Vassouras Observatory magnetometers at Rio de Janeiro state (lat: 22:4o S and lon: 43:6o W), Brazil. The characterization of the geomagnetic fluctuations is performed throughout the singular power spectra deviations obtained from a global wavelet spectrum approach. We interpret our findings as evidence that there is a multifractal underlying process driving the intermittent coupling between the solar wind and the geomagnetic field.

4.5.34. Presenting Author: Marina E. Wosniack

Random Search Dynamics for Distinct Types of Targets: Optimizing a Weighted Efficiency

M. E. Wosniack and M. G. E. Da Luz

Departamento de Física, Universidade Federal do Paraná

In this work we propose a new formula to calculate the search efficiency of a super-diffusive random walker when the resources are patchily distributed and the gain in finding each target depends on its type and the previous history of searching. In this way, the so called weighted efficiency is defined such to take into account the advantage in finding different kinds of targets instead of get many of them, but of an unique characteristic. Our results are associated to biological contexts, where the forager has to optimize several tasks in order to maximize its search efficiency.

4.5.35. Presenting Author: Garcia, Guillermo Daniel

Percolation of binary gas mixture adsorbed on square lattice

Guillermo D. Garcia[1], Fabricio O. Sanchez Varretti[1], Paulo Centres[2], and José A. Ramirez Pastor[2]

[1] Grupo de Físico-Química de Sistemas Complejos, Universidad Tecnológica Nacional – Facultad Regional San Rafael, Urquiza 314 340M5602GCH, San Rafael, Mendoza, Argentina

[2] Intituto de Física Aplicada (INFAP) – Universidad Nacional de San Luis, Facultad de Ciencias Físicas, Matemáticas y Naturales, Ejercito de Los Andes 950 - D5700HHW - San Luis - Argentina.

In spite of many decades of research there is no analytical way of predicting the percolation threshold for a particular system. This makes computational simulation one of the main tools finding the percolation threshold.

In this presentation, we study the percolation of the adsorbed phase of a binary gas mixture on a square lattice. The adsorption process is limited to the monolayer adsorption. It is studied using the well-known Monte Carlo and Metrópolis algorithm and protocol for lattice gas model. We explore the behavior of the percolation threshold as a function of inter-particle forces. The considered interactions are repulsive forces to first neighbors.

4.5.36. Presenting Author: Fernando Montani

Characterization of a neuronal network efficiency using causal quantifiers

Fernando Montani[1,2], Emilia B. Deleglise[1,2], and Osvaldo A. Rosso[3]

[1]IFLYSIB, Universidad Nacional de La Plata, La Plata, Argentina

[2]: Departamento de Física, Facultad de Ciencias Exactas, UNLP, Calle 49 y 115. C.C. 67 (1900), La Plata, Argentina.

[3]Laboratorio de Sistemas Complejos, Facultad de Ingeniería, Universidad de Buenos Aires (UBA). (1063) Av. Paseo Colón 840, Ciudad Autónoma de Buenos Aires, Argentina.

We consider a network of cortical neurons with axonal conduction delays and time-dependent plasticity, which is representative of a cortical column. Each neuron is triggered following the dynamic of the Hodgkin-Huxley equations, and is randomly interconnected to other neurons. In our current work we use an information theory approach based on causal quantifiers (entropy and statistical complexity evaluated PDF with Bandt-Pompe) to characterize the dynamics of neural activity of a population of neurons. This allows us to investigate the temporal structure of complex neural signals not only by using probability distributions associated with the inter-spikes intervals (PDF histograms), but considering instead much more subtle measures accounting for its causal structure.

4.5.37. Presenting Author: Andre Vieira

Microstructure identification via detrended fluctuation analysis of ultrasound signals

P. G. Normando[1], R. S. Nascimento[1], E. P. Moura[1], and A. P. Vieira[2]

[1]Departamento de Engenharia Metalúrgica e de Materiais, Universidade Federal do Ceará, 60455-760, Fortaleza, CE, Brazil

[2]Instituto de Física, Universidade de São Paulo, Caixa Postal 66318, 05314-970, São Paulo, SP, Brazil

We describe an algorithm for simulating ultrasound propagation in random one-dimensional media, mimicking different microstructures by choosing physical properties such as domain sizes and mass densities from probability distributions. By combining a detrended fluctuation analysis (DFA) of the simulated ultrasound signals with tools from the pattern-recognition literature, we build a Gaussian classifier which is able to associate each ultrasound signal with its corresponding microstructure with a very high success rate. Furthermore, we also show that DFA data can be used to train a multilayer perceptron which estimates numerical values of

physical properties associated with distinct microstructures.

4.5.38. Presenting Author: Ana Laura Schaigorodsky

Memory and long-range corralations in chess's games

A. L. Schaigorodsky[1], J. I. Perotti[3], and O. V. Billoni[1,2]
[1]Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, Argentina.
[2]Instituto de Física Enrique Gaviola (IFEG-CONICET).
[3]Department of Biomedical Engineering and Computational Science (BECS), Aalto University, Findland.

In this paper we report the existence of long-range memory in the opening moves of a chronologically ordered set of chess games using an extensive chess database. We used two mapping rules to build discrete time series and analyzed them using two methods for detecting long-range correlations; rescaled range analysis and detrented fluctuation analysis. We found that long-range memory is closely related to the existence of high level players. This result is robust against the assignation rules and the method employed in the analysis of the series.

4.5.39. Presenting Author: Nuno Crokidakis

The influence of intransigent agents in the opinion formation process

N. Crokidakis[1], V. Blanco[1], and C. Anteneodo[1,2]
[1]Departamento de Física, PUC-Rio, Rio de Janeiro, Brazil
[2]National Institute of Science and Technology for Complex Systems, Brazil

In this work we study the opinion formation in a fully-connected population where the agents may be in three different states, representing any public debate with three choices (yes, no, undecided). The interactions occur by pairs and are competitive, being negative with probability p or positive with probability $1 - p$. This bimodal distribution of interactions produces a behavior similar to the one resulting from the introduction of Galam's contrarians in the population. In addition, we consider a fraction d of intransigent or obstinate individuals, also called inflexibles in opinion dynamics, that keep their opinions unchanged. We study the impact of the competition among contrarians and inflexibles on opinion spreading by means of computer simulations. Our results show that the presence of inflexibles affects the critical behavior of the population only if such disorder is quenched, i.e., if the intransigents do not change their convictions with time. On the other hand, in the annealed version of the model, where the inflexibles are chosen at each time step (i.e., inflexibility is occasional), the nonequilibrium phase transition that occurs in the absence of inflexibles remains unchanged. We also discuss the

relevance of the model for real social systems.

4.5.40. Presenting Author: C. Masoller

Ultrahigh intensity pulses in the nonlinear dynamics of semiconductor lasers

Cristina Masoller

Universitat Politècnica de Catalunya, Barcelona, Spain

Extreme events are rare and often catastrophic events, examples including tsunamis, earthquakes, supernovas, stock market crashes, etc. A particular type of extreme event is an ocean rogue wave, that can develop suddenly even in calm and apparently safe seas, and have been responsible for several boat accidents, representing a major challenge for the design of off-shore platforms. In optics, several rogue wave phenomena have been discovered, and in particular in lasers, extreme and rare pulses have been observed in the output of mode-locked lasers and semiconductor lasers. Because optics provides an inexpensive and controllable experimental setup, and well-known models, the study of optical rogue waves and extreme pulses has significantly advanced the research in the field of extreme events. I will present our experimental and numerical observations of the statistics of the extreme optical pulses, induced in semiconductor lasers either by external optical injection [1, 2], or by external optical feedback [3]. I will discuss the statistical features of rare and ultra-high intensity pulses and will interpret them in terms of simple rate-equation models. These models allow identifying the key features of the phase space that allow for the presence of extreme events in the laser dynamics.

References

[1] C. Bonatto, M. Feyereisen, S. Barland, M. Giudici, C. Masoller, J. R. Rios Leite, and J. R. Tredicce, "Deterministic Optical Rogue Waves", Phys. Rev. Lett. 107, 053901 (2011).

[2] J. Zamora-Munt, B. Garbin, S. Barland, M. Giudici, J. R. Rios Leite, C. Masoller, and J. R. Tredicce, "Rogue waves in optically injected lasers: Origin, predictability, and suppression", Phys. Rev. A 87, 035802 (2013).

[3] J. A. Reinoso, J. Zamora-Munt, C. Masoller, "Extreme intensity pulses in a semiconductor laser with a short external cavity", Phys. Rev. E 87, 062913 (2013).

4.5.41. Presenting Author: Suárez, Gonzalo Pablo

Single-file diffusion on self-similar substrata

G. P. Suárez[1,2], H. O. Mártin[1,2], and J. L. Iguain[1,2]

[1]Instituto de Investigaciones Físicas de Mar del Plata (IFIMAR)

[2]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Deán Funes 3350, 7600 Mar del Plata, Argentina

The diffusion of particles, interacting through a hard-core potential, in an unidimensional infinite lattice is known as single file diffusion. Double occupancy and jumps over other particles

are not allowed. It is well known that the mean square displacement of a tagged particle behaves as $\boldsymbol{\Delta^2 x \sim t^{2\nu}}$ and presents two regimes: normal diffusion ($\boldsymbol{\nu = 1/2}$) for short times, and a sub-diffusive regime ($\boldsymbol{\nu = 1/4}$) for long times. Modifying the substrate on which the particles move, it is possible to change its time behavior. In particular, if we place barriers on a self-similar arrangement the time dependence of the mean square displacement is now modulated by logarithmic-periodic oscillations. In this work we use simple arguments to explain these oscillations and how the diffusion of the center of mass is affected. We also found a expression for the new exponents $\boldsymbol{\nu}$ in both regimes and investigated the effect of changing the concentration of particles. Monte Carlo simulations where used to confirm theoretical results.

4.5.42. Presenting Author: Horacio Castellini

Implementation of the Recurrence Quantified Analysis to study of Complexity Statistics

H. Castellini

Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Rosario, Pellegrini 250

In this poster we study the implementation of recurrence plot and recurrence quantified analysis to statistical complexity of Shiner, Davison and Landsberg (SDL), as well as statistical complexity of López-Ruiz, Mancini, and Calbert (CML). To this end we use the periodic statistical of diagonal of recurrence plot graph and then use one of the three possible definitions of distance on the probability space, so it can see what would be the most optimal candidate. This technique was tested on a convex combination of periodic and random signals and a continuous chaotic dynamical system (the attractor Rösler).

4.6. Non-equilibrium and fluctuation phenomena

4.6.1. Presenting Author: Alicia Arzúa

Surface dispersive waves phase velocity in water

Alicia Arzúa[1], Carlos Negreira[1], and Ismael Nuñez[2]
[1]Instituto de Física, Facultad de Ciencias, Universidad de la República
[2]Instituto de Física, Facultad de Ingeniería, Universidad de la República

Surface wave in water are highly dispersive. The addition of gravity force and capillary effects leads to a dispersion relation depending on the surface tension, density and depth. This work is aimed at measuring the phase velocity of such surface waves in a certain range of frequencies and contrast the results obtained with those obtained from theory. From numerical simulations of the dispersion relation we obtain the phase velocity as a function of the frequency. This function displays a minimum delimiting the behavior of the wave in two distinct regions. In the range of low frequencies the effect of gravity prevails, while in the other region capillary effects are more important. In the laboratory, waves are produced by a shaker driven by a pulse generator. The deformation of the surface is detected by means of laser ray incident inciding normally to the surface and deflected towards a screen. The motion of the spot light in the screen is captured using a video camera and digitalized. The experiment is repeated varying the distance between the incident laser and the position excitation source by the shaker. The phase velocity is obtained from the phase shift due to the change in the distance. In this way, we obtain a set of values of phase velocity and frequency (recover in a table). The range of frequencies of the excitation is in a neighbor about 13.4 Hz (which corresponds to the minimum velocity). From the experimental values the surface tension can also be obtained.

4.6.2. Presenting Author: Jorge A. Revelli, Horacio S. Wio, Roberto R. Deza

KPZ: Recent variational formulation developments

Jorge A. Revelli[1], Horacio S. Wio[2], Roberto R. Deza[3], and Carlos Escudero[4]
[1] IFEG-FaMAF (CONICET-UNC), 5000 Córdoba, Argentina
[2] IFCA (UC and CSIC), E-39005 Santander, Spain
[3] IFIMAR (CONICET-UNMdP), 7600 Mar del Plata, Argentina
[4] Math. Dept. UAM & ICMAT, E-28049 Madrid, Spain

So far it is well known that:“ KPZ equation is a genuine kinetic equation describing a non equilibrium process that cannot be derived from an effective free energy...“ . However, in contrast to that assertion, here we show that it is possible to introduce and develop a variational formulation of the KPZ equation. This formulation gives rise to a non equilibrium potential (that is, a thermodynamic potential-like that takes place in far away equilibrium situations). The knowledge of such a potential allows to prove certain invariant properties. We also discuss the stationary distribution in arbitrary dimensions. Besides, it is shown strong restrictions for the election of the discrete form of the KPZ equation. On one hand there are some consistent

discretization forms, while on the other well-known ones do not fullfill the consistence restrictions. The fundamental difference between a consistent discretization and non consistent one arises in the galilean invariance. However, both show the same critical exponents. This fact establishes doubts about if the role of this symmetry is so important in order to define the KPZ universality class. Finally, by exploring variational formulation techniques, new possibilities to analyze KPZ dynamics and related systems are opened.

References

[1] Wio H.S., Int. J. Bif. Chaos v.18, 2813 (2009)

[2] H.S.Wio, J.A.Revelli, R.R.Deza, C.Escudero and M.S.de La Lama, Europhys.Lett. 89, 40008 (2010)

[3] H.S.Wio, J.A.Revelli, R.R.Deza, C.Escudero and M.S. de La Lama, Phys. Rev. E v.81, 066706 (2010)

[4] H.S.Wio, J.A.Revelli, R.R.Deza, C.Escudero and M.S.de La Lama, Phil. Trans. Royal Soc. A v.369, 396-411 (2011).

[5] C.Escudero, E. Korutcheva, H.S.Wio, R.R.Deza and J.A.Revelli,"KPZ Equation as a Gradient Flow: Nonequilibrium Potential Expansion and Renormalization Group for Fluctuations" submitted.

4.6.3. Presenting Author: G. P. Saracco

Damage Spreading in a Driven Lattice Gas Model

Gustavo P. Saracco[1], M. Leticia Rubio Puzzo[1], and Ezequiel V. Albano[2]

[1]Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas (INIFTA), UNLP, CCT La Plata - CONICET, c.c. 16, Suc. 4, (1900) La Plata, Argentina.

[2]Instituto de Física de Líquidos y Sistemas Biológicos (IFLYSIB), UNLP, CCT La Plata - CONICET, calle 59 nro 789, (1900) La Plata, Argentina.

We studied damage spreading in a Driven Lattice Gas (DLG) model as a function of the temperature T, the magnitude of the external driving field E, and the lattice size. The DLG model undergoes an order-disorder second-order phase transition at the critical temperature $T_c(E)$, such that the ordered phase is characterized by high-density strips running along the direction of the applied field; while in the disordered phase one has a lattice-gas-like behaviour. It is found that the damage always spreads for all the investigated temperatures and reaches a saturation value D_{sat} that depends only on T. D_{sat} increases for $T < T_c(E = \infty)$, decreases for $T > T_c(E = \infty)$ and is free of finite-size effects. This behaviour can be explained as due to the existence of interfaces between the high-density strips and the lattice-gas-like phase whose roughness depends on T. Also, we investigated damage spreading for a range of finite fields as a function of T, finding a behaviour similar to that of the case with $E = \infty$.

4.6.4. Presenting Author: Rebeca Cardim Falcão

Statistical model of impact fragmentation in a disk.

R. C. Falcão and F. Parisio

Departamento de Física, Universidade Federal de Pernambuco

This work calculated the fragments size distribution of a two-dimensional region with a punctual impact from which cracks originate. We assume the patterns to be built by two simple ingredients: concentric circumferences, whose radii assume random values in the interval]0,R] and semi-infinite straight lines emanating from the center of the circumference, with angles that are also random variables. The radii distribution of circular cracks was achieved by basics concepts of physics such as energy, and the angles distribution of radial cracks was considered equal a uniform distribution, because of the system's simmetry.

4.6.5. Presenting Author: Tiago Oliveira

Height distributions in competitive one-dimensional Kardar-Parisi-Zhang systems

Tiago J. Oliveira

Federal University of Viçosa, Brazil

We study competitive growth models with EW-KPZ crossover, focusing on the validity of the Kardar-Parisi-Zhang (KPZ) ansatz $h(t) = v_\infty t + (\Gamma t)^\beta \chi$ and the universality of the height distributions (HDs) near the probability ($p = p_c$) where the models have Edwards-Wilkinson (EW) scaling. Using numerical simulations for long times, we show that the systems are asymptotically KPZ, as expected, for values of the probability very close to p_c. Namely, the growth exponents converge to $\beta_{KPZ} = 1/3$ and the HDs converge to the GOE Tracy-Widom distribution, however, the convergence is faster in the last ones. The well studied EW-KPZ crossover in the roughness scaling is shown to be accompanied by Gaussian-GOE crossover in the height distributions, for values of p very close to p_c. Furthermore, the same scaling laws governing the crossover in the roughness scaling appears in height distributions cumulants.

4.6.6. Presenting Author: Gabriela A. Casas

Entropy production in systems described by nonlinear master equations

Gabriela A. Casas[1,2], Fernando D. Nobre[1,2], and Evaldo M. F. Curado[1,2]

[1]Centro Brasileiro de Pesquisas Físicas (CBPF)

[2]National Institute of Science and Technology for Complex Systems

The H-theorem, and consequently the second law of thermodynamics, which states that the entropy of an isolated system always increases for irreversible processes, leads to the interesting phenomenon of entropy production. Within the statistical definition of entropy, the entropy production depends directly on the time derivative of the corresponding probability; for this purpose one may use, e.g., the Boltzmann, or Fokker-Planck equations in the case of continuous probabilities, or the master equation, when dealing with discrete probabilities. In the present work we study the entropy time rate of systems described by master equations, using generalized entropic forms. Both entropy production, associated with irreversible processes, and entropy flux from the system to its surroundings, are studied. Some examples of known generalized entropic forms are considered, and particularly, the expression for the production of the Boltzmann-Gibbs entropy, obtained from the standard master equation, is recovered as

a particular case. Since nonlinear effects, introduced through the transition probabilities of the master equation, are relevant for several physical phenomena in nature, like many within the realm of complex systems, the present analysis should be applicable to irreversible processes in a large class of nonlinear systems, such as those described by Tsallis and Kaniadakis entropies.

4.6.7. Presenting Author: Adrián Adolfo Budini

Fluctuation relations with intermittent non-Gaussian variables

Adrián A. Budini[1,2]

[1]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Centro Atómico Bariloche, Avenida E. Bustillo Km 9.5, (8400) Bariloche, Argentina

[2]Universidad Tecnológica Nacional (UTN-FRBA), Fanny Newbery 111, (8400) Bariloche, Argentina

Non-equilibrium stationary fluctuations may exhibit a special symmetry called fluctuation relations (FR). We show that this property is always satisfied by the subtraction of two random and independent variables related by a thermodynamic-like change of measure. Taking one of them as a modulated Poisson process, it is demonstrated that intermittence and FR are compatibles properties that may coexist naturally. Strong non-Gaussian features characterize the probability distribution and its generating function. Their associated large deviation functions (LDF) develop a "kink" at the origin and a plateau regime respectively. Application of this model in different stationary nonequilibrium situations is discussed.

4.6.8. Presenting Author: Matheus Palmero Silva

Study of decay of energy in a time-dependent stadium billiard: Concervative case.

M. S. Palmero[1], **A. L. P. Livorati**[2], **and E. D. Leonel**[1]

[1]Departamento de Física - UNESP - Rio Claro

[2]Instituto de Física - USP - SP

In this project we are studying the dynamics of a particle with mass m confined inside a stadium billiards with timedependent boundaries. As is known in literature [A. Loskutov, A. Ryabov, J. Stat. Phys. vol. 108, pp. 995 (2002)], for a certain combination of control parameters the particle dynamic shows the Fermi acceleration phenomenon. Fermi acceleration is a phenomenon of energy increase of a classical particle because a colisions with timedependent boundaries. However, due to a resonance between a period of rotations around the fixed points and a period of external boundary perturbation, we can observe a decay of particle's average velocity. This resonant velocity also depends on the control parameters of the system. We are trying to understand better and characterize this decay of velocity in function of control parameters, studying the influence of this resonance for the differents fixed points of the system. We already rewrite this mapping using only dimensionless variables, allowing us to study more

precisely this resonant velocity, and we are working, as well, in a algorithm for calculation of Lyapunov exponent.

4.6.9. Presenting Author: Oscar A. Barbosa

Irreversibilidade por competição para um modelo de Glauber-Ising a partir da produção de entropia

Oscar A. Barbosa and Tânia Tomé Martins de Castro

Instituto de Física da Universidade de São Paulo (IFUSP), Brasil

An irreversible and out of equilibrium system is analyzed by means of a stochastic dynamics based on an approach that aims to understand the macrosopic effects as a consequence of the microscopic characteristics. The study focus on the kinetic phase transitions that take place by assuming a lattice model, intended to describe the stationary states by the entropy production, which characterize the system behavior, clarifying the reversibility conditions. Thus one condiders a kinetic Ising model with up-down symmetry and under the influence of two competing Glauber dynamics. In this sense one considers a square lattice formed by two sublattices interconnected, which are in contact with two heat baths at different temperatures. The study is made by means of the analytical approach of a mean-field approximation and Monte Carlo simulations. The results show a phase transition of the second order in the steady state regime, which is evidenced by a logarithm divergence of the entropy production derivative.

4.6.10. Presenting Author: Felipe Mondaini

Free Energy Evaluation in Polymer Translocation via Jarzynski Equality

F. Mondaini and L. Moriconi

CEFET-RJ Centro Federal de Educac ao Tecnologica Celso Suckow da Fonseca

The phenomenon of polymer translocation through membrane pores has received a great deal of attention in recent years. Important issues are related to the translocation of complex biomolecules in the methabolism of living cells, and, on the technological forefront, to developments in the fields of targeted drug/gene delivery and DNA sequencing. In studying the thermodynamic state of a physical system, the free energy $\boldsymbol{F}$ is a quantity of fundamental importance. It describes the equilibrium properties of systems that may exchange energy with their environments. Formally, it is related to the internal energy, $\boldsymbol{U}$, by a Legendre transform $\boldsymbol{F = U - TS}$, where $\boldsymbol{T}$ is the temperature and $\boldsymbol{S}$ the entropy. The free energy is a state function and hence, for any process connecting two equilibrium states, the respective change of the free energy $\boldsymbol{F = U - TS}$, solely depends on the final and initial states without regard to the particular process connecting them. In contrast, the work $\boldsymbol{W}$ done on the system and the heat $\boldsymbol{Q}$ exchanged with the environment are process-dependent. Yet, their sum yielding the change in internal energy, $\boldsymbol{U = W + Q}$, does not depend on the details of the path connecting the final

with the initial state. Recently, Jarzynski found a relation between the path dependent work and the path independent free energy change in terms of the following rule: $\langle e^{-\beta W} \rangle = e^{-\beta \Delta F}$

The process from which this work results, starts out in a state of thermal equilibrium at temperature $T = (k_B)^{-}1$, and is induced by the action of forces, or more generally by changes of parameters characterizing the Hamiltonian of the considered system. In this work we compare the results obtained by Jarzynski Equality with those established by Muthukumar in the estimation of the free energy in the polymer translocation problem.

4.6.11. Presenting Author: Roberto Barreto

Thermal transport and rectification in 2D strained nanostructures

R. Barreto[1,2], A. Mancardo Viotti[1], M. F. Carusela[1,2], and A. G. Monastra[1,2]

[1]Instituto de Ciencias, Universidad Nacional de General Sarmiento, J. M. Gutiérrez 1150 (1613), Los Polvorines, Buenos Aires, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas, Av. Rivadavia 1917 (1033), Ciudad Autónoma de Buenos Aires, Argentina

Inspired by some recent molecular dynamics (MD) simulations and experiments on suspended graphene nanoribbons [1,2], we study a simplified model where the atoms are disposed in a rectangular lattice coupled by harmonic nearest neighbor interactions. The system has a mechanical strain in a given direction, and the border atoms are coupled to Langevin thermal baths at different temperatures. Moreover, the atom masses vary linearly in the longitudinal direction, modelling an isotope or doping distribution. This asymmetry and the mechanical tension control and modify thermal transport properties. Although the atom-atom interaction is harmonic, the two degrees of freedom introduce anharmonic effects. Comparing direct MD simulations to results from Fokker-Planck equations, which are valid at very low temperatures, we can understand better the role of anharmonicities in thermal rectification. In both methods we observe an increasing thermal current with an increasing applied mechanical tension. The temperatures and thermal currents vary along the transverse direction. This effect can be useful to establish which parts of the system are more sensitive to thermal damage. We also study these effects as a function of system size.

References

[1] N. Wei, L. Xu, H-Q. Wang, and J-C. Zheng, Nanotechnology **22**, 105705 (2011);

[2] K. G. S. H. Gunawardana, Kieran Mullen Jiuning Hu Yong P. Chen and Xiulin Ruan, Phys, Rev B **85**, 245417 (2012)

4.6.12. Presenting Author: Cínthia Helena Claudino Silvestre

Properties of ergodicity for self-gravitating systems in two dimensions

Cínthia Helena Claudino Silvestre[1] and Tarcísio Marciano da Rocha Filho[1,2]

[1]Instituto de Física - Universidade de Brasília

[2]International Center for Condensed Matter Physics - Universidade de Brasília

Systems with long range interactions have been extensively studied in the last two decades. In this class of systems we can cite Self-gravitating systems and non-neutral plasmas and some models such as Hamiltonian Mean Field (HMF) model, wave-particle interaction and one and two-dimensional self-gravitating systems. A pair interaction potential is considered long-ranged if decays at large distances as $r^{-\alpha}$, with $\alpha \leq d$, where d is the spatial dimension. These systems present many peculiar behaviors not observed for short-range interactions: negative heat capacity, anomalous diffusion, ensemble inequivalence, non- Gaussian quasi-stationary states and, particularly, violent relaxation, which is a very rapid evolution from the initial condition into a quasi-stationary state, which then evolves very slowly to the thermodynamic equilibrium. A relevant aspect of systems with long range interactions is its non-ergodicity. In the present work we discuss the non-ergodic behavior in two-dimensional self-gravitating systems for different energy values using state of the art dynamical simulations on Graphics Processing Units. Two approaches are used: first we show that the time required for a single particle history to represent the ensemble properties is extremely long, and diverges with the number of particles. This is obtained by considering the time evolution of the standard deviation taken among all particles of the time average of a velocity component of single particle. The other approach consists in determining the statistics of the sojourn times in cells in momentum space, and this for different energies values. We show that the sojourn time statistics has a truncated power law tail, with the truncation diverging with the number of particles, leading to a very long time to attain ergodicity if the number of particles is finite. Ergodicity is then obtained asymptotically in the thermodynamics limit.

4.6.13. Presenting Author: Bruno V. Ribeiro

Brownian corrections to particle motion in the Hamiltonian Mean Field Model

B. V. Ribeiro[1], Y. Elskens[3], and M. A. Amato[1,2]

[1]Instituto de Física, Universidade de Brasília, CP: 04455, 70919-970 - Brasília - DF, Brazil

[2]International Center for Condensed Matter Physics, Universidade de Brasília, CP: 04455, 70919-970 - Brasília - DF, Brazil

[3]Equipe turbulence plasma, case 321, PIIM, UMR 7345 CNRS, Aix-Marseille université, campus Saint-Jérôme, 13397 Marseille, France

We study the dynamics of the N-particle system evolving according to the Hamiltonian

$$H = \sum_{i}^{N} \frac{p_i^2}{2} + \frac{K}{2N} \sum_{i,j}^{N} [1 - \cos(\theta_i - \theta_j)], \tag{4.3}$$

commonly known as the Hamiltonian Mean Field (HMF) model. θ_i is the position of the i-th particle on the circle $S_{2\pi} = \mathbb{R}/2\pi$ and p_i its conjugate momentum. This model has two behaviours, viz. *(i)* for an attractive potential ($K = 1$), a phase transition occurs from an inhomogeneous, clustered phase to a homogeneous phase for a given value of temperature ; *(ii)* for a repulsive potential ($K = -1$), no phase transition occurs.

In the second case, particle motion may be approximated by the ballistic motion with small corrections. For particles with initial positions uniformly distributed in $S_{2\pi}$, while initial velocities are distributed in equally spaced (by Δv_0) beams containing one particle each, i.e., $v_{j0} \sim (j/N - 1/2)\Delta v_0$ for the initial velocity of the j-th particle, it is shown that corrections to the ballistic velocities are in the form of independent Brownian noises. Moreover, we also estimate a time validity for this approximation. Molecular dynamics simulations of the HMF model with the proposed “particles in monokinetic beams" initial conditions are presented to confirm our preliminary theoretical results.

For the attractive case, we model the system, in presence of the ordered phase, as composed of two sets of particles: N_p *passing particles* move according to a ballistic motion corrected by the presence of N_c *cluster particles*, that lay inside the cat's eye and are assumed to have fixed positions. Thus, we focus on the dynamics of passing particles with the same strategy as above. The presence of cluster particles, however, no longer allows us to admit small corrections to a ballistic motion. Preliminary numerical simulations for this case show that these corrections diverge from a Brownian noise in very short times.

We are still carrying out the calculations for the attractive case. As a first order correction to the velocities, we expect to get Brownian noise and non-negligible corrections for higher orders.

4.6.14. Presenting Author: Christine Lourenço

Generalized Hertel–Thirring Model and the scaling of dynamics of one-dimensional homogeneous long-range interacting systems

Christine R. Lourenço[1] and Tarcísio M. Rocha Filho[1,2]

[1]Instituto de Física - Universidade de Brasília

[2]International Center for Condensed Matter Physics - Universidade de Brasília

It is a not so well known fact that the collision integral in the Boltzmann, Landau and Balescu-Lenard kinetic equations vanish for homogeneous one-dimensional many-particle systems. Some attempts were made to obtain a correct description of the kinetics of these systems [M. M. Sato, J. Phys. Soc. Japan **81**, 024008 (2012), W. Ettoumi and M.- C. Firpo, Phys. Rev. E **87**, 030102 (R) (2013)], but none was still satisfactory. Recently Rocha Filho [T. M. Rocha Filho, A. E. Santana, M. A. Amato and A. Figueiredo, arXiv:1305.4417v1] and collaborators in our group obtained a generalized Landau equation valid in the weak coupling correctly predicting the scaling of the dynamics as a function of the number N of particles and cofirmed by large N molecular dynamics simulations. Here we discuss a special class of long-range potentials that allow to investigate the kinetics by using larger values of N than previsouly and introduce some analytical simpifications usefull in studying equilibrium and the initial stages which correspond to a violent relaxation [D. Lynden-Bell, Mon. Not. R. Astr. Soc. **136**, 101 (1967)]. The pair-interaction potential is writen as $V(x_i - x_j) = -u(x_i)u(x_j)$, with $u(x)$ a non-decreasing function of x, and generalizes a model proposed by Hertel and Thirring [P. Hertel and W. Thirring, Ann. of Phys. **63**, 520 (1971)] to discuss negative specific heat in Astrophysics. Simulations presented in this work are perfomed using a parallel code on a GPU developed in our group.We confirm previous results by Rocha Filho et al. For a wider interval of particle numbers and for some choices of the function $u(x)$. We also discuss the equilibrium and violent relaxation properties for each case. The simplified nature of these models are particularly usefull for discussing some fundamental open-problems in the study of systems with long-range interactions, such as the prediction of the outcome of the highly non-linear violent relaxation process, for which a satisfactory theory is still lacking, and is investigated here by solving numerically (also on a GPU) the Vlasov equation which describes such sustems in the thermodynamic limit.

4.6.15. Presenting Author: Paulo Paneque Galuzio

Evidences of determinism for intermittent behaviour in spatially extended dynamical systems

P. P. Galuzio and S. R. Lopes

Universidade Federal do Paraná

Intermittent transport is a very important feature of several physical sys- tems, e.g. the blob like structures observed in the scrape off layer of magnet- ically confined devices. Experimental data show that there is an universal distribution of density fluctuation as well as an unique parabolic relation be- tween skewness and kurtosis, which can be obtained by a superposition of stochastic and deterministic events. A well know deterministic effect, namely, the loose of transversal stability of periodic orbits embedded in an invariant (inertial) manifold is used to model the spiky nature of these time series. The intermittent emissions are proposed to be due to local unstable transversal directions of the invariant manifold resulting in an ejection of particles and a consequent burst in the signal. We show that characteristics observed by the emissions namely an impulsive ejection followed by a slow recovery phase can be directly related to the deterministic mechanism proposed.

4.6.16. Presenting Author: David Matesanz Gómez

Exchange rate volatility and macroeconomic calendar announcements: Some causal calculations

David Matesanz Gómez[1] and Guillermo Ortega[2]

[1]Applied Economics Department, University of Oviedo, Avda. Cristo s/n, 33006, Oviedo, Spain

[2]Science and Technology Department, National University of Quilmes and CONICET, R. S. Peña 352, B1876BXD, Bernal, Argentina

This work revisits the influence of macro-economic announcements on the exchange rates volatility, but from a different perspective as it is the usual in the econometric literature. By quantifying world-wide economic calendar announcement news in several recent years we were able to construct a long time series with the objective to test whether it influence exchange rate movements in several currencies. In order to do that, Granger causality test was employed by using a computational approach. Our results show that announcements from U.S.A are, by far, the most important influence over the three rates considered, Euro/Dollar, Euro/Yen and Dollar/Yen. The method proposed here opens the door to address several open questions until

now.

4.6.17. Presenting Author: Romain Bachelard

Diverging relaxation times in lattices with long-range interactions

Romain Bachelard[1] and Michael Kastner[2]

[1]Instituto de Fısica de Sao Carlos, Universidade de Sao Paulo, 13560-970 Sao Carlos, Sao Paulo, Brazil

[2]National Institute for Theoretical Physics (NITheP), Stellenbosch 7600, South Africa

The dynamics of systems with mean-field interaction, when all the particles interact with equal strength, is characterized by very long equilibration times: The system gets trapped in quasi-stationary states, where macroscopic quantities (temperature, magnetization, etc) evolve very slowly toward their equilibrium value. We here investigate the equilibration of lattice systems with long-range pair interactions, decaying like $1/r^{\alpha}$ with the distance r. The long-range regime corresponds to $\alpha < d$, with d the dimension of the system. We characterize the relaxation times and show that long-range lattice systems also exhibit quasi-stationarity, as well as relaxation times that diverge with the size of the system.

However, upon varying the interaction range α, we find evidence for the existence of a threshold at $\alpha = d/2$, at which the relaxation behaviour changes qualitatively and the corresponding scaling exponents switch to a different regime. Since our observation is based on the behaviour of both a quantum and a classical system, investigated analytically and numerically, for ferro- and anti-ferromagnetic interactions, we conjecture this threshold and some of its characteristic properties to be universal.

Ref: R. Bachelard and M. Kastner, Phys. Rev. Lett. 110, 170603 (2013)

4.6.18. Presenting Author: Zolacir Trindade de Oliveira Jr.

Truncated Lévy Flights and Weak Ergodicity Breaking in the Hamiltonian Mean Field Model

A. Figueiredo[1,2], T. M. Rocha Filho [1,2], M. A. Amato [1,2], T. O. Zolacir [1,3], R. Matsushita [4], and A. S. Werneck [5]

[1] CIFMC/Universidade de Brasília, DF, Brasil

[2] IF/Universidade de Brasília, DF, Brasil

[3] DCET/Universidade Estadual de Santa Cruz, Ilhéus - Ba, Brasil

[4] Dpto. Estatística/Universidade de Brasília, DF, Brasil

[5] Faculdade de Ceilândia /Universidade de Brasília, DF, Brasil

The dynamics of the Hamiltonian mean field model is studied in the context of continuous time random walks. We show that the sojourn times in cells in the momentum space are well described by a Lévy truncated distribution. Consequently the system in weakly non-ergodic for long times that diverge with the number of particles. For a finite number of particles ergodicity is only attained for very long times both at thermodynamical equilibrium and at quasi-stationary out of equilibrium states.

4.6.19. Presenting Author: ADRIANO WILLIAN DA SILVA

Analysis of the Reaction Rate Coefficient for Binary Gaseous Mixtures Far from Chemical Equilibrium

A. W. Silva

Instituto Federal do Paraná- Câmpus Curitiba

A simple binary gaseous mixture of type $\boldsymbol{A + A \rightarrow products}$ is modeled with the chemical kinetic Boltzmann equation, assuming hard sphere cross sections for elastic collisions and line-of-centers modified for reactive interactions. The Chapman-Enskog method and Sonine polynomial representation of the distribution functions are used to obtain the solution of the Boltzmann equation in a chemical regime for which the reactive interactions of the less frequent than the elastic collisions, i. e., in the early stage of the reaction when the constituent A is in a large amount with respect products and the affinity of the reaction tends to infinity. The aim of this work is: (i) to evaluate the effect of the reaction heat on the Maxwellian distribution functions and on the production therm of the particle number densities and mixture energy density; (ii) to analyse spatially homogeneous solutions for the particle number density of the reactants when the chemical reaction advances. The results shown that the reaction heat changes the Maxwellian distribution functions and the production terms particle number density and temperature of the reactants. Moreover, these changes differ for exothermic and endothermic reactions.

Keywords: Boltzmann equation, cross section, reaction rate

4.6.20. Presenting Author: Reinaldo García-García

Zero crossings and extreme value statistics of stochastic entropy production

R. García-García

Centro Atómico Bariloche, San Carlos de Bariloche 8400, Río Negro, Argentina.

The energy changes associated to any process occurring in mesoscopic systems exhibit a stochastic nature due to the effect of fluctuations. This also implies that for single trajectories in phase space, the thermodynamic observables like work, heat, and entropy production, are random quantities.I study the zero crossings and record values statistics of the stochastic entropy production at single trajectories in phase space, obtaining general symmetry relations for the relevant probability density functions. This study is closely connected to the occurrence of local violations of the second law of thermodynamics at single trajectories in phase space due to the effect of fluctuations.

4.7. Nonlinear optics

4.7.1. Presenting Author: Vincent Odent

Front pinning induced by spatial inhomogeneous forcing in a Fabry-Pérot Kerr cavity with negative diffraction

V. Odent, S. Coulibaly, P. Glorieux, M. Taki, and Eric Louvergneaux.

Université Lille1, Laboratoire de Physique des Lasers, Atomes et Molécules, CNRS UMR8523, 59655 Villeneuve d'Ascq Cedex, France

In a bistable system, the front dynamics connecting two states is a problem concerning many domains of physics [1,2]. In this system, under a parameter breaking symmetry, the front propagates, except at the Maxwell point. To observe front locking behavior, a spatial periodic forcing has been proposed [3]. In optics, usually we work with Gaussian laser beam which presents inhomogeneous spatial profile, so a natural question arises: Is the dynamics of fronts in optical system affected by an inhomogeneous spatial profile? In the present work, we study front pinning phenomena due to a Gaussian optical forcing. The final pattern is a localized state bounded by two pinned fronts.

We develop an analytical model of front dynamics subjected to spatial forcing from the imperfect pitchfork equation [4]. Under a parabolic forcing approximation, we obtain an analytical expression of the front core trajectory. The analytical study is verified by numerical simulations of this model with parabolic and Gaussian forcing. In this latter case, the numerical simulations show a transitory regime where the front propagation velocity slowly decreases until reach a pinned state.

We carried out experiments in a one-dimensional Perot-Fabry passive Kerr cavity submitted to negative diffraction with a $4f$ lens arrangement. The Kerr medium is a nematic liquid crystal thin film. The spatial forcing comes from the Gaussian profile of the laser beam and cylindrical lenses, which generate one-dimensional Gaussian beam. Fronts are generated using cavity under negative diffraction feedback. This last feature is achieved via $4f$ lens arrangement that allows to obtain negative optical cavity length and consequently negative diffraction [5].

Under these conditions, experimental fronts are pinned after a nonlinear transitory propagating regime, showing a good agreement with the theory. The final state is a spatial localized structure. Numerical simulations of the Kerr cavity dynamics are consistent with the core trajectory analytical expression.

References

[1] Y. Pomeau, *Phys. D* **23** 3 (1986)

[2] W. Vansaarloos, *Phys. Rep.* **386** 29 (2003).

[3] F. Haudin, et al., *Phys. Rev. Lett.* **103** 128003 (2009).

[4] M. Cross and H. Greenside, *Cambridge University Press*, New York, (2009).

[5] P. Kockaert, *J. Opt. Soc. Am. B* **26** 1994 (2009).

4.7.2. Presenting Author: Vincent Odent

Statistical analysis of spatial frequency supercontinuum in pattern forming feedback systems

V. Odent, M. I. Kolobov, M. Taki, and E. Louvergneaux

Université Lille 1, Laboratoire de Physique des Lasers, Atomes et Molécules, CNRS UMR8523. 59655 Villeneuve d'Ascq Cedex, France

The dynamics of highly nonlinear regime in physics is very complex and the underlying physical processes are still under investigation [1,2]. In the spatiotemporal optical systems, highly nonlinear regimes are characterized by the spatiotemporal chaos and can presented the supercontinuum generation. Their transition from the weakly nonlinear to highly nonlinear dynamics remains an open field of research [3].

We report on generation of spectral supercontinua in a one-dimensional transverse Kerr slice medium, subject to an optical feedback. We show that these supercontinua are closely related to generation of abnormally high intensity peaks in the transverse patterns that disappear as fast as they appear. The associated highly nonlinear regime [4] is far above the threshold for the Turing instability (spatial modulational instability), where stationary rolls are observed.

We investigate numerically this spatiotemporal chaotic regime using a statistical approach in terms of probability density functions (PDFs) of the pattern intensity maxima. We find that statistical distribution of these maxima is well described by the generalized gamma distribution, characterized by three parameters. These parameters are used as quantitative indicators to characterize the transition from the weakly to the highly nonlinear dynamical regime.

Most interestingly, we discover that the generalized gamma PDF reduces to the gamma PDF with the shape parameter equal to $3/2$ for the spatiotemporal chaotic regime very high above the Turing threshold. It should be noted that in terms of the probability density function for the peak amplitudes (instead of intensities) this corresponds to the Rayleigh distribution which was observed for the statistics of the oceanic waves. This behavior of the PDF can be an indicator of the universality of the spatiotemporal chaotic regime and calls for similar investigations in other types of dynamical systems manifesting chaos.

References

[1] J. M. Dudley, G. Genty, and S. Coen, Rev. Mod. Phys. 78, 1135 (2006).

[2] B. Kibler, K. Hammani, C. Michel, C. Finot, and A. Picozzi, Phys. Lett. A 375, 3149 (2011).

[3] R. Neubecker, B. Thuring, M. Kreuzer, and T. Tschudi, Chaos, Solitions Fractals 10, 681 (1999).

[4] G. D'Alessandro and W. J. Firth, Phys.Rev.A 46, 537 (1992).

4.7.3. Presenting Author: Rene Rojas

Vortex Emission Accompanies the Advection of Optical Localized Structures

René Rojas

Pontificia Universidad Católica de Valparaíso

We show that the advection of optical localized structures is accompanied by the emission of vortices, with phase singularities appearing in the wake of the drifting structure. Localized structures are obtained in a light-valve experiment and made to drift by a mirror tilt in the feedback loop. Pairs of oppositely charged vortices are detected for small drifts, whereas for large drifts a vortex array develops. Observations are supported by numerical simulations and linear stability analysis of the system equations and are expected to be generic for a large class of translated optical patterns.

4.7.4. Presenting Author: Lauro Tomio

Solitons in cross-combined linear and nonlinear optical lattices

Lauro Tomio[1,2], H. L. F. da Luz[2], F. Kh. Abdullaev[2], A. Gammal[3], and M. Salerno[4]

[1] Centro de Ciências Naturais e Humanas, Universidade Federal do ABC, Santo André, Brazil
[2] Instituto de Física Teórica, Universidade Estadual Paulista, São Paulo, Brazil
[3] Instituto de Física, Universidade de São Paulo, São Paulo, Brazil
[4] Dipartimento di Fisica "E.R. Caianiello", CNISM and INFN-Gruppo Collegato di Salerno, Università di Salerno, Salerno, Italy

We report results obtained for the existence of multidimensional matter-wave solitons in crossed optical lattices (OL) with linear and nonlinear optical lattices (NOL), where the NOL can be generated by periodic spatial modulations of the scattering length using optically induced Feshbach resonances. We investigate soliton stability considering both, two and three-dimensional cases. The solutions for the soliton stability are investigated analytically, by using a multi-Gaussian variational approach, with the Vakhitov-Kolokolov necessary criterion for stability; and numerically, by using the relaxation method and direct numerical time integrations of the Gross-Pitaevskii equation.

4.7.5. Presenting Author: Tiago José Arruda

Fano resonances in dispersive chiral spheres

Tiago J. Arruda[1], Felipe A. Pinheiro[2], and Alexandre S. Martinez[1,3]

[1] Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto-SP, Brazil
[2] Instituto de Física, Universidade Federal do Rio de Janeiro, Rio de Janeiro-RJ, Brazil
[3] National Institute of Science and Technology in Complex Systems, Rio de Janeiro-RJ, Brazil

Originally discovered in quantum mechanics, the Fano resonance can also be explored to control electromagnetic mode interactions in nanoparticles exhibiting plasmon resonances. In plasmonic systems, the Fano resonance results from the interference between a broad bright –"superradiant"– mode with a narrow dark –"subradiant"– mode, producing an asymmetric lineshape. The modulation of the Fano lineshape may give rise to the plasmon-induced transparency, a classical analogue to the electromagnetic induced transparency in atomic systems. This phenomenon has been observed in metamaterials and has many potential applications, such as the development of low-loss and "slow light" plasmonic metamaterials. In Lorenz-Mie scattering, there are basically two types of Fano resonances: the one originated from the interference between different modes (dipole-quadrupole interference), known as the conventional Fano resonance, and the one provided by the interference between the same modes (dipole-dipole interference), referred to as the unconventional Fano resonance. These conventional and unconventional Fano effects appear, for instance, in the differential and the total cross-sections in the electromagnetic scattering by coated spheres, respectively. Here, we consider the light scattering by a chiral sphere, with radius a and optical properties $(\epsilon_1, \mu_1, \kappa)$, embedded in a non-optically active medium (ϵ_0, μ_0), where ϵ and μ are the electric permittivity and magnetic permeability, respectively, and κ is the chirality parameter. Based on the Bohren's decomposition of the electromagnetic field for optically active spheres, we obtain the Lorenz-Mie solution for the internal fields in the magnetic case. The refractive indices associated with the right-circularly polarized (RCP,+) and left-circularly polarized (LCP,−) waves inside the chiral material are $m_{\pm} = \sqrt{\epsilon_1/\epsilon_0}\sqrt{\mu_1/\mu_0} \pm \kappa$. Hence, for a real positive κ, it is possible to obtain negative refraction ($m < 0$) for LCP waves even if the real parts of ϵ_1 and μ_1 are positive. Our aim is to study the Fano resonances via the electromagnetic fields within a dispersive chiral sphere and its connection to the differential and total cross-sections. We investigate the behavior of internal resonances inside the sphere (near-field) and their corresponding resonances in the extinction cross-section (far-field). A relation between the absorption cross-section and the internal electromagnetic fields reveals that strong chirality leads to an off-resonance field enhancement within weakly absorbing spheres. This weak absorption could be achieved by using nonlinear dielectric shells or coatings with optical gain, leading to the possibility of using the unconventional Fano effect for chiral spheres. These results could be exploited in applications involving dispersive chiral scatterers and Fanoshells.

4.7.6. Presenting Author: Panayotis Panayotaros

Localization and multistability in a dissipative discrete NLS system

Panayotis Panayotaros and Felipe Rivero

Depto. Matematicas y Mecanica, IIMAS – UNAM, Mexico

We present theoretical and numerical results on attractors and pullback attractrors for some finite dissipative NLS lattices with localized forcing and time dependent perturbations. Pullback attractors generalize the notion of attractivity for nonautonomous systems and we give examples of autonomous and nonautonomous systems with multiple attracting sets representing spatially localized coherent structures.

4.7.7. Presenting Author: Daniel Alejandro Martin

Homogeneous solutions and Pattern formation in Ring cavities with composite and negative refractive materials

D. A. Mártin[1,2,3] and M. Hoyuelos[1,2]

[1]Departamento de Física, Universidad Nacional de Mar del Plata, Argentina
[2]IFIMAR (Instituto de Física de Mar del Plata), UNMdP-CONICET, Argentina
[3]currently at INIFTA-CONICET, La Plata, Argentina

Homogeneous solutions and Pattern formation in Ring cavities with composite and negative refractive materials

We study a ring cavity filled with a Kerr-like medium. We allow the nonlinear medium to be a composite material with positive (PRM) or negative (NRM) refractive index [1]. The cavity is subject to a linearly or elliptically polarized incoming field.

If the nonlinear material is a composite material, either NRM or PRM, intense nonlinear efects may be expected. Also, the coupling parameter between different polarizations, $^{-}$B, may take a wide range of possible values (at odds with "classical" materials) [2]. Also, nonlinear magnetization may arise [3], so that equations for magnetic field propagation (which should also couple to the electric field) are expected [4].

In the mean field limit, we found that Electric and Magnetic field should remain proportional [5], so that cavity can be described by means of two coupled Lugiato– Lefever [6] equations.

For linearly polarized fields, We find that considering a NRM does not bring cualitatively different behaviour, althoug stability of some solutions may vary [7]. Results for NRM can be related to results for PRM.

We have found that, depending on $^{-}$B and the cavity detuning, steady homogeneous solutions may present multiple bifurcations: up to two pitchfork birurcations and more that two saddle node biffurcations for some fixed parameters as we vary the imput intensity [8].

Pattern formation is also studied. Examples of marginal instability diagrams are shown. It is shown that, within the model, instabilities cannot be of codimension higher than 3. A method for finding parameters for which codimension 2 or 3 takes place is given. The method allows us to choose parameters for which unstable wavenumbers fulfill different relations. Numerical integration results where different instabilities coexist and compete are shown [9].

References

[1] D.R. Smith, W.J. Padilla, D.C. Vier, S.C. Nemat-Nasser and S. Schultz, Phys. Rev. Lett. 84, 4184 (2000); R.A. Shelby, D.R. Smith and S. Schultz, Science 292, 77 (2001).

[2] J.E. Sipe and R.W. Boyd, Phys. Rev. A 46, 1614 (1992); V. Yannopapas, Opt. Commun. 283, 1647 (2010); M. Lapine and M. Gorkunov, Phys. Rev. E 70, 066601 (2004);

[3] A.A. Zharov, I.V. Shadrivov, and Y.S. Kivshar, Phys. Rev. Lett. 91, 037401, (2003); S. O'Brien, D. McPeake, S.A. Ramakrishna, and I.V. Shadrivov, A.B. Kozyrev, D.W. van der Weide, and Y.S. Kivshar, Opt. Express 16, 20266 (2008);

[4] I. Kourakis and P.K. Shukla, Phys. Rev. E 72, 016626 (2005); N. Lazarides and G.P. Tsironis, Phys. Rev. E 71, 036614 (2005).

[5] Daniel A Mártin and Miguel Hoyuelos, Physical Review E 80, (056601) 2009.

[6] L.A. Lugiato and R. Lefever, Phys. Rev. Lett. 58, 2209 (1987).

[7] P. Kockaert, P. Tassin, G. Van der Sande, I. Veretennicof and M. Tlidi, Phys. Rev. A 74, 033822 (2006); P. Tassin, L. Gelens, J. Danckaert, I. Veretennicof, P. Kockaert and M. Tlidi, Chaos 17, 037116 (2007).

[8] Daniel A. Mártin and Miguel Hoyuelos, Physical Review A 82 (033841) 2010.

[9] Daniel A. Mártin y Miguel Hoyuelos, Accepted for publication in PHYSICA D, http://dx.doi.org/10.1016/j.physd.2013.05.008.

4.8. Nonlinearities in social and biological systems

4.8.1. Presenting Author: Guillermo Solovey

Biases in subjective visual perception: a simple form of stochastic resonance?

Guillermo Solovey[1], Jorge Morales[2], Brian Maniscalco[1], Dobromir A. Rahnev[1,3], Floris P. de Lange[4], and Hakwan Lau[1,4,5]

[1] Columbia University, Psychology Department. 1190 Amsterdam Avenue, Mail Code: 5501, New York, NY 10027.

[2] Columbia University, Philosophy Department. 708 Philosophy Hall, 1150 Amsterdam Avenue, Mail Code: 4971, New York, NY 10027.

[3] University of California Berkeley, The Helen Wills Neuroscience Institute. 10 Giannini Hall D'Esposito Lab. Berkeley, CA 94720.

[4] Radboud University Nijmegen, Donders Institute of Brain, Cognition and Behavior. P.O. Box 9101 - NL-6500 HB, Nijmgen, The Netherlands.

[5] University of California Los Angeles, Department of Psychology. 1285 Franz Hall, Box 951563, Los Angeles, CA 90095-1563.

There is ample evidence that unattended stimuli are associated with weak perceptual processing. Yet, humans seem unduly confident in their perceptual decisions when they are not attending. For example, subjects seem to experience an inappropriately strong sense of vividness and detail in peripheral vision (which usually receives less attention than central vision) despite its limited processing resolution and color sensitivity.

In previous work we tried to account for some of these phenomena within the framework of signal detection theory. According to our model, in addition to increasing the strength of the internal perceptual response, attention also reduces its trial-by-trial variability. The model also presupposes that subjects use a single common decision criterion for detecting or discriminating attended and unattended stimuli. The model accounts for the finding that subjects have a liberal response bias for detecting unattended targets (i.e. their propensity to report detecting a target is higher in unattended than in attended trials). It also accounts for a related finding that subjects give high visibility ratings for unattended stimuli even though subjects are not better at discriminating the stimuli. This intriguing phenomenon potentially represents a simple and straightforward case of stochastic resonance.

I will focus on one particularly counterintuitive aspect of the model. According to well-established Bayesian proposals, when the perceptual signal is weak, observers should rely more on prior expectations in order to behave optimally. For example, if one is told that the stimulus is likely to be A rather than B, one should follow this prior information if one perceives poorly on a trial (such as when attention is directed elsewhere). If one perceives very clearly, one may as well ignore the prior and go with what is actually seen. This means that the weight given to a source of information should scale with its reliability. However, our model predicts that, because of the common decision criterion constraint and the reduction of variance by attention, subjects would do just the opposite: when faced with a biased prior expectation of stimulus likelihood, subjects would not be able to adjust their response bias in the unattended trials as effectively as they do for the attended trials. To test this prediction, we conducted a series of experiments in which subjects discriminated between left- and right-tilted grating patterns that were presented either in attended or in less attended locations. To anticipate, we confirmed our a priori prediction repeatedly in four different experiments, in a fashion that seems incompatible with commonsensical Bayesian principles.

4.8.2. Presenting Author: Gabriela Petrungaro

Effects of fluctuations on dynamic oscillators with delayed coupling.

Gabriela Petrungaro[1,2] and Luis G. Morelli[1,2]
[1]Departamento de Física - FCEyN - UBA
[2]Instituto de Física de Buenos Aires (IFIBA) - CONICET

During development of multicellular organisms pattern formation depends in a crucial way on the collective behavior of many cells. An example of a fundamental pattern forming mechanism is the vertebrate segmentation clock, controlling a rhythmic dynamical process which could not be possible without synchronization of cellular oscillators. It has been shown that each of the cells involved in that process acts as an autonomous genetic oscillator. Communication between cells couple their dynamics and give rise to synchronization. However, factors such as cell movement or noise in signaling pathways between cells can introduce fluctuations that could affect cell organization.

To gain insight into these kind of processes it is useful to study the dynamics of coupled oscillator networks that can capture the important features of cell communication and fluctuations. The complexity of cell communication, which involve synthesis and transport of signaling macromolecules, can be captured by including time delays in the coupling between oscillators. But it is not known in which way fluctuations affect delayed coupling, and how this influences the way in which cells achieve a coherent collective behaviour. In order to tackle these issues we consider fluctuations in the context of a network of coupled phase oscillators with delayed coupling.

4.8.3. Presenting Author: Luis G. Morelli

Optimal cellular mobility for synchronization arising from gradual recovery of intercellular interactions

Koichiro Uriu[1], Saul Ares[2], Andrew C. Oates[3], and Luis G. Morelli[4]
[1] Theoretical Biology Laboratory, RIKEN Advanced Science Institute, 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan
[2] Logic of Genomic Systems Laboratory, Centro Nacional de Biotecnología - CSIC, Calle Darwin 3, 28049 Madrid, Spain
[3] Max Planck Institute of Molecular Cell Biology and Genetics, Pfotenhauerstr. 108, 01307 Dresden, Germany
[4] Departamento de Física, FCEyN, UBA and IFIBA, Conicet, Pabellón 1, Ciudad Universitaria, 1428 Buenos Aires, Argentina

Intercellular communication enables the flow of information in living tissues. During embryonic development, tissues undergo massive reorganization involving cellular movements. These cellular movements can be beneficial for the flow of information, because cells get to see effectively more neighbors as they move. However, cells may need some time to establish and develop new communication channels with their new neighbors. Then, if the movement is too fast, they may fail to establish functional communication channels, and movement will be detrimental to information flow. Here we address these questions in the context of moving coupled oscillators, a model system motivated by genetic oscillations in the vertebrate segmentation clock. We find that there is an optimal moving rate for which synchronization is faster and stronger, and a critical moving rate above which synchronization is not possible. These features are the consequence of a competition between the time scale for cellular mobility and that for the recovery of intercellular interaction. Our study indicates that the competition between these two time scales is key to the flow of information in living tissues.

4.8.4. Presenting Author: Charles Novaes de Santana

Motifs-synchronization: a new approach to dynamic brain networks analysis

R. S. Rosário[1], P. T. C. Canário[1], G. Moura-Alvares[1], I. S. Costa[2], X. Rosselló[2], M. A. Muñoz[2], P. Montoya[2], C.N. de Santana[3], and J. G. V. Miranda[1]

[1]Institute of Physics / UFBA, Salvador, Brazil
[2]IUNICS / Universitat de les Illes Balears, Palma, Espanha
[3]Department of Fish Ecology and Evolution / EAWAG, Kastanienbaum, Switzerland

One of the greatest challenges of modern science is to understand the patterns of connectivity between brain regions, the causal relations in the information's flow and the synchronization among these regions. The connectivity between brain regions can't be measured directly, however, can be estimated by applying some analysis's methods of Complex Networks and Graph Theory. This kind of study can characterize quantitatively some patterns of static nature from network. An alternative to this kind of analysis is the method called TVG (Time-Varying Graphs). With this method we have the possibility of a more detailed analysis of both static and dynamic characteristics of Brain Functional Networks (BFN). The TVG uses small time windows that cover the whole period of each signal (or time series), making a network for each window. Thus, the TVG can include the cerebral dynamic in the BFN analysis, generating new parameters to be evaluated and characterized. Other important methods to be considered are the BFN methods association. Beyond to verify the connectivity level between the networks nodes, such methods can estimate a preferred direction to this connectivity. The main objective of this work is to propose a new association method known as Motifs-Synchronization. This method provides the synchronization degree and direction between the networks nodes by counting the number of occurrences of some patterns between each time series considered. Further more, here we present a new methodology for brain networks analysis, which combines the TVG method with a directional association method. For comparison, in this work we use two methods of directional association, the Event-Synchronization and the Motifs-Synchronization, plus one un-directional association method, the Pearson correlation. The Event-Synchronization (ES) is based on the relative timings of events in the time series of each signal. The degree of synchronization is given by the number of quasi-simultaneous occurrence of these events, and the synchronization direction is calculated of the events' precedence from one signal and related to the events from others. To validate the methodology, the BFN are built from the EEG signals from 32 channels of fibromyalgia patients and healthy control subjects, provided

by the Institute for Research in Health Sciences of the University of the Balearic Islands in Palma de Mallorca, in the Spain.

4.8.5. Presenting Author: Silvia A. Menchón

A mathematical model considering system size expansion for describing neuronal symmetry breaking

Silvia A. Menchón

IFEG-CONICET and FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina

Neurons can spontaneously establish and maintain asymmetric distributions of signalling molecules on the plasma membrane, even in a homogeneous environment, suggesting the existence of an internal polarity-generating mechanism. This spatial self-organization involves an autocatalytic process and small random fluctuations. In this work we propose a stochastic model and study neuronal polarity via the system size expansion. The mean-field equations are derived and shown to lead to organized Turing patterns within a specific parameters region. With this approach we also consider the cross-diffusive terms, often neglected in the derivation of reaction-diffusion schemes, and analyze the power spectra of the fluctuations.

4.8.6. Presenting Author: Mario E. Di Salvo

Microbial motility increase due to speed-dependent nutrient absorption

Mario E. Di Salvo[1,2] and C. A. Condat[1,2]

[1]Instituto de Física Enrique Gaviola - CONICET

[2]Facultad de Matemática, Astronomía y Física - Universidad Nacional de Córdoba

Many marine microorganisms are motile; they convert their internal energy into kinetic energy in order to swim. For these biological entities, high speeds are often necessary either to take advantage of evanescent nutrient patches or to beat Brownian forces. It is reasonable to assume that, since fast motion entails high energy expenditure, some microorganisms can increase their nutrient uptake by increasing their speed, in a virtuous circle that would help the microorganism to keep a high translational speed and explore larger regions. We formulate a model that uses the concept of internal energy depot to investigate this hypothesis. Solutions obtained using realistic parameter values indicate that the speed increase due to the enhanced nutrient absorption may be substantial even for small microbes such as bacteria. Surprisingly, we find that the speed increase may be rather high even if the advection-mediated nutrient uptake is

rather modest.

4.8.7. Presenting Author: K. Tucci

Spatial inhomogeneities in social dynamics: effects of carriers and holes

C. Echeverria[1], K. Tucci[1,2,3], and M. G. Cosenza[3]

[1]CeSiMo, Facultad de Ingeniería, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.
[2]SUMA, Departamento de Física, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.
[3]Centro de Física Fundamental, Universidad de Los Andes, Mérida, Mérida 5251, Venezuela.

We study the effect of inhomogeneities in the spatial distribution of social agents whose dynamics is described by Axelrod's model for dissemination of culture. The state of an agent is described by a vector whose components represent cultural attributes. Two kind of inhomogeneities are considered: carriers and holes. Carriers are agents dispersed on a two-dimensional network that share an unchanging state but that can influence others agents; they can represent social leaders or cultural messengers. The presence of carriers can be interpreted as a nonuniform field acting on the system. Holes or defects are empty sites; they can describe physical barriers or geographical obstacles. We assume that either carriers or holes are spatially non-contiguous. The presence of either type of inhomogeneity is characterized by its density. In both cases, we find a critical value of the corresponding density below which the system reaches a homogeneous, ordered phase, where all the agents share a single state, and above which the system settles in a disordered phase, where the agents persist in many states. Thus, the presence of carriers or holes can induce cultural diversity when their density is greater than some threshold value. In this regard, carriers and holes have a counterintuitive effect similar to that of global mass media on a social system. For a given number of options, we find that the critical value of the density of carriers above which cultural diversity emerges is less than the corresponding critical value for holes. The critical boundary separating the two phases is calculated on the parameter space of the system, given by the corresponding inhomogeneity density and the number of options per cultural attribute.

4.8.8. Presenting Author: Gustavo J. Sibona

Opinion formation in a system of interacting moving agents

Gustavo J. Sibona[1,2], J. Revelli[1,2], and G. Terranova[1,2]

[1]FaMAF, Universidad Nacional de Córdoba, Argentina
[2]CONICET

We study the influence of spatial dynamics of interacting self propelled agents in the opinion formation. We propose a general non linear analytical framework which allow us to determine the evolution of the opinion of the population. It is possible to obtain analytical results for some special perturbative cases and numerical results in general. In the model agents adopt one of the n possible opinions or states, which may change while the agent keeps contact with another

one. We implement a computational model to perform molecular dynamics-type simulations in order to check theoretical results for a specific case, finding an excellent agreement

4.8.9. Presenting Author: Sabrina Camargo

Nonstationarities of heart beat intervals

Sabrina Camargo[1], Maik Riedl[1], Celia Anteneodo[2,3], Jürgen Kurths[1,4,5], and Niels Wessel[1]

[1] Department of Physics, Humboldt-Universität zu Berlin, Berlin, Germany
[2] Department of Physics, PUC-Rio, Rio de Janeiro, Brazil
[3] National Institute of Science and Technology for Complex Systems, Rio de Janeiro, Brazil
[4] Potsdam Institute for Climate Impact Research, Potsdam, Germany
[5] Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Aberdeen, United Kingdom

In this work we present the analysis of nonstationarities in heart rate by means of a nonparametric segmentation algorithm. The idea of the segmentation applied to time series is to provide patches of the signal where stationarity is verified. Instead of testing only the difference for the mean, we perform a nonparametric segmentation, taking into account the whole distribution, with all moments, especially mean and variance. We aim at characterize the nonstationarities present in three groups consisting of 15 young (YH; 11 females, 4 males, age 31±6 years) and 18 elderly subjects (EH; 11 males, 7 females, age 50±7 years), and 15 patients suffering from congestive heart failure (CHF; 11 males, 4 females, age 56±11 years). For analysis, we consider 24 hours measurements of the electrocardiogram, and the series of time intervals between consecutive heart beats, the beat-to-beat intervals, are extracted from the electrocardiograms.

To quantify the nonstationarities, we obtain statistical values of the segmentation, which include not only segment length and jump size but also the number of segments greater than 300, $L_{>300}$, and $\%\mu_{50}$. $L_{>300}$ corresponds to approximately 5 min of observation, the shortest required segment length of HRV analysis and $\%\mu_{50}$ reflects the percentage of differences of the mean of two consecutive segments, $\mu_{i+1} - \mu_i > 50$ ms, in an analogy to the standard HRV measure $pNN50$, the percentage of consecutive RR intervals differing by more than 50 ms.

We found high positive correlations $\%\mu_{50}$ and the overall standard deviation as well as a negative correlation between $L_{>300}$ and the normalized very low frequency power, VLF/P, linking the segmentation outcomes to standard measures. In order to understand the scaling behaviour of the extracted trends in the time series, we compute the mean variance of the segments given a segment length, which indicates a power function. Our results show significant differences between CHF and age-matched EH, as well as CHF and YH. Also, differences between YH and EH can be detected, showing the aging effect in the loss of complexity of the heart rate $(p < 0.05)$.

Through the outcomes of segmentation we have access to time characteristics of the signal that were no longer available, making possible a different approach to quantify nonstationarities in HRV analysis. Results are in agreement with previous knowledge and do not require arbitrary thresholds or excludes fragments of the time series.

Ref.: Front. Physiol. **4** 107 (2013).

4.8.10. Presenting Author: Luciano H. Miranda

Living-Zombie interaction as a model for infectious diseases: numerical simulations

L. H. Miranda Filho[1], B. V. Ribeiro[1], P. M. M. da Rocha[1], D. D. A. Santos[1], and N. C. de Sena[1]

[1] Instituto de Física, Universidade de Brasília, Distrito Federal, Brasil

We consider a model describing the dynamics of a two species population. These species are able to interact with each other and have different rules for growth and death. While for one, the usual birth and death cycles are valid, the other is fed by the deceased individuals of the previous one and can only decrease through interaction.

The rules model the dynamics of a *living-zombie* population, based on previous work by Munz *et al.* [1] and on recent literature, cinematography and games. The evolution of the system can be described by a set of Lotka-Volterra-like differential equations. To simulate this dynamics, we employ a Monte-Carlo method, in which a discrete treatment of the problem, *i.e.*, individual-to-individual interaction, is considered.

In this approach, the parameters of the simulation are based on the coefficients of the equations. Qualitatively, the results obtained by direct integration of these equations are recovered, showing that our method accurately describes the system at hand. This allows exploration of spatial aspects of the dynamics. Particularly, spatial structuration and migration can be investigated by implementing a lattice in which the population interacts locally under the same rules. We observe that for a large enough population, given an uniform initial distribution of the individuals and for random migration, the results match those of the non-strutured Monte-Carlo method. Furthermore, we study different configurations and migration rules, searching for favorable outcomes to the living population.

References

[1] Munz, P., Hudea, I., Imad, J., Smith, R.J. In: *Infectious Disease Modelling Research Progress* Editors: J.M. Tchuenche and C. Chiyaka pp. 133-150 (2009) Nova Science Publishers, Inc.

4.8.11. Presenting Author: Natália C. de Sena

Living-Zombie interaction as a model for infectious diseases: population dynamics approach

L. H. Miranda Filho[1], B. V. Ribeiro[1], P. M. M. da Rocha[1], D. D. A. Santos[1], and N. C. de Sena[1]

[1] Instituto de Física, Universidade de Brasília, Distrito Federal, Brasil

We present a model describing the dynamics of a two species population. These species are able to interact with each other and have different rules for growth and death. While for one, the usual birth and death cycles are valid, the other is fed by the deceased individuals of the previous one and can only decrease through interaction.

The rules model the dynamics of a *living-zombie* population, based on previous work by Munz *et al.* [1] and on recent literature, cinematography and games. The evolution of the population obeys a system of Lotka-Volterra-like differential equations

$$\begin{aligned} \dot{L} &= (\alpha - \beta)L - \gamma LZ \\ \dot{Z} &= \rho\beta L + (\gamma - \delta)LZ, \end{aligned}$$

where L and Z represent, respectively, the quantity of living and zombies. The coefficient α is the living birth rate and β its death rate. The average strenghts of the species are related to coefficients γ and δ, the latter being associated to the living and the former, to the zombies. A fraction of the living, given by ρ, is assumed to be infected and, upon dying, increases Z.

A stability analysis of the differential equations system is presented through a search for fixed points of the dynamics and regions of species coexistence. We point out criteria for survival of the living species, which are corroborated by numerical solutions of the equations of the dynamics.

References

[1] Munz, P., Hudea, I., Imad, J., Smith, R.J. In: *Infectious Disease Modelling Research Progress* Editors: J.M. Tchuenche and C. Chiyaka pp. 133-150 (2009) Nova Science Publishers, Inc.

4.8.12. Presenting Author: Marcelo Otero

Comparison of two stochastic spatial dynamical models of Aedes aegypti

Marcelo Otero[1], Mathieu Legros[2,3,4], Victoria Romeo Aznar[1], Tomas W. Scott[3], Hernan Solari[1], Fred Gould[4], and Alun L. Lloyd[4]

[1] IFIBA-CONICET, Depto. de Física, FCEyN, Universidad de Buenos Aires, Buenos Aires, Argentina
[2] ETH Zurich, Zurich, Switzerland
[3] University of California, Davis, CA, United States
[4] North Carolina State University, Raleigh, NC, United States

Mosquito population models are useful tools for guiding the development of successful vector control programs. Models can differ in their level of complexity, which affects in an elaborate fashion their predictive ability and robustness. In order to investigate the impact of this complexity in model assumptions, we present a direct comparison of two detailed, spatially-explicit, stochastic models of the population dynamics of Aedes aegypti, the main vector of dengue and yellow fever. Both models describe the mosquito's biological and ecological characteristics, but differ in their level of complexity. We compared the predictions of these models in two selected climatic settings, a tropical and weakly seasonal climate in Iquitos, Peru, and a temperate and strongly seasonal climate in Buenos Aires, Argentina. Both models were calibrated to operate at identical average densities in unperturbed conditions in both settings, by adjusting parameters regulating densities in each model: density of breeding sites and amount of nutritional resources. We show that the models differ in their sensitivity to environmental conditions, temperature and rainfall, and trace differences to specific model assumptions, e.g., egg hatching and larval competition. Temporal dynamics of the Ae. aegypti populations predicted by the

two models differ more widely under strongly seasonal Buenos Aires conditions. We model control interventions in selected areas by simulating killing of larvae and/or adults. We show that predictions of population recovery differ substantially, an effect likely related to model assumptions regarding larval development and, direct or delayed, density dependence. Our methodical comparison provides important guidance for model improvement by identifying key areas of Ae. aegypti ecology that substantially affect model predictions, and revealing the impact of model complexity on population dynamics predictions in unperturbed and perturbed conditions.

4.8.13. Presenting Author: David Schneider

Effect of mutations in populations subjected to assortative mating

D. M. Schneider[1], A. B. Martins[2], E. do Carmo[3], and M. A. M. de Aguiar[1]

[1]Universidade Estadual de Campinas, 13083-970, Campinas, SP, Brazil

[2]Instituto de Biociências, Universidade de São Paulo, 05508-090, São Paulo, SP, Brazil

[3]Universidade Federal da Integração Latino Americana, 85867-970, Foz do Iguaçu, PR, Brazil

In a recent paper [Schneider et al, **2013**, *Evolutionary consequences of assortativeness in haploid genotypes*, Submitted to Evolution] we have analyzed in detail the dynamics of allele frequencies in large populations without mutations, and connected it to previous classic models in population genetics. We considered the simplest case of two loci, $B = 2$, and $G = 1$, so that gametes whose alleles were different in both loci would be considered incompatible and fertilization would not happen. In this case there are only four haploid genotypes, AB, Ab, aB and ab and fertilization between $AB - ab$ and $Ab - aB$ does not occur. Evolution equations for the genotype frequencies $p_{u'u''}$ (with $u' = A, a$ and $u'' = B, b$) can be written down and solved. We found that the coupling between the loci introduced by the restricted fertilization leads to a strong correlation between the allele frequencies. If $\tilde{p}_A = p_{AB} + p_{Ab}$ is the frequency of allele A and $\tilde{p}_B = p_{aB} + p_{AB}$ that of allele B, the quantity $T = (\tilde{p}_A - 1/2)/(\tilde{p}_B - 1/2)$ remains constant during the evolution. Using this conserved quantity we were able to solve the dynamical equations and show that one of the alleles always disappears from the population.

The aim of this work is to extend those results including the effects of mutations. We show that, surprisingly, the function T remains constant for arbitrary values of the mutation rate and all the equilibrium solutions of the population can be found analytically. The previous solutions corresponding to the loss of an allele changes into solutions where the same allele appears in small proportions. Moreover, we found that these solutions collapse at a critical mutation rate where a biologically meaningful bifurcation occurs. Another bifurcation takes places for negative mutations rates. Not being relevant from a biological point of view, this second bifurcation is very illustrative to describe, in addition to the former, the global structure of the phase space.

4.8.14. Presenting Author: Carolina Daza

Development of a simple model to characterize the emerging spatial patterns in the primary visual cortex of mammals

Daza C.[1], Gleiser P.[2], Tamarit F.[3], and Tauro C.[3]

[1] IFEG, CONICET-FAMAF UNC
[2] CAB, CONICET-CNEA
[3] FAMAF UNC

There are phenomena in Nature in which some elements of a system present the same rhythmic behaviour. When this occurs, we say that there is a synchronization between the elements or parts of the system. An example of this phenomenon is the synchronization of the neuronal activity in the brain, in particular in the visual cortex of mammals, where it is possible to observe different patterns of activity. In order to understand the emergence of these patterns we model each neuron as a simple phase oscillator, and, as a result of the coupling between neurons, a synchronization of the phases arises under some circumstances.
In this work we analyze the formation of patterns using a scale-free topology of connections. With the purpose of making a more realistic model, this network is embedded in a low-dimensional Euclidean space and the interaction function is modelled with a mexican hat function that depends on the distance and also on the location of the site in the network. We analyze the parameters that allow us to obtain different sets of patterns, such as bubbles, oriented stripes or labyrinths. Subsequently, we characterize quantitatively the patterns obtained. We compare our results with real data obtained in macaque visual cortex.

4.8.15. Presenting Author: Daniela Ospina Toro

Spiking-Bursting Transition in a Huguenard-McCormick Nonlinear Thalamocortical Neuron Model

D. Ospina-Toro and O. Henao-Gallo

Physiology Group, Universidad Tecnológica de Pereira

This paper analizes dynamically the Huguenard-McCormick (HMC) model, including critical points, phase planes and bifurcation analysis to obtain spikes and bursts responses of neurons. Through Hopf bifurcation, dynamical transition of the system is made at parametric mode vs. excitation current. By means of calcium-dependent response limit cycle tightening, the neuron comes from an oscillatory behavior to a chaotic one.

Particular emphasis has been placed in T-type calcium current for a subthreshold excitation and hyperpolarization-activated membrane, which is a pivotal factor of the bifurcation parameter. The value range for the positive excitation is obtained for a change in the neural response using a subcritical Hopf bifurcation.

Thalamical neuron dynamics achieved in this work allows to elucidate experimental different kind of responses reported, letting the neuron behave as an integrate-and-fire model, as well as a resonator and a chaotic oscillator.

4.8.16. Presenting Author: J.L. Blengino Albrieu

A moving boundary model for the root water uptake: a comparation with fixed boundary models

J. L. Blengino Albrieu[1], J. C. Reginato[1], and D. A. Tarzia[2]
[1]Departamento de Física; Facultad de Ciencias Exactas Físico-Químicas y Naturales; Universidad Nacional de Río Cuarto; Ruta 36 km601, X5804BYA, Río Cuarto, Córdoba, Argentina
[2]Departamento de Matemática; CONICET; Facultad de Ciencias Empresariales; Universidad Austral; Paraguay 1950, S2000FZF Rosario, Santa Fe, Argentina

This work presents a model of moving boundary (MB) for water uptake by roots and a comparison with two fixed boundary models for fixed volumes of soil. These models are strongly non-linear as the water transport equation is non-linear, and in addition, in the model MB domain variation adds another non-linearity. The Fixed boundary models (FB) used are Fixed Boundary with Fixed Root Length (FBFRL) and Fixed Boundary with Growing Root Length (FBGRL). Both FB and MB models are solved by domain adimensionalization and using the finite element method. The water uptake is calculated with a variable domain integral in the case of models with growing root length, while for the fixed root length model the same integral is calculated on a fixed domain. The results indicate that in the case of model MB mass is conserved and the root water uptake dynamic differs with the FBFRL model, which also conserves the mass. In the model FBGRL the mass of water is not conserved, although the dynamics is similar to the model MB. MB model, then, can incorporate the complexity of the root growth and conserves the mass of water for the simulations for a unit length of root.

4.8.17. Presenting Author: Guadalupe Cascallares

What season suits you best? Seasonal light changes and cyanobacterial competition

G. Cascallares and P. M. Gleiser

CAB-CONICET

Nearly all living organisms, including some bacterial species, exhibit biological processes with a period of about 24 h called circadian rhythms. These rhythms allow living organisms to anticipate the daily alternation of light and darkness. Experiments carried out by Woelfle et al. (1998-2004) have shown the adaptative value of circadian clocks in Cyanobacteria. In these experiments a wild type cyanobacterial strain (with a 24h circadian rhythm) and a mutant strain (with a longer or shorter period) grow in competition. The external light dark cycle was changed in different experiments in order to match the circadian period of the different strains. They found that the strain whose circadian period matches the light-dark has a larger fitness. As a consequence the initial population of one strain grows while the other decays.

These experiments were made under fixed light and dark intervals. However, in Nature this relationship is not constant, and it changes according to the season. Therefore, seasonal changes in light could affect the competition between different strains. Using a theoretical model proposed by Gonze et al. (2002), which takes into account cell growth, secretion of a cell growth inhibitor and the existence of a light-sensitive circadian oscillator, we analyze how modulation of light can change the survival of the different cyanobacterial strains. Our results show that there is a clear shift in the competition due to the modulation of light, which could be experimentally verified.

4.8.18. Presenting Author: Gioconda C. Herrera Almarza

Modeling chromosome motility in eukaryotic mitosis

Gioconda C. Herrera Almarza[1,2] and Juan Luis Cabrera[2]

[1]Department of Mathematics and Stochastic Dynamics Lab., Center for Physics, Venezuelan Institute for Scientific Research, Caracas 1020A, Venezuela.

[2]Stochastic Dynamics Lab., Center for Physics, Venezuelan Institute for Scientific Research, Caracas 1020A, Venezuela.

In this paper we propose an extremely simple mathematical model based on the dynamics of a genetic circuit with positive and negative feedback loops that reproduces the main properties of chromosome motility during the process of cell mitosis without requiring external parameter turing in contrast to other approaches reported in the literature. The agreement between theoretical predictions and the experimental evidence supports the idea that cell mitosis is based on a unstable dynamic process.

4.8.19. Presenting Author: Fabiano A. S. Ferrari

Neuronal desynchronization induced by lesions in the brain

F. A. S. Ferrari and R. L. Viana

Federal University of Parana

To accomplish a task the brain works like a synchronized neuronal network where all the neurons involved work together but when a lesion begins to spread in brain and reaches a significant portion of some relevant area in the brain then a phase transition occurs such the neurons become unsynchronized and the brain becomes unable to accomplish the task. We will present a simplified model of neuronal network subject to random lesions to try understand how large a lesion has to be to induce a desynchronization in the network.

4.8.20. Presenting Author: J. Sparacino

Effect of the microtubule-associated protein tau in dynamics of single-headed motor proteins KIF1A

J. Sparacino[1], M.G. Farías[2], and P. W. Lamberti[1]

[1]FaMAF-UNC, CONICET

[2]IMMF, INIMEC-CONICET

Intracellular transport is fundamental for cellular function, survival, and morphogenesis. Kinesin superfamily proteins (also known as KIFs) are important molecular motors that directionally transport cargoes along microtubules (MTs), including membranous organelles, protein complexes and mRNAs. Disruptions or defects of MT-based transport are observed in many neurodegenerative diseases. MTs are decorated with non-motile microtubule-associated proteins (MAPs) that promote MT assembly and play important roles in organizing the MT cytoskeleton. Kinesin proteins interfere with MAPs, being the latest able to inhibit active transport of cytoplasmic material. Kinesin competes with MAPs to bind to the MT surface and MAPs bound to MTs might also block the path of motor proteins. Tau is a mainly neuronal MAP, enriched in the axonal compartment that has been shown to inhibit plus end-directed transport of vesicles along MTs by kinesin. Tau reduces not only the attachment frequency of kinesin to MTs but also the distance that kinesin travels along the MT in a single run. It is also known that when single kinesin motors encounter tau patches on the MT, most of the motors detach from the MT surface. Motivated by experiments on kinesin-tau interactions [Dixit et al. Science 319, 1086 (2008)] we developed a stochastic model of interacting single-headed motor proteins KIF1A that also takes into account the interactions between motor proteins and tau molecules. Our model reproduce experimental observations and predicts significant effects of tau on bound time and run length which suggest an important role of tau in regulation of kinesin-based transport.

4.8.21. Presenting Author: Cabrera Octavio, Zanette Damían

Dynamics epidemic Pediculus humanus capitis in social groups

O. Cabrera[1] and D. Zanette[2]
[1]Instituto Balseiro
[2]CONICET

We study the epidemiology of the human head lice (Pediculus humanus capitis) over social groups. Using stochastic numerical simulations, we first analyze the population dynamics of a lice colony, with emphasis on nonlinear effects such as self-grooming of the infected individual. Then, we study the epidemics on social groups, represented by a social network where the connected nodes (human heads) are susceptible to mutual contagion. We quantify the critical transition from infection extinction to the endemic situation where the infection persists over arbitrary long times. The transition is characterized in terms of the parameters that define the network, highlighting the number of humans in the group, and the network connectivity, among others. Finally, we propose a phenomenological model that predicts this critical phenomenon.

4.8.22. Presenting Author: Marco Bayas

First Passage Times analysis of the forced rupture of a DNA Hairpin in the nanosecond scale

M. V. Becerra and M. V. Bayas

Departamento de Física, Escuela Politécnica Nacional, Ladrón de Guevara E11-253, Quito, Ecuador.

Steered Molecular Dynamics Simulations were used to disrupt the tertiary structure of the DNA Hairpin: AACC4, which has five A-T pairs. The hairpin was subjected to constant forces between 100 and 500 pN so that the pairs can be separated. The forces were applied until all the base pairs dissociated. The final structure was an extended DNA strand. For each force, seven simulated ruptures were performed. The rupture times ranged from several picoseconds to up to one nanosecond. It depended not only on the external force but also on the location of the pair. For each pair, the relation between the averaged rupture time and the applied force was first analyzed in the context of the Bell-Kramers theory that predicts a linear relationship between the logarithm of the rupture times and the force. As a result, we concluded that the forced dissociation process do not follow the above mentioned linear relationship but a quadratic one. These simulations have rendered insights into the energetics of this Hairpin. The simulations were performed with the package NAMD (Nano Scale Molecular Dynamics).

4.8.23. Presenting Author: Ariel Haimovici

Optimal Strategy to Sample Complex Brain Dynamics

Ariel Haimovici[1,3], Matteo Marsili[2], and Dante R. Chialvo[3,4]

[1] Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
[2] The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy
[3] Concejo Nacional de Investigaciones Científicas y Tecnológicas, Buenos Aires, Argentina
[4] Facultad de Ciencias Médicas, Universidad Nacional de Rosario, Rosario, Argentina

An important constraint in the study of complex systems is the fact that only few relevant variables are accessible for modelling, and its dynamics is strongly undersampled. Recent work [1] shows that the under sampling regime can be distinguished from the regime where the sample becomes informative of systems behavior, suggesting how this feature can be optimized to identify the most informative representation of complex data. In this work we explored the consequence of this issues on the analysis of large scale brain dynamics both in models and experimental imaging data.

References

[1] M. Marsili, I. Mastromatteo, & Y. Roudi. arXiv:1301.3622 (2013).

4.8.24. Presenting Author: Cintia Simoncini

Dynamics and evolution of the population of birds and mosquitoes on the prevalence of Avian Malaria

C. N. Simoncini[1], D. H. Margarit[2], J. B. H. Njagarah[3], and L. M. Romanelli[1,2]

[1]CONICET
[2]Science Institute, National University of General Sarmiento

[3]Biomethematics, Stellenbosch University

From a population model we examine the different vector-host behavioural interactions, with focus on avian malaria transmission. We analize two models: a) random preference model (the mosquito randomly chooses an infected or healthy bird) and b) preference model depending on the abundance of the host, analyzing in each case, the basic reproduction number as transmission threshold. Consequently determine the stability conditions of each of them.

4.8.25. Presenting Author: David Margarit

Analysis of population competition model for the study of tumor growth

D. H. Margarit[1], L. M. Romanelli[1,2], and C. N. Simoncini[2]
[1]Universidad Nacional de General Sarmiento
[2]CONICET

In this paper, based on a competency model population of two species (tumor cells and immune cells), will study the parameters that influence the evolution of the tumor, as well as influence of noise in the system.

4.8.26. Presenting Author: Francisco Redelico

Classifying cardiac dynamics using permutation entropy and multifractal detrended analysis

I. G. Vilaboa, F. O. Redelico, and M. Risk

Instituto Tecnológico de Buenos Aires

A database developed collaboratively at Harvard Medical School (HMS, Children's Hopspital), Massachuset Institute of Technology (MIT) and the Favaloro Foundation Medical (FFMS), i.e. HMS-MIT-FFMS database (M. Risk et al. (1995) Ann. Int. Conf. of the IEEE Eng. in Medicine and Biology - Proc. 17 (1), 201-202) is analyzed in order to relate both permutation entropy and multifractal detrended analysis results with physiological features of the patients. This database consists of ten 24 hours each, two-channel electrocardiogram (ECG) recordings, digitalized at a sampling rate of 256Hz. Permutation entropy, was first proposed in Bandt C. and Pompe B. (2002, Phys. Rev. Lett. 88, 1–4) as a measure capable to grasp the correlation structure of a signal into an entropic measure. However, one assumption of this measure is the continuity of the time series analysed. This is not the case of ECG time series where the signal is discrete and with a low resolution. For these re asons C. Bian et al. (2012, Physical Review E 85, 021906) proposed a modified permutation entropy in order to allow repetited values. In this contribution, the modified permutation entropy, along with the original version of it, is calculated for each rercording of the HMS-MIT-FFMS database and related with some physiological parameters of the heart rate varibillity within the time domain. Multifractal structure of heart rate variability seems to reflect important features of the regulation of the heart rate (Goldberger A. L. et al. (2002) Proc. Natl. Acad. Sci. U.S.A. 99, 2466–2472) In this contribution the heart rate variability is related to the multifractal structure of the patient belonging HMS-MIT-FFMS database using multifractal dedrented analysis.

4.8.27. Presenting Author: Andrés Quiroga

Adjoint method for a tumor invasion PDE-constrained optimization problem

A. A. Quiroga[1,2], D. R. Fernández[1,2], G. A. Torres[1,2], and C. V. Turner[1,2]

[1] Facultad de Matemática, Astronomía y Física, Córdoba, Argentina

[2]Centro de Investigaciones y Estudios en Matemática - CONICET, Córdoba, Argentina

We present [1] a method for estimating unknown parameter that appear on a non-linear reaction-diffusion model of cancer invasion [2]. This model describe for the non dimensional spatial distribution and temporal evolution of the density of normal tissue ($\boldsymbol{u_1}$), the neoplastic tissue growth ($\boldsymbol{u_2}$) and the excess concentration of H^+ ions ($\boldsymbol{u_3}$). A coupled system reaction-diffusion describing this model is given by three partial differential equations:

$$\begin{aligned}
\frac{\partial u_1}{\partial t} &= u_1 (1 - u_1) - \delta_1 u_1 u_3, \\
\frac{\partial u_2}{\partial t} &= \rho_2 u_2 (1 - u_2) + \nabla \cdot (D_2 (1 - u_1) \nabla u_2), \\
\frac{\partial u_3}{\partial t} &= \delta_3 (u_2 - u_3) + \Delta u_3.
\end{aligned}$$

Each of the model parameters has a corresponding biological interpretation, for instance, the growth rate of neoplastic tissue ($\boldsymbol{\rho_2}$), the diffusion coefficient($\boldsymbol{D_2}$), the reabsorption rate ($\boldsymbol{\delta_3}$) and the destructive influence of H^+ ions in the healthy tissue ($\boldsymbol{\delta_1}$). The last one cant be estimated in the direct form.

After solving the forward problem properly, we use the model for the estimation of parameters by fitting the numerical solution with real data, obtained via in vitro experiments and fluorescence ratio imaging microscopy [3]. We define an appropriate functional to compare both the real data and the numerical solution using the adjoint method [4] for the minimization of this functional. We apply Finite Element Method (FEM) to solve both the direct and inverse problem.

References

[1] A. A.I. Quiroga, D. R. Fernández, G. A. Torres, and C. V. Turner, *Adjoint method for a tumor invasion PDE-constrained optimization problem using FEM.* Prepint.

[2] R. A. Gatenby and E. T. Gawlinski, *A reaction-diffusion model of cancer invasion*, Cancer Research, **56**, (1996), 5745–5753, (1996).

[3] G. R. Martin and R. K. Jain, *Noninvasive measurement of interstitial ph profiles in normal and neoplastic tissue using fluorescence ratio imaging microscopy*, Cancer research, **54**, 5670–5674, (1994)

[4] J. Nocedal and S. J. Wright, *Numerical optimization*, Springer Science+ Business Media, (2006).

4.8.28. Presenting Author: María da Fonseca

Photoreceptor absorption curves account for human chromatic discrimination ability

M. da Fonseca[1,2] and I. Samengo[1,2]
[1]CONICET
[2]Instituto Balseiro

Photoreceptors constitute the first stage in the processing of color information; many more stages are required before a human subject can consciously report whether two stimuli are perceived as chromatically equal or not. Therefore, although photoreceptor absorption curves are expected to condition conscious discriminability, there is no reason to believe that they should suffice to explain it. Here, however, by calculating the Fisher Information about wavelength defined by the activity of photoreceptor absorption curves, we demonstrate that human color discrimination ability can be predicted from the properties of the first stage of visual processing. This result implies that the bottleneck in chromatic information transmission is determined by photoreceptor absorption characteristics. Subsequent encoding stages preserve the wavelength dependence of chromatic discriminability at the photoreceptor level. Finally, by varying the numbers of photoreceptors of each type, we predict the color discrimination ability of different types of color-blind subjects.

4.8.29. Presenting Author: Jorge Amador

Nonlinear and Nonsmooth Dynamics in Stress-Sickness Processes

Jorge Amador[1], Johan M. Redondo[2], and Gerard Olivar[1]
[1]Universidad Nacional de Colombia - Sede Manizales
[2]Universidad Sergio Arboleda

The first ideas about the influence of stress in the development of diseases date back to ancient medical writings of the Assyrians, Greeks, and Romans. But it was only in the 20th century that doctors were able to identify stressful events such as heat, cold and hunger, as well as establish the relationship between emotions and the psychological response to these events. Ransom Arthur designed a model of stress and coping which explains how stress can generate diseases. His model (non-mathematical) is an epidemiological statistics based-process that explain the different stages that occur in an individual with symptoms of stress

In this work, we perform a nonlinear and nonsmooth dynamic representation of Ransom Arthur model, as an alternative for the study of diseases that stem from the psychological response to events, specifically, the stress-sickness relationship, and how the results could help to identify and/or understand certain behaviours of individuals.

Our model is constructed from the identification of causal relations, following the study by Ransom Arthur and represents the dynamic relationship between stress and sickness. The model is a nonlinear system of the form $\dot{\boldsymbol{x}} = \boldsymbol{f}(\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{\mu})$, where $\boldsymbol{x_1}$ represents the level of stress, $\boldsymbol{x_2}$ the level of sickness, and $\boldsymbol{\mu}$ system parameters. Results are mainly state space simulations and some sensitivity analysis in order to analyse different behaviours under parameter variation.

It is also proposed a nonsmooth model which assumes that a better approximation of the stress-disease dynamics is a Filippov system with multiple discontinuities and crossing boundaries. The results obtained in this case suggests multiple steady states which involved phenomena such as sliding and the existence of pseudo-equilibria.

4.8.30. Presenting Author: L. A. da Silva

Stochastic neural field equations: dynamics and pattern formation

L. A. da Silva and C. Anteneodo

PUC-Rio, Rio de Janeiro, Brazil

The understanding of both basic and high-level functions performed by the nervous system requires theoretical models in multiple scales. The development and improvement of experimental techniques in the last decades as, for example, multi-electrode array and non-invasive methods as functional magnetic resonance imaging, shed light on the collective behavior of neural populations and consequently generated a renewed interest in the creation of a robust theoretical framework. Also, it has been highlighted in the literature the fundamental and many times constructive (as in stochastic resonance and stochastic coherence phenomena) role of statistical noise in many neuronal processes at essentially all scales. All these findings lead us to assume the brain as a system out of equilibrium whose dynamics is intrinsically stochastic at both cellular and global levels.

In this work, we assume that the cell population in a given domain is high and dense enough to justify the substitution of a discrete topology for a continuous one, which allows us to resort to a field approach to the neuronal activity. Our starting point is an extension of the infinite dimensional Wilson-Cowan model, that originally is a non-local deterministic differential equation that describes the space and time dynamics of neuronal activity through a scalar field. We consider a stochastic version of this model in order to study how additive and multiplicative spatiotemporal noise terms (either colored or white) affect the conditions to pattern formation, both global periodic and spatially localized ones. Also, we contrast the dynamical behavior of the stochastic field equation with its deterministic version in order to provide an accurate description of noise effects in the neuronal activities.

4.8.31. Presenting Author: Eduardo H. Colombo

Nonlinear diffusion as a mechanism for population fragmentation

Eduardo H. Colombo and Celia Anteneodo

Department of Physics, PUC-Rio, Rio de Janeiro, Brazil

In order to understand the effects of individuals mobility within the pattern formation context, a nonlinear diffusion term is considered in a paradigmatic model for the evolution of a single species density distribution $u(x,t)$. The original model includes growth and nonlocal competition. Nonlocal competitive interactions are the main mechanism that induces spatial instability, yielding patterns and also defining their periodicity. We model the population spread through nonlinear diffusion of the form $\partial_t u = D\partial_{xx}u^{\nu}$ (with $D,\nu > 0$), encompassing the cases where the state-dependent diffusion coefficient either increases ($\nu > 1$) or decreases ($\nu < 1$) with the density, yielding subdiffusion or superdiffusion, respectively. By means of numerical simulations and analytical considerations, we display and discuss how that nonlinearity alters spatial patterns. Our results indicate that the dominant persistent mode is the initially fastest growing one, which can be obtained through the linear approximation. That identification of the main mode selected at long times allows to perform analytical predictions.

Diffusion imposes a critical threshold of the model parameters for pattern formation. The type of diffusion regime has impact on patterns shape. Counterintuitively, superdiffusion ($\nu < 1$) may facilitate pattern formation, requiring shorter interaction widths and manifesting larger amplitudes than in normal diffusion. An important qualitative change occurs for the subdiffuion case ($\nu > 1$), in which the population becomes fragmented, emerging isolated sub-groups, with compact support properties. The occurrence of fragmentation may have important consequences in diseases dissemination and other spreading processes triggered by contacts between individuals.

4.8.32. Presenting Author: Shirlene Vega

Could T. Rangeli Protect Us From Chagas Disease?

Shirlene Vega[1,2] and Gustavo J. Sibona[1,2]
[1]CONICET
[2]FaMAF, Universidad Nacional de Cordoba

It has been shown in murine models that an infection with the parasite Trypanosoma rangeli decreases the parasite levels of a Trypanosoma cruzi (causing agent of the Chagas disease) later infection. In this work we present a mathematical model that describe this situation, taking into account the no intracellular replication of the T. rangeli, the delay in the answer of the mammal immunological system against the T. cruzi infection and its intracellular reproductive cycle as well. In general we show that a parasite mixed infection exhibits one of three possible stationary states: Healing, Chronic Parasitemia and Dead. The model reproduces experimental data from murine models found in the literature. As a final remark we demonstrate that the protective effect against Chagas disease obtained by preinfecting with T. rangeli is just temporary.

4.8.33. Presenting Author: Natalia C. Clementi

Reflection vs Persuasion. Modeling opinion formation in a society.

Natalia C. Clementi[1,2], Jorge A. Revelli[1,2], and Gustavo J. Sibona[1,2]
[1]Instituto de Física Enrique Gaviola (IFEG) - CONICET

[2]FaMAF-UNC

Large systems consisting of many coupled excitable units occur in a wide variety of fields. Recently, it has been shown that in arrays of all-to all coupled units, the dynamics of the average activity of the network is ruled (in the limit of $N \to \infty$) by a low dimensional dynamical system. In this work we investigate the actual size of a finite array whose dynamics can be represented by the behavior of the infinitely large one. We compare those two cases studying the topological organization of periodic orbits found in their average dynamics.

4.8.34. Presenting Author: Elizabeth Baptestini

Competition-Induced Disruptive Selection in a Spatially Explicit Model

Elizabeth M. Baptestini[1], Marcus A. M. de Aguiar[1,3], and Márcio Araújo[3]

[1]Universidade Estadual de Campinas
[2]Universidade Estadual Paulista "Júlio de Mesquita Filho"
[3]New England Complex Systems Institute

Many quantitative genetic and adaptive dynamic models suggest that disruptive selection can maintain genetic polymorphism and be the driving force causing evolutionary divergence. These models also suggest that disruptive selection arises from frequency-dependent intraspecific competition. In spatially structured populations evolutionary branching driven by localized and frequency-dependent ecological interactions can generate phenotypic diversification across a linear environmental gradient. This diversification can occur more easily than in non-spatial models. In the present study we propose a spatially explicit analytical model to evaluate how alternative shapes of the carrying capacity and competition kernels interact to determine the likelihood of disruptive selection. Our results suggest that the relationship between the degree of frequency dependence and the likelihood of disruptive selection is more complex than previously thought.

4.9. Other nonlinear phenomena

4.9.1. Presenting Author: Nicasio Barrere, Cecilia Cabeza, Alberto Pérez-Muñuzzuri

A Lagrangian Anlaysis to study mixing and coherence of structures on non-stationary flows

Nicasio Barrere[1], **Cecilia Cabeza**[1], **and Alberto Pérez-Muñuzzuri**[2]
[1]Instituto de Física, Facultad de Ciencias, UdelaR
[2]Grupo de Física no lineal, Universidad de Santiago de Compostela, España

It is well known that the characterization of non stationary flows is usually provided by a Lagrangian approach. Even in this kind of flows coherent structures, more precisely Lagrangian Coherent Structures (LCS), were widely reported on the literature. In this work we applied to a laboratory controlled experiment and oceanic currents data a series of tools in order to get a Lagrangian description of the flow and to find LCS. A commonly used method to localize LCS is the Finite Time Lyapunov Exponents (FTLE) which basically gives a measure of exponential separation between particle trajectories in a finite time interval for every point in the domain. This work mainly relies on the study of FTLE on the systems previously named. A computational algorithm was developed to compute the FTLE from its velocity fields. The study of FTLE, as well as Lagrangian Synoptical maps and Density maps in finite time intervals revealed the bahavior of this structures and mixing as well. Because of the major role which plays vorticity on mixing processes, we applied multivariate analysis which shows a strong correlation between LCS ridges (i.e. FTLE local extrema) with vorticity in those regions of vorticity with high modulus and opposite signs.

4.9.2. Presenting Author: Marcos Gaudiano

Fractal Cartography of Urban Areas

M. E. Gaudiano

Universidad Nacional de Córdoba

In a world in which the pace of cities is increasing, prompt access to relevant information is crucial to the understanding and regulation of land use and its evolution in time. In spite of this, characterization and regulation of urban areas remains a complex process, requiring expert human intervention, analysis and judgment. Here we carry out a spatio-temporal fractal analysis of a metropolitan area, based on which we develop a model which generates a cartographic representation and classification of built-up areas, identifying (and even predicting) those areas requiring the most proximate planning and regulation. Furthermore, we show how different types of urban areas identified by the model co-evolve with the city, requiring policy regulation to be flexible and adaptive, acting just in time. The algorithmic implementation of the model is applicable to any built-up area and simple enough to pave the way for the automatic

classification of urban areas worldwide.

4.9.3. Presenting Author: Fernando Montani

Spike correlations: Beyond pairwise interaction models

Lisandro Montangie[1,2] and Fernando Montani[1,2]

[1] IFLYSIB, CONICET-Universidad Nacional de La Plata, La Plata, Argentina

[2]Departamento de Física, Facultad de Ciencias Exactas, UNLP Calle 49 y 115. C.C. 67 (1900), La Plata, Argentina

To understand how information is processed by the brain we need to investigate how information is encoded by the activity of a population of neurons. Despite providing an accurate description of the neurophysiological behavior of the neurons in the retina, pairwise interaction models do not always provide a realistic characterization of the population dynamics in the cortex, and higher order interactions should be taken into account. In this work, we present an information theoretical approach by means of an analytically solvable model to formally estimate spike correlations up to third order within maximum entropy principle. Furthermore, we apply the current formalism to study functional interactions underlying the neural code dynamics in healthy and unhealthy tissue.

4.9.4. Presenting Author: Arnaldo Gammal

Nonlinear Schrodinger flow past obstacles

A. Gammal

Universidade de Sao Paulo

We present the developments of Nonlinear Schroedinger flow past obstacles as a paradigm for quantum fluids, in contrast to classical fluids.

4.9.5. Presenting Author: M. A. Bab

Modeling the interfaces dynamics between magnetic domains obtained by heat-assisted magnetization reversal in high coercitive ultrathin films

M. A. Bab, S. M. Cotes, and G. P. Saracco

Insituto de investigaciones Fisicoquímicas Teóricas y Aplicadas, Univesidad Nacional de La Plata, CCT-La Plata CONICET

In order to develop high-density information recording devices with storage densities above terabits/cm^2, it is necessary to simultaneously achieve high thermal stability at operation

temperatures and high recording rates. However, for area data density above terabits/cm^2 the size of the bit approaches the superparamagnetic limit where the thermal fluctuations degrade the stability of the magnetization. Moreover, actual standard requirements for applications imply that a 95

4.9.6. Presenting Author: Omar Gustavo Zabaleta

Communications protocol based on the Quantum Minority Game

O.G. Zabaleta, J. P. Barrangú and C.M. Arizmendi

Depto. de Física, Facultad de Ingeniería, Universidad Nacional de Mar del Plata, Av. J.B. Justo 4302, 7600 Mar del Plata, Argentina

Wireless networks users make individual decisions regardless other users causing loss of information due to the interference produced by collisions or simultaneous transmissions. The minority game self-organization properties are suitable to model and solve limited resources sharing problems, such as those on sharing the scarce resource frequency spectrum. On the other hand, quantum communications have been shown to provide faster and safer ways than classical communications. Taking into account both, the minority game and quantum communications properties, we propose a quantum communication protocol based on the quantum minority game that enhances the present classical communi- cations protocols, diminishing collisions and avoiding the need torebroadcast. The proposed communication protocol may be applied to future quantum networks development and also to share resources in present networks.

4.9.7. Presenting Author: Federico Abellá

Interaction between moving spheres in a viscoelastic fluid

Federico Abellá, Daniel Freire, Cecilia Cabeza, Arturo C. Martí, and Gustavo Sarasúa

Instituto de Física, Universidad de la República, Montevideo, Uruguay

This work is an experimental study of the interaction between two spheres falling vertically along the axis joining their centers when submerged in a viscoelastic fluid. Particularly, it is centered in the interaction of ceramic spheres with diameters in the range of micrometers, falling in a polyacrylamide solution when the initial separation between their centers is varied. For each value of the initial separation, the distance between the centers is studied as a function of time through video acquisition. While for newtonian fluids and moderate initial separations, the second sphere approaches the first while falling due to a pathway of reduced viscosity, this is not the case in viscoelastic fluids. Instead, certain threshold values for the initial separation can be defined that set apart significantly different behaviours where the second sphere might approach the first, move away from it, or remain at the same distance. This is repeated for three different

concentrations of polyacrylamide, relating the threshold values with the rheological properties of the fluid.

4.9.8. Presenting Author: Ivana Carola Ramos

A pseudospectral method for Rayleigh-Bénard convection

Ivana C. Ramos[1,2] **and Carlos B. Briozzo**[1,2]

[1]FaMAF, UNC

[2]IFEG, CONICET

We present the adaptation to non-free boundary conditions of a pseudospectral method based on the (complex) Fourier transform. The method is applied to the numerical integration of the Oberbeck–Boussinesq equations in a Rayleigh– Bénard cell with no-slip boundary conditions for velocity and Dirichlet boundary conditions for temperature. We show the first results of a 2D numerical simulation of dry air convection at high Rayleigh number ($\boldsymbol{Ra} \sim \mathbf{10^9}$). These results are the base for the later study, by the same method, of wet convection in a solar still.

4.9.9. Presenting Author: Pamela Carolina Guruciaga

Spins vs. magnetic charges in spin ice: to what extent can the monopole picture describe these systems?

Pamela C. Guruciaga[1,2] **and Rodolfo A. Borzi**[1]

[1]Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas, CONICET-UNLP

[2]Instituto de Investigaciones Físicas de Mar del Plata, CONICET-UNMdP

Particles analogous to magnetic monopoles have been recently found - not in vacuum, but as collective excitations of a kind of frustrated magnetic materials known as spin ices. The ground states of these systems present a degeneracy that grows exponentially with their size, giving rise to a finite entropy even at zero degrees kelvin. A direct mapping between the spin degrees of freedom in spin ice and proton positions in conventional water ice makes their residual entropies identical (motivating the name of these magnetic materials).

Excitations of the multiple ground states are local defects in the magnetic structure, which interact approximately following a Coulomb law. They resemble non conserved magnetic charges, and hence their association with magnetic monopoles with four different types of charge: positive or negative, single or double. Therefore, the rotation of magnetic moments is equivalent to the creation, annihilation or translation of magnetic charge in a discrete lattice.

How far can we extend the analogy between these monopoles and conventional electric charges? May magnetic crystals (similar to ionic crystals) exist? To answer these and other questions we study spin ice systems, performing Monte Carlo simulations over two models: one with nearest-neighbour interactions between spins, and another taking into account the full long-range dipolar interactions. The non-trivial phase diagrams we find can be understood in

terms of the usual phases found in ionic systems. However, we will see that the mechanism leading to charge correlations is more subtle than a simple interaction between charges.

4.9.10. Presenting Author: Jose Francisco Gomes

Integrable Hierarchies, Solitons e Infinite Dimensional Algebras

J.F. Gomes[1], **G. Starvaggi Franca**[2], **and A.H. Zimerman**[1]
[1]Instituto de Fisica Teorica, IFT-Unesp, Sao Paulo, SP, Brazil
[2]Department of Physics, Cornell University, Ithaca, NY, USA

An algebraic construction for the mKdV hierarchy giving rise to time evolutions associated to graded Lie algebraic structure is proposed. New examples are given for negative even grades. The dressing method is modified in order to incorporate a non-trivial vacuum configuration and a deformed vertex operator for $\hat{sl}(2)$ is constructed to provide the systematic construction of explicit soliton solutions for the entire negative even grade equations.

4.9.11. Presenting Author: Everlin Carolina Ferreira da Silva

Study of technique of Magnetic Resonance for some applications aimed at Neurology and Neuroscience

E. C. F. Silva

Universidade Estadual Paulista "Júlio de Mesquita Filho", Campus Rio Claro

Magnetic resonance imaging (MRI), which is studied since 1938, is a technique used in medicine to produce high quality images from inside the human body. These images are produced non-invasively and without ionizing radiation. In addition, MRI is an extremely flexible technique, with which it is possible to produce images with different contrasts that provide different information about the anatomy, structure and function of the human body, and it is therefore one of the techniques preferred by radiologists. The phenomenon of MRI is based on the interaction of magnetic fields with the nuclear spins of the scanned sample. In this work a detailed study of the technique of magnetic resonance imaging is presented, with a description of the main features of the images produced by the technique and an analysis of its application to the fields of applications Neurology and Neuroscience.

4.9.12. Presenting Author: D'Angelo

Transverse and lateral confinement effects on the oscillations of a free cylinder in a viscous flow.

Luciano Gianorio [1], **M. Veronica D'Angelo** [1 2], **Mario Cachile** [1 2], **Jean-Pierre Hulin** [3], **and Harold Auradou** [3]

[1] Grupo de Medios Porosos, Facultad de Ingeniería, Paseo Colon 850, 1063, Buenos Aires (Argentina), [2] CONICET [3]Univ Pierre et Marie Curie-Paris 6, Univ Paris-Sud, CNRS, F-91405. Lab FAST, Bât 502, Campus Univ, Orsay, F-91405 (France).

The different types of instabilities of free cylinders (diameter D, length L) have been studied in a viscous flow (velocity U) between parallel vertical walls of horizontal width W at a distance H: the influence of the confinement parameters D/H and L/W has been investigated. The oscillations could be observed down to values of Re as low as 30: this is lower than usual values for vortex shedding in confined geometries, which suggests that one deal with a different instability mechanism. As D/H increases, there is a transition from stable flow to oscillations transverse to the walls and then to a fluttering motion with oscillations of the angle of the axis with respect to the horizontal. The two types of oscillations may be superimposed in the transition domain. The frequency f of the transverse oscillations is independent of the lateral confinement L/W in the range: $0.055 \leq L/W \leq 0.94$ for a given cylinder velocity V_{cx} and increases only weakly with V_{cx}. These results are accounted for by assuming a $2D$ local flow over the cylinder with a characteristic velocity independent of L/W for a given V_{cx} value. The experimental values of f are also independent of the transverse confinement D/H. The frequency f_f of the fluttering motion is significantly lower than f: f_f is also nearly independent of the cylinder diameter and of the flow velocity but decreases significantly as L/W increases. The fluttering instability is then rather a $3D$ phenomenon involving the full length of the cylinder and the clearance between its ends and the side walls.

4.9.13. Presenting Author: Bruno F. Venancio

Unveiling and exemplifying the unitary equivalence of discrete time quantum walk models

Bruno F. Venancio[1], Fabiano M. Andrade[2], and Marcos G. E. da Luz[1]

[1] Departamento de Física, Universidade Federal do Paraná, Curitiba-PR, Brazil
[2] Departamento de Matemática e Estatística, Universidade Estadual de Ponta Grossa, Ponta Grossa-PR, Brazil

The two major discrete time formulations for quantum walks, coined and scattering, are unitarily equivalent for arbitrary position-dependent transition amplitudes and any topology (Andrade et al 2009 Phys. Rev. 80 052301). Although the proof explicitly describes the mapping obtention, its high technicality may hinder relevant physical aspects involved in the equivalence. Discussing concrete examples—the most general constructions for the line, square and honeycomb lattices—here we unveil the similarities and differences of these two versions of quantum walks. We moreover show how to derive the dynamics of one from the other by means of proper projections. We perform calculations for different probability amplitudes such as, Hadamard, Grover, discrete Fourier transform and the uncommon in the area (but interesting) discrete Hartley transform, comparing the evolutions. Our study illustrates the models' interplay, an

important issue for implementations and applications of such systems.

4.9.14. Presenting Author: D.A Matoz-Fernandez

Nonmonotonic size dependence of the critical concentration in 2D percolation of straight rigid rods

D. A. Matoz-Fernandez, D. H. Linares, and A. J. Ramirez-Pastor

Departamento de Física, Instituto de Física Aplicada, Universidad Nacional de San Luis-CONICET, Ejercito de los Andes 950, D5700BWS San Luis, Argentina

Numerical simulations and finite-size scaling analysis have been carried out to study the percolation behavior of straight rigid rods of length $\boldsymbol{k}$ ($\boldsymbol{k}$-mers) on two-dimensional square lattices. The $\boldsymbol{k}$-mers, containing $\boldsymbol{k}$ identical units (each one occupying a lattice site), were adsorbed at equilibrium on the lattice. The process was monitored by following the probability $\boldsymbol{R_{L,k}(\theta)}$ that a lattice composed of $\boldsymbol{L \times L}$ sites percolates at a concentration $\boldsymbol{\theta}$ of sites occupied by particles of size $\boldsymbol{k}$. A nonmonotonic size dependence was observed for the percolation threshold, which decreases for small particles sizes, goes through a minimum, and finally asymptotically converges towards a definite value for large segments. This striking behavior has been interpreted as a consequence of the isotropic-nematic phase transition occurring in the system for large values of $\boldsymbol{k}$.

4.9.15. Presenting Author: Flora Souza Bacelar

A mathematical model for the effect of anti-angiogenic therapy in the treatment of cancer tumours by chemotherapy

S. T. R. Pinho[1], F.S. Bacelar[1], R. F. S. Andrade[1], and H. I. Freedman[2]

[1]Instituto de Física, Universidade Federal da Bahia, 40210-340, Salvador, Brazil

[2]Department of Mathematical and Statistical Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2G1

Neoplastic diseases are responsible for 12We present a model of cancer treatment, including anti-angiogenic drugs that help chemotherapy drugs for chemo-resistant tumors. We take into account competition between normal cells and cancer cells, as well as the growth of the population of endothelial cells associated with the angiogenic process, which helps tumor growth. In this way the model is constituted by a system of differential equations to simulate five interactions between normal cells, cancer cells, endothelial cells, and chemotherapeutic agent anti-angiogenic agent in tumor growth. For a partial analysis of the subspace free of cancer, is shown as the anti-angiogenic agent can help control cancer chemotherapy. This is illustrated by numerical examples and bifurcation diagrams. We proved the complete model is limited and dissipative also imposed the "hypothesis of cancer" to the case without treatment, or no treatment system progresses to a cancer state. Under this assumption, we prove that the anti-angiogenic therapy alone is not able to drive the system to a state of healing. However, the

tumor is more effectively reduced for combination therapy than for chemotherapy alone as noted for some types of tumors.

4.9.16. Presenting Author: Santiago Gil

Time series in film editing

Santiago Gil

Center for Complex Network Research, Northeastern University, USA

Within the practice and theory of filmmaking, the film medium is often thought of as a language. However, no consensus exists on how the specifics of that analogy are to be understood. In particular the idea of film grammar is rarely used as more than a metaphor. In a simple attempt to uncover underlying statistical principles of film editing I analyze time-series of shot lengths and look for measures of information content that can quantify syntactic consistencies across films.

4.9.17. Presenting Author: Centres, P. M.

Percolation of polyatomic species on a simpe cubic lattice

F. O. Sanchez-Varretti[1], G. D. Garcia[1], P. M. Centres[2], and A. J. Ramirez-Pastor[2]

[1] Universidad Tecnológica Nacional, Facultad Regional San Rafael, Gral J. J. De Urquiza 340, C. P. M5602GCH, San Rafael, Mza, Argentina

[2] Departamento de Física, Instituto de Física Aplicada, Universidad Nacional De San Luis-CONICET, Ejercito de Los Andes 950 - D5700HHW, San Luis, Argentina

In the present paper, the site-percolation problem corresponding to linear $\boldsymbol{k}$-mers (containing k identical units, each one occupying a lattice site) on a simple cubic lattice has been studied. The $\boldsymbol{k}$-mers were irreversibly and isotropically deposited into the lattice. Then, the percolation threshold and critical exponents were obtained by numerical simulations and finite-size scaling theory. The results, obtained for k ranging from 1 to 64, revealed that (i) the percolation threshold exhibits a decreasing function when it is plotted as a function of the $\boldsymbol{k}$-mer size; and (ii) the phase transition occurring in the system belongs to the standard 3D percolation universality class regardless of the value of $\boldsymbol{k}$ considered.

4.9.18. Presenting Author: Rene Orlando Medrano Torricos

Torsion-Adding in period-adding cascades: A new nonlinear phenomenon

E. S. Medeiros[1], R. O. Medrano-T.[2], I. L. Caldas[1], and S. L. T. de Souza[3]

[1]Instituto de Física, Universidade de São Paulo, São Paulo, Brasil

[2]Departamento de Ciências Exatas e da Terra, Universidade Federal de São Paulo, Brasil
[3]Departamento de Física e Matemática, Universidade Federal de São João del-Rei, Minas Gerais, Brasil

In parameter space of nonlinear dynamical systems, windows of periodic states are aligned following routes of period-adding configuring periodic window sequences. In state space of driven nonlinear oscillators, we determine the torsion associated with the periodic states and identify regions of uniform torsion in the window sequences. Moreover, we find that the measured torsion differs by a constant between successive windows in periodic window sequences. Finally, combining the torsion-adding phenomenon, reported in this work, and the known period-adding rule, we deduce a general rule to obtain the asymptotic winding number in the accumulation limit of such periodic window sequences.

4.9.19. Presenting Author: Olavo H. Menin

Solving the electrical impedance tomography inverse problem by generalized simulated annealing

Olavo H. Menin[1,2], Vanessa Rolnik[2], and Alexandre S. Martinez[2,3]
[1]Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Brazil
[2]Universidade de São Paulo, Brazil
[3] National Institute of Science and Technology in Complex Systems, Brazil.

Electrical impedance tomography (EIT) is a promising technique to obtain inner images of an object. Applying an electric potential pattern through electrodes on the object external surface and measuring the corresponding electric current on the same electrodes, the conductivity distribution inside the object is reconstructed computationally. Although the EIT technique presents several potential applications in medical and engineering area it presents technical difficulties. Indeed, mathematically the EIT image reconstruction is a well-known inverse and nonlinear problem. The EIT problem modeling is based on the boundary value problem (BVP) given by the partial differential equation $\vec{\nabla} \cdot \left(-\sigma \vec{\nabla} \phi\right) = 0$ with the boundary conditions, $\phi = \overline{\phi}$ and $-\sigma \partial\phi/\partial n = \overline{J}$, where ϕ is the electrical potential inside the domain Ω, σ is the conductivity distribution, $\overline{\phi}$ is the electrical potential applied on the boundary $\partial\Omega$ and $\overline{J}$ is the current flux on the same boundary. Among several approaches that have been purposed to address the EIT reconstruction image, a typical one is to treat it as an optimization problem. In this case, one must minimize an objective function $f(\sigma_{trial})$ which expresses the discrepancy between the actual current flux J_{actual} obtained experimentally and the numerical one J_{actual} obtained through solving the BVP considering a trial conductivity distribution σ_{trial} given by $f\left(\sigma_{trial}\right) = (1/N) \sum_i |J_{actual} - J_{num}|^2 + R$, where N is the number of electrodes and R is a suitable regularization function. The searching of the global minimum is carried out iteratively such that in the end of the process, the trial conductivity distribution that minimizes the objective function corresponds to the sought conductivity distribution σ_{actual}. Nevertheless, the roughness of the objective function landscape requires a powerful and robust optimization method to avoid that the searching ends in a local minimum basin. Our goal in this paper is to present an algorithm to solve the EIT reconstruction problem by the Generalized Simulated Annealing (GSA). Initially proposed by Tsallis and Stariolo, GSA is a stochastic optimization method based on the generalization of the Metropolis acceptance criteria $p(\sigma^{old} \rightarrow \sigma^{new}) = \min[1, \exp(-\Delta f/T_a)]$ and the Gaussian visitation distribution

$G(\Delta x) = \exp(-\Delta x^2/2T_v)/\sqrt{2\pi T_v}$, where $\Delta f = f(\sigma^{new}) - f(\sigma^{old})$, T_a is the acceptance temperature, Δx is the trial jump length and T_v is the visitation temperature which represents the distribution visitation variance. To solve the direct problem (BVP) for each trial conductivity distribution σ_{trial} we have chosen the Boundary Element Method (BEM) and to generate the q-Gaussian deviate, we have used the generalized Box-Muller method. We have performed numerical tests to address the performance of the algorithm and results show its accuracy and robustness.

Keywords: electrical impedance tomography; nonlinear problem, boundary element method; generalized simulated annealing.

4.9.20. Presenting Author: Daniel Fernandes Orsini

Comparison between some bipartite entanglement measures and a geometrical approach.

Daniel Fernandes Orsini and Marcos Gomes Eleuterio da Luz.

Departamento de Física, Universidade Federal do Paraná.

We compare in this work, numerically and analytically, some entanglement measures applied to bipartite pure systems. The measures are the following: the Q measure, by Meyer and Wallach, von Neumann Entropy, Linear Entropy and distance from an unantangled state. Besides that, we present a geometrical study, starting from the Q measure, that enables a visualization of the entanglement behavior in bipartite pure systems.

4.9.21. Presenting Author: Oscar Alejandro Pinto

Adsorption of binary mixtures with non-additive interactions: simulations and theoretical approximations

O. A. Pinto[1], P. M. Pasinetti[2], A. J. Ramirez-Pastor[2], and F. Nieto[2]

[1]Laboratorio de sistemas nano estructurados y electroquímica– CITSE - UNSE

[2]Instituto de física aplicada San Luis (CONICET) – UNSL

In the present work, the adsorption thermodynamics of binary mixtures has been studied by mean of Grand Canonical Monte Carlo simulations in the framework of a lattice gas model. Total and partial isotherms as well as differential heat of adsorption corresponding to each species have been calculated. We consider non-additive lateral interactions between particles, where the bonding energy of any atom is strongly dependent on the occupational state of the first coordination sphere. An interesting behavior has been observed and analyzed in terms of the low temperature ordered phases appearing in the system. Finally, the quasichemical

approximation was derived for the system, and the results compared with those obtained from simulation.

4.9.22. Presenting Author: Juliano A. de Oliveira

Scaling properties of the diffusion coefficient in a family of two-dimensional Hamiltonian mappings

Juliano A. de Oliveira1, Carl P. Dettmann[2], Diogo R. da Costa[3], and Edson D. Leonel[4]

[1] Univ. Estadual Paulista - UNESP, Câmpus São João da Boa Vista - São João da Boa Vista, SP, Brazil
[2] School of Mathematics, University of Bristol, Bristol, United Kingdom
[3] Instituto de Física da USP, Cidade Universitária, São Paulo, SP, Brazil
[4] Departamento de Física, Univ. Estadual Paulista - UNESP, Rio Claro, SP, Brazil

We consider a family of two-dimensional nonlinear area-preserving mappings that generalize the Chirikov standard map and model a variety of periodically forced systems. The action variable diffuses with increments whose phase is controlled by a negative power of the action and hence effectively uncorrelated for small actions, leading to a chaotic sea in phase space. For larger values of the action the phase space is mixed and contains a family of elliptic islands centered on periodic orbits and invariant KAM curves. The transport of particles along the phase space is considered by starting an ensemble of particles with a very low action and letting them evolve in the phase until they reach a certain height h. For chaotic orbits below the periodic islands, the survival probability for the particles to reach h is characterized by an exponential function, well modeled by the solution of the diffusion equation. On the other hand when h reaches the position of periodic islands, the diffusion slows markedly. We show that the diffusion coefficient is scaling invariant with respect to the control parameter of the mapping when h reaches the position of the lowest KAM island.

4.9.23. Presenting Author: P.M.M. Rocha

Invariant Solutions of the 2+1 dimensional Gross-Neveu Equations

P. M. M. Rocha[1], Faqir Khanna[2], A. E. Santana[1,3], and T. M. Rocha Filho[1,3]

[1]Instituto de Física, Universidade de Brasilia
[2]Physics Department, Theoretical Physics Institute, University of Alberta
[3] International Center for Condensed Matter Physics, Universidade de Brasilia

We apply Lie and nonclassical symmetry methods to partial differential equations in order to derive solutions of the Gross-Neveu model in d = (2 + 1) space-time dimensions. Nonclassical symmetries are determined and used to derive new solutions for the Gross-Neveu model. Finally, steps are taken to facilitate the incorporation of boundary conditions.

We utilize of a computer algebra system, SADE, to obtain symmetry generators and classical solutions to the Gross-Neveu equations in 2 space-time dimensions, namely

$$\left(i\gamma^{\mu}\partial_{\mu} - \lambda\left(\overline{\Psi}\Psi\right)\right)\Psi = 0 \tag{4.4}$$

where is a spinorial variable in 2 space time dimensions.

Non-classical symmetries, are used to obtain not yet known solutions to this spinor model in the specific case of $2 + 1$ dimensions. The method used to simplify and solve the determining system for nonclassical symmetries will be outlined, and a choice of ansatz will be justified in this case. The resulting symmetry generators will be utilized to obtain invariant solutions. Remarks about ways to incorporate boundary conditions into this specific case will also be made.

4.9.24. Presenting Author: Paola Concha

Evolución del entrelazamiento cuántico bajo una dinámica no Markoviana

P.C. Obando[1] and Adrian A. Budini[2]

[1]Instituto Balseiro, UnCuyo, Av. Bustillo Km 9.5 (8400), Bariloche

[2]Centro Atómico Bariloche, Av. Bustillo Km 9.5 (8400), Bariloche

Las interacciones con el ambiente inevitablemente degradan la coherencia cuántica y así el entrelazamiento. En el estudio del fenómeno de muerte súbita del entrelazamiento (ESD) [Yu and Eberly, Phys. Rev. Lett. , (2004)], se ha observado que aunque los elementos de matriz densidad (poblaciones y coherencias) decaen en forma monótona, la concurrencia puede anularse abruptamente en un tiempo finito. La evolución irreversible del entrelazamiento depende de los tipos de reservorios que actúan sobre el sistema.

Presentaremos los resultados obtenidos del estudio del fenómeno de muerte súbita del entrelazamiento considerando sistemas bipartitos que están acoplados a fluctuaciones no-Markovianas. Con el objetivo de analizar la evolución del entrelazamiento a este tipo de ambientes no-Markovianos. Se propone una dinámica que corresponde a sistemas acoplados a fluctuaciones correlacionadas. El sistema propuesto se estudia dentro de dos límites de interés y se analizan las características que estos deben presentar para que el fenómeno de muerte súbita ocurra.

4.9.25. Presenting Author: Pcentres P. M.

From single-file diffusion to two-dimensional cage diffusion and the generalization of TASEP to higher dimensions

P. M. Centres[1] and S. Bustingorry[2]

[1] Departamento de Física, Instituto de Física Aplicada, Universidad Nacional de San Luis-CONICET, Ejercito de Los Andes 950, D5700HHW, San Luis, Argentina

[2] CONICET, Centro Atómico Bariloche, 8400 San Carlos de Bariloche, Río Negro, Argentina.

In present work a two-dimensional constrained diffusion model is presented and characterized by numerical simulations. The model generalizes the one-dimensional single-file diffusion model not only by considering volume exclusion but including the cage constriction induced by the particles neighbors. Using numerical simulations we characterize the diffusion process and we particularly show that asymmetric transition probabilities lead to the two-dimensional Kardar-Parisi-Zhang universality class. Therefore this very simple model generalizes the one-dimensional totally asymmetric simple exclusion process to higher dimensions

4.9.26. Presenting Author: Bruno V. Ribeiro

Ornstein-Uhlenbeck limit for the velocity process of an N-particle system interacting stochastically

B. V. Ribeiro[1] and Y. Elskens[2]

[1]Instituto de Física, Universidade de Brasília, CP: 04455, 70919-970 - Brasília - DF, Brazil

[2]Equipe turbulence plasma, case 321, PIIM, UMR 7345 CNRS, Aix-Marseille université, campus Saint-Jérôme, FR-13397 Marseille cedex 13

We consider a 3-dimensional N-particle system with mass m and no potential energy. The interaction is modeled as random momentum exchange between particles, obeying conservation of energy. The dynamics of the system is given by a single stochastic differential equation for a $D = 3N$ dimensional velocity vector ($\mathbf{V}$) driven by a D-dimensional Brownian noise term. A quick look at this evolution equation shows us that a single component of $\mathbf{V}$ evolves independently of the remaining directions according to an one dimensional Ornstein-Uhlenbeck process driven by a single noise term along the same direction (corresponding to a particle moving in "white noise" with friction) , when this component is small enough. Our interest, however, is to study the limiting process for the components of $\mathbf{V}$ when these are of order one.

Let A be the noise amplitude and $k_B T/2$ be the total energy per degree of freedom. We thus consider the component V_1 of $\mathbf{V}$ and the component AB_1 of the noise term driving $\mathbf{V}$. Call U_1 the Ornstein-Uhlenbeck process driven by the noise AB_1 in a viscous bath with friction rate $mA^2/(k_B T)$. We prove that V_1 converges in probability to this U_1 as $N \to \infty$. The proof easily extends to any finite number $n(< 3N)$ of components of the velocity vector $\mathbf{V}$; these n components become independent and identically distributed (i.i.d.) in the limit $N \to \infty$. Furthermore, we show that our model relates to the class of Kac systems.

If we impose total momentum conservation, the three-dimensional velocities of individual particles converge in probability to independent three-dimensional Ornstein-Uhlenbeck processes as $N \to \infty$. Further, a change in velocity variables, proposed by Kiessling and Lancellotti, allows to analyse the N-particle system with total energy and momentum conservation in terms of a $(N-1)$-particle system with only energy conservation.

4.9.27. Presenting Author: Miguel Ré

Reaction rate in an evanescent random walkers system

M. Ré[1,2] and N. Bustos[2]

[1]Facultad Regional Córdoba, Universidad Tecnológica Nacional

[2]Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba

Diffusion mediated reaction models are particularly ubiquitous in the description of physical, chemical or biological processes. The random walk schema is an useful tool for formulating

these models. Recently evanescent random walk models have received attention to include finite lifetime processes. For instance activated chemical reactions, such as laser photolysis, exhibit a different asymptotic limit when compared with inmortal walker models.
It is presented here a diffusion limited reaction model based on an evanescent random walkers system. The absorption probability density and the reaction rate are analytically calculated in the Laplace domain for a continuous time random walk model on a lattice. A finite absorption rate is considered, a model usually referred to as imperfect trapping. Short and long time behaviours are analyzed. The results obtained are ilustrated by considering a one dimensional problem with consequent discussion.

4.9.28. Presenting Author: Bruno F. Venancio

Unveiling and exemplifying the unitary equivalence of discrete time quantum walk models

Bruno F. Venancio[1], Fabiano M. Andrade[2], and Marcos G. E. da Luz[1]

[1] Departamento de Física, Universidade Federal do Paraná, Curitiba-PR, Brazil
[2] Departamento de Matemática e Estatística, Universidade Estadual de Ponta Grossa, Ponta Grossa-PR, Brazil

The two major discrete time formulations for quantum walks, coined and scattering, are unitarily equivalent for arbitrary position-dependent transition amplitudes and any topology (Andrade et al 2009 Phys. Rev. 80 052301). Although the proof explicitly describes the mapping obtention, its high technicality may hinder relevant physical aspects involved in the equivalence. Discussing concrete examples—the most general constructions for the line, square and honeycomb lattices—here we unveil the similarities and differences of these two versions of quantum walks. We moreover show how to derive the dynamics of one from the other by means of proper projections. We perform calculations for different probability amplitudes such as, Hadamard, Grover, discrete Fourier transform and the uncommon in the area (but interesting) discrete Hartley transform, comparing the evolutions. Our study illustrates the models' interplay, an important issue for implementations and applications of such systems.

4.9.29. Presenting Author: Amanda Prina de Oliveira

Shrimp-like Structures in a 1-D Fermi accelerator model

A. O. Prina and E. D. Leonel

Universidade Estadual Paulista "Júlio de Mesquita Filho" - Rio Claro - São Paulo - Brasil

As a possible explanation for the origin of the high-energy cosmic rays, Enrico Fermi proposed that a charged particle can be accelerated by interactions with time-dependent magnetic structures which were know to exist in the space. A corresponding mechanical model that uses the basic Fermi's idea is called as Fermi-Ulam model (FUM). The model consists of a classical particle which is confined to bounce between two rigid walls. One of them is fixed (working as a returning mechanism) while the other one, assumed to be sufficiently massive, is moving

periodically in time. The dynamics is given by a two dimensional, non-linear mapping for the variables velocity and time immediately after the collision. For the non-dissipative dynamics, the phase space is mixed and contains a set of periodic islands, invariant spanning curves and a large chaotic sea. The existence of invariant spanning curves prevent the particle to exhibit unlimited energy growth (Fermi acceleration). The introduction of inelastic collisions lead to a fractional loss of energy of the particle upon collision. Therefore attractors appear in the phase space. For weak dissipation, the scenario shows a coexistence of many different periodic fixed points of sink type. On the other hand for strong dissipation, say a coefficient of restitution larger than 0.5, chaotic attractors are observed and a route to chaos via doubling period recovering Feigenbaum's critical exponents is observed. For this strong dissipation regime, the parameter space exhibits a set of shrimp-like structures. In this work we investigate the organization of such structures of shrimp-like type and show, among other things, routes to chaos via period adding.

4.9.30. Presenting Author: Finn Box

Torsional oscillations of a sphere in a viscous fluid: Magnetic forcing, dynamic response and generated flow.

F. Box, A. B. Thompson, and T. Mullin

Manchester Centre for Nonlinear Dynamics, University of Manchester, Oxford Road, Manchester, M13 9PL, UK

The torsional oscillations of a single free sphere in a Stokes flow are studied. The nonlinear response of the sphere to magnetic forcing is characterised in terms of the dimensionless forcing $\boldsymbol{F} = 8\pi\mu a^3\boldsymbol{\omega}$, which incorporates both the strength and frequency of the applied magnetic field. Comparisons between the experimentally observed and numerically determined angular displacement are found to be in excellent agreement. Visualisation of the flow generated by the small-angle, rotary motion of the sphere is then conducted using the Particle Image Velocimetry technique, and good agreement is also found between the observed and the analytically calculated fluid velocity.

4.9.31. Presenting Author: Diogo Ricardo da Costa

Dynamical properties for an ensemble of classical particles moving in a driven potential well with different time perturbation

D. R. da Costa[1,2], I. L. Caldas[1], and E. D. Leonel[3]

[1]Instituto de Física, Universidade de São Paulo, Rua do Matão, Cidade Universitária, 05314-970 São Paulo, SP, Brazil

[2]School of Mathematics, University of Bristol, Bristol BS8 1TW, United Kingdom

[3]Departamento de Física, UNESP – Universidade Estadual Paulista, Av. 24A, 1515, 13506-900 Rio Claro, SP, Brazil

We consider dynamical properties for an ensemble of classical particles confined to an infinite box of potential and containing a time-dependent potential well described by different nonlinear

functions. For smooth functions, the phase space contains chaotic trajectories, periodic islands and invariant spanning curves preventing the unlimited particle diffusion along the energy axis. Average properties of the chaotic sea are characterised as a function of the control parameters and exponents describing their behaviour show no dependence on the perturbation functions. Given invariant spanning curves are present in the phase space, a sticky region was observed and show to modify locally the diffusion of the particles.

4.10. Small systems

4.10.1. Presenting Author: Roberto Raúl Deza

Coupling-enhanced energy harvesting out of colored fat-tailed fluctuations

J. Ignacio Deza[1], **Horacio S. Wio**[2], **Roberto R. Deza**[3], and **Julián I. Peña Rosselló**[3]

[1]DONLL-UPC, Rambla Sant Nebridi s/n, Edifici Gaia-TR14, E-08222 Terrassa, Spain
[2]IFCA (U. of Cantabria and CSIC), Av. de los Castros s/n, E-39005 Santander, Spain
[3]IFIMAR (UNMdP and CONICET), Deán Funes 3350, B7602AYL Mar del Plata, Argentina

We propose a model nonlinear inertial device capable of harvesting energy from strongly self-correlated fat-tailed fluctuations through piezoelectric conversion, which can interpolate between square-well and harmonic-like behaviors. We study the interplay between the potential shape and the noise's spectrum and statistics, and show that 1) its output power increases with the departure from Gaussian statistics, 2) the overall performance is enhanced when an ensemble of such oscillators is coupled nearest-neighborwise but in an antiphase fashion. We also report a real experiment on an electronic analog of the proposed system.

4.11. Soft matter

4.11.1. Presenting Author: Daniel A. vega

Dynamic response of polymer networks with dangling molecules

Diana C. Agudelo[1], Enrique M. Vallés[1], Marcelo A. Villar[1], and Daniel A. Vega[2]

[1] Department of Chemical Engineering, Planta Piloto de Ingenieria Quimica, Universidad Nacional del Sur, CONICET, CC 717, 8000 Bahia Blanca, Argentina

[2] Department of Physics, Instituto de Física del Sur (IFISUR), Universidad Nacional del Sur, CONICET, Av. L.N. Alem 1253, 8000 Bahia Blanca, Argentina

The equilibrium and dynamic properties of cross-linked polymer networks are highly sensitive to the presence of dangling molecules. These imperfections that are unavoidable produced during a cross-linking reaction, alter the network connectivity and also affect the damping response of elastomers. Here the dynamics of pendant chains trapped in a cross-linked network is investigated using end-linked poly(dimethyl-siloxane networks with well defined structure. Model networks with linear bimodal pendant chains were prepared by the end-linking technique. These networks were characterized by the extraction of soluble material and rheology. While the equilibrium behavior of the network can be well described by a mean field theory for rubber elasticity, the terminal region follows a power law dependence in time. This dynamic response resembles the behavior random networks, where the relaxation modulus follows the empirical Chasset-Thirion equation. It was found that the long-time dynamic response of the networks was nearly insensitive the content of the pendant material but deeply influenced by the average molecular mass of these defects. The parameters in the Chasset-Thirion equation are related to the molecular structure of the network and the Rouse time of the pendant chains while the exponent in the power law is dictated by the weight average molecular weigh of the pendant material. In entangled linear polymers, the slow relaxational dynamics is dictated by the diffusion of the molecules along its own contour, a process known as reptation [Milner and McLeish, Phys. Rev. Lett., 81, 725, 1998]. Differently from linear chains, here the dangling molecules cannot reptate to recover equilibrium configurations and renew their configurations through a different mechanism, named arm retraction, in which the end of each arm independently retracts partway down its confining tube and then loose the memory of its early configuration reemerging along a different path [Vega et al., Phys. Rev. Lett., 95, 166002, 2005]. This process is entropically unfavorable and in the entangled regime the time scale for complete retraction increases roughly exponentially with the size of the branch.

4.11.2. Presenting Author: Daniel A. vega

Shape instabilities induced by defects in free standing two-dimensional crystals

Aldo D. Pezzutti and Daniel A. Vega

Instituto de Fısica del Sur (IFISUR), Consejo Nacional de Investigaciones Cientificas y Tecnicas (CONICET), Universidad Nacional del Sur, Av. LN Alem 1253, 8000 Bahıa Blanca, Argentina.

During the last decades the study of low-dimensional systems has been driven by different technological applications, ranging from soft matter and biophysics to electronics and nanotechnology. For example, quasi-two-dimensional films of block copolymers have been used as nanolithographic masks for pattern transfer and the synthesis of graphene, a two-dimensional crystal with unprecedented physical properties, has opened new horizons for science and technology. One of the main difficulties associated with these systems for practical applications is the lack of long-range order due to the presence of topological defects that often control key material properties. For example, the non-local disorder introduced by disclinations in smectic systems reduces the applicability to several nanodevices, and the fact that graphene is actually not flat but exhibits pronounced wrinkles into the third dimension was attributed to the presence of defects, like dislocations and grain boundaries. Here we study through a phase field model the coupling between the geometry and topological defects in free standing flexible membranes. To describe the dynamic of defects in a crystalline membrane we propose a minimal model that includes a Brazovskii Hamiltonian geometrically coupled to the topography of the membrane. We consider a membrane that at high temperatures is a disordered structureless deformable surface, with equilibrium properties dictated by a Helfrich-Canham Hamiltonian. The low-temperature phase is described through the Brazovskii model, where the fluid membrane phase separates into a buckled crystalline state with hexagonal symmetry. We observe that the coupling between the membrane geometry and the defects is determined by the topological charge and bending stiffness and surface tension. The overall dynamics and membrane configuration agrees remarkably well with recent experiments of aberration-corrected transmission electron microscopy on graphene containing arrays of dislocations [Lehtinen et al., Nature Communications 4, 2098, 2013].

4.11.3. Presenting Author: Nicolás A García

Defect dynamics and domain growth in 2D curved crystals

N. A. García[1], R. A. Register[2], D. A. Vega[1], and L. R. Gómez[1]

[1]Department of Physics, Universidad Nacional del Sur - IFISUR - CONICET, 8000 Bahía Blanca, Argentina

[2]Department of Chemical and Biological Engineering, Princeton University, Princeton, New Jersey 08544, USA

Curved crystalline structures are ubiquitous in nature. For example, they can be found in viral capsids, insect eyes, pollen grains, and radiolaria. During the last decade these crystals have attracted the interest of different communities because of the richness associated with the coupling between geometry, structure, and functionality. Recently, curved crystals have been obtained in a controlled fashion by the use of colloidal matter [W. T. M. Irvine et al., Nature, 2010; W. T. M. Irvine et al., Nat. Mater., 2012]. Other self-assembled systems with great potential to develop such structures are block copolymers and liquid crystals [N. Xie et al., Soft Matter, 2013]. In curved crystals, defects can be a feature of the fundamental (equilibrium) state. Depending on the substrate's topology and curvature, defects can be required to reduce lattice distortions and to satisfy topological constraints. Thus, from a condensed matter perspective, the presence of curvature in ordered phases appears as an opportunity for accurate control of the density and location of topological defects [D. R. Nelson et al., Nano Lett., 2002].

Although theoretical and experimental work has led to a substantial advance in the knowledge of equilibrium structures and features, the out-of-equilibrium dynamics leading to the formation of curved crystals, highly relevant for technological applications like defect functionalization engineering or soft lithography, remain almost unexplored.

In this work we study the processes leading to the formation of two-dimensional (2D) curved crystal structures. This crystallization process is found to strongly deviate from its counterpart in flat systems. The quenching of a liquid into a crystal phase leads to the formation of a curved polycrystalline structure, characterized by different domains of the crystal phase and the location of defect configurations with a net topological charge on regions of high curvature. In general, the formation of the crystal order starts in regions of low curvature, where the geometrically-induced frustration to form the lattice is reduced. Mechanisms of curvature-driven grain growth and defect annihilation lead to increasing crystalline order. Linear arrays of defects diffuse to regions of high curvature, where they are absorbed by free disclinations. At long times, grain boundaries may become pinned due to the local traps generated by high curvature regions, inducing the formation of stable but not fully equilibrated domain structures.

4.11.4. Presenting Author: Pablo Díaz

Dark soliton dynamics in a Fermi system

Pablo Díaz[1], **David Laroze**[2], and **Boris A. Malomed**[3]

[1]Departamento de Ciencias Físicas, Universidad de La Frontera, Casilla 54-D, Temuco, Chile
[2]Instituto de Alta Investigación, Universidad de Tarapacá, Casilla 7D, Arica, Chile
[3]Department of Physical Electronics, School of Electrical Engineering, Faculty of Engineering, Tel Aviv University, Tel Aviv IL-69978, Israel

We study collective behavior of Fermi gases in the framework of the mean-field description. Using a variational method, we derive effective dynamical equations for the one- and two-dimensional settings from the general three-dimensional mean field equation. The respective confinement is provided by trapping potentials with the cylindrical and planar symmetries, respectively. The resulting equations are non-polynomial Schrödinger equations coupled to equations for the local transverse size of the trapped states. Numerical simulations demonstrate close agreement of results produced by the underlying 3D equation and the effective low-dimensional ones [1]. In the one-dimensional case we found different soliton solutions. In absence of an external potential we find a dark solution state such that its width decreases exponentially when the transverse confinement increases. Also, when an harmonic potential is applied the dark solitons start to oscillate with a period which depends on the scattering parameter as well as the frequency of the potential.

References

[1] P. Díaz, D. Laroze, I. Schmidt, and B. A. Malomed, One- and two-dimensional reductions of the mean-field description of degenerate Fermi gases, 2012, J. Phys. B: At. Mol. Opt. Phys. 45 145304.

4.11.5. Presenting Author: Nelson Ramallo

Dynamic and Rheology of binary colloidal mixtures

N. J. Ramallo[1] and **A. J. Banchio**[1,2]

[1]Facultad de Matemática Astronomía y Física - Universidad Nacional de Córdoba

[2]Instituto de Física Enrique Gaviola de Córdoba, CONICET-UNC

The dynamical and rheological properties of well-characterized suspensions of spherically shaped colloidal particles have been studied in detail in recent years. While the properties of monodisperse hard-sphere suspensions have been investigated thoroughly both experimentally and theoretically, less is known about colloidal mixtures. In this kind of systems additional diffusion mechanics not present in monodisperse suspensions arise, such as inter- and tracer-diffusion. Also, properties well-known in monodisperse systems are strongly influenced by the new components' relative concentrations.

The aim of this work is to study the dynamical and rheological properties of colloidal mixtures, such as: tracer-diffusion, cooperative-diffusion, interdiffusion and viscoelasticity. With this purpose, a generalization of the mode coupling scheme (MCS) for monodisperse systems is used, regardless of hydrodynamic interactions. Where possible the results are compared with data form the literature.

4.11.6. Presenting Author: Mariano E. Brito

Gelation of diluted dipolar colloidal systems

M. E. Brito[1], M. A. Carignano[2], and V. I. Marconi[1,3]

[1]Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, Córdoba X5000HUA, Argentina.

[2]Qatar Environment and Energy Research Institute, Doha, Qatar.

[3]IFEG-CONICET, Córdoba X5000HUA, Argentina.

Dipolar colloidal systems, one of the simpler materials presenting anisotropic interactions, have attracted recent attention since their interactions are easy to control and represent a building block for the design of new soft materials. Using stochastic dynamics simulations we investigate the gelation process in a high dilute system of dipolar colloidal particles with implicit solvent. This system self assembles in a rich variety of structures, where we highlight three different regimes at very low packing fraction and decreasing temperature: fluid, string-fluid and string-gel. We perform simulations assuming a continuous model for the solvent in which the particles are embedded, and explicit particle-particle interactions. We present a phase diagram, density vs temperature, determined from thermodynamics and structural analysis. We characterize as well in detail the string-gel structure studying the topological defects as a function of the packing fraction, and the porosity versus both, temperature and dielectric constant. In addition we study the particular system slow dynamic behavior at very low temperature.

4.11.7. Presenting Author: Alexandre Penteado Furlan

Influence of the random porous media on anomalous properties in a continuous waterlike model

A. P. Fulrna, C. E. Fiore, and M. C. B. Barbosa

Universidade Federal do Rio Grande do Sul

Water exhibits thermodynamic, dynamic and structural anomalous properties when compared with other substances. While most liquids contract upon cooling, water expands below T=$4°C$ at ambient pressure, which characterize the density anomaly. Recently, confined water has been receiving a lot of attention due the its applications in industrial and biological systems. In this work, we study the effects of confinement of a waterlike model in random porous media. We employ molecular dynamics simulations in the canonical ensemble. The system exhibits two type of interaction: a particle-particle and particle-obstacle. We observe that in the presence of the matrix of fixed particles, the excluded volume effects decrease the inter particle distance, increase the first peak in the pair correlation function g(r) and decrease the second peak. In addiction our results showed that the interval in densities and temperatures where the anomalous behavior is present is contracted for all anomalous properties studied, t, s_2, Q_6 and diffusion D. In particular, the presence of fixed obstacles in the system forces a structuring of fluid and move the maximums and minimums in the translation order parameter to lower densities. The diffusion coefficient decreases substantially showing that the excluded volume effects are very important for dynamical behavior of waterlike liquids.

4.11.8. Presenting Author: Susana Hernández

Interfacial tension at the boundary line of films of superfluid helium

E. S. Hernández[1,2]

[1]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires

[2]Instituto de Física de Buenos Aires, UBA-CONICET

This work focuses on the structure of the interfaces occuring at the edge of inhomogeneities on a chemically patterned substrate, consisting of one or more different components. A typical example of such a material is a striped surface with alternating wettable and nonwettable adsorbers with respect to a given fluid. In such a case, the boundary tension is the interfacial energy cost that arises as a consequence of energy and entropy imbalance among the particles in the phases that meet at the boundary line. In this work I present data on structure and energetics of the interfacial profile between two half–films of liquid ^{4}He of nanoscopic spread, adsorbed on a chemically heterogeneous substrate consisting of two alkali metals. The theoretical frame involves the solution of a nonlinear, integro–differential Schrödinger– like equation derived from a finite temperature–finite range density functional that permits detailed calculations of adsorption isotherms of ^{4}He on semiinfinite planar substrates. The results are analysed in terms of chemical potential at film coexistence, relative transverse spread of the half films and difference between adsorbing strenghts of the components. It is found that the highest energy cost is associated to the disappearance of layers occurring on the strongest adsorber side.

4.11.9. Presenting Author: Leandro Batirolla Krott

Understanding dynamic and thermodynamic properties of a waterlike model confined between plates

L. B. Krott and M. C. Barbosa

Universidade Federal do Rio Grande do Sul

Water is one the most mysterious liquids. In addition to the well known density anomaly it has other 68 anomalous behaviors. The large increase of the response functions as the temperature is decreased let to the hypothesis of the existence of a liquid-liquid critical point. Due to the homogeneous nucleation this coexistence region is not observed experimentally. However, confining water is believe to be a good strategy to avoid the homogeneous nucleation. Considering that, raises the question: does confined water exhibit the same thermodynamic and dynamic properties observed in bulk water? In order to answer to this question we employed molecular dynamic simulations to study a core-softened potential of two length scales confined between hydrophobic plates. The two length scales model in the bulk presents some properties observed in water, like thermodynamic, dynamic and structural anomalous behavior, the vapor-liquid critical point (VCLP) and the hypothetical liquid-liquid critical point (LLCP). In this work we explore the pressure-temperature phase diagram of the model confined between two hydrophobic parallel plates. The molecular dynamics was done with 529 particles at NVT constant ensemble, where the Nosé-Hoover thermostat was used to keep fixed the temperature. The plates are formed by spherical particles in a square lattice and they are separated by a distance $\boldsymbol{d^* = 4.2}$, that results in particles structured in two or three layers, depending on the temperature and density considered. Trying to understand the changes in the properties of the system, we found that the LLCP and the waterlike anomalies are shifted to lower temperatures and higher pressures in relation to bulk, while the VLCP is shifted to lower temperatures and lower pressures. The solid-fluid transition will occur at different temperatures, depending on the intensity of the hydrophobicity of the plates. [1,2]

References

[1] L. B. Krott and M. C. Barbosa. ANOMALIES IN A WATERLIKE MODEL CONFINED BETWEEN PLATES. J. Chem. Phys., 138, 084505, 2013.

[2] L. B. Krott and J. R. Bordin. DISTINCT DYNAMICAL AND STRUCTURAL PROPERTIES OF A CORE-SOFTENED FLUID WHEN CONFINED BETWEEN FLUCTUATING AND FIXED WALLS. (Submitted)