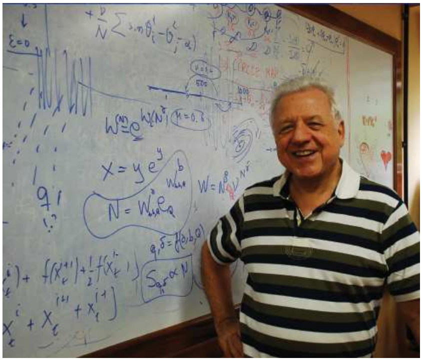
Complex Systems
Foundations and Applications

Scientific Program



Also: A celebration of the 70th birthday of Constantino Tsallis

CBPF - Rio de Janeiro - Brazil

From October 29 to November 1 – 2013

CNPq FAPERJ

The digital version of this book of abstracts can be downloaded at:

http://www.cbpf.br/~compsyst/index.php

Cover photo: C. Tsallis in his CBPF office, 2013, Rio de Janeiro, Brazil. Credits: J. Ricardo.

Foreword

Dear Colleagues,

We are very pleased to meet you here in CBPF, Rio de Janeiro, for the *Complex Systems – Foundations and Applications* conference. This will be an international event covering many topics in the area of complex systems, like nonlinear phenomena, econophysics, foundations and applications of non-extensive statistical mechanics, biological complexity, far-from-equilibrium phenomena, nonequilibrium in social and natural sciences, and interdisciplinary applications, among others. In this event, we will also celebrate the 70th birthday of Constantino Tsallis.

We wish you all a great conference.

André M. C. Souza (UFS)
Evaldo M. F. Curado (CBPF)
Fernando D. Nobre (CBPF)
Roberto F. S. Andrade (UFBA)

ORGANIZING COMMITTEE

Scientific Program

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‡Posters should be fixed before the morning section ($\sim$ 8:30 a.m.) and removed at the end of each day.</td></tr>
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	DAY I TUESDAY 29/10/2013	DAY II WEDNESDAY 30/10/2013	DAY III THURSDAY 31/10/2013	DAY IV FRIDAY 01/11/2013
08h00 – 09h00	**Registration**			
09h00 – 09h30	**Opening**	S. Canuto	H. J. Jensen	R. Dickman
09h30 – 10h00	H. Herrmann	A. Deppman	J. Naudts	R. Maynard
10h00 – 10h30	B. Cabral	A. R. Plastino	S. Umarov	F. L. Ribeiro
10h30 – 11h00	**Coffee Break**			
11h00 – 11h30	U. Tirnakli	A. Pluchino	P. Bourgine	S. Thurner
11h30 – 12h00	H. Suyari	S. D. Queirós	N. Kalogeropoulos	R. Hanel
12h00 – 12h30	A. S. Martinez	L. S. Lucena	J. S. Dehesa	A. Morais
12h30 – 14h30	**LUNCH**			
14h30 – 15h00	J. S. Andrade	A. Coniglio	R. Rossignoli	S. C. Ferreira
15h00 – 15h30	L. R. da Silva	G. P. Pavlos	R. S. Mendes	G. Ruiz
15h30 – 16h00	M. B. Ribeiro	L. Karakatsanis	R. Riera	O. A. Rosso
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16h30 – 17h00	A. Rapisarda	**POSTER SESSIONS**‡		R. Wedemann
17h00 – 17h30	A. R. Mesas	A. Robledo	**C. TSALLIS**	M. Barbosa
17h30 – 18h00	E. E. Vogel	G. C. Yalcin	**SPECIAL**	**Closure**
18h00 – 18h30	**Cocktail**		**TALK**	
20h00			**Dinner**	

All talks: 25 minutes (presentation) + 5 minutes (questions).

‡Posters should be fixed before the morning section (∼ 8:30 a.m.) and removed at the end of each day.

Day I – Tuesday – 29/10/2013

08:00h **Registration**

09:00h **Opening:** Fernando L. Freire Júnior & Fernando D. Nobre

Oral Communications Morning I

Chair: Fernando D. Nobre

09:30h Hans Herrmann – ETH Zürich/Switzerland & UFC/Ceará/Brazil
Fluids in curved space **34**

10:00h Benedito J. C. Cabral – ULisboa/Lisboa/Portugal
Hydrogen bond networks and electronic properties of complex systems **27**

10:30h **Coffee Break**

Oral Communications Morning II

Chair: Roberto F. S. Andrade

11:00h Ugur Tirnakli – Ege University/İzmir/Turkey
Central limit behaviour of dynamical systems: Emergence of q-Gaussians and scaling laws **59**

11:30h Hiroki Suyari – Chiba University/Japan
Combinatorial basis for Tsallis entropy and its applications **36**

12:00h Alexandre Souto Martinez – USP/São Paulo/Brazil
Ergodic transition in partially self-avoiding stochastic walks **21**

12:30h **LUNCH**

Oral Communications Afternoon I

Chair: Roger Maynard

14:30h José Soares de Andrade Jr. – UFC/Ceará/Brazil
Optimal synchronizability of bearings **38**

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Day I – Tuesday – 29/10/2013

15:00h Luciano R. da Silva – UFRN/Rio Grande do Norte/Brazil

The general preferential attachment growth model and nonextensive statistical mechanics **41**

15:30h Marcelo B. Ribeiro – UFRJ/Rio de Janeiro/Brazil

Testing the Goodwin growth-cycle macroeconomic dynamics in Brazil **43**

16:00h **Coffee Break**

Oral Communications Afternoon II

Chair: Celia B. Anteneodo

16:30h Andrea Rapisarda – UNICT/Catania/Italy

The beneficial role of random strategies in social and financial complex systems **23**

17:00h Antonio Rodríguez Mesas – UPM/Madrid/Spain

A scale-invariant probabilistic model based on Leibniz-like pyramids . . . **25**

17:30h Eugenio E. Vogel – UFRO/Temuco/Chile

Stock market variations by means of information theory **28**

18:00h **Cocktail**

Day II – Wednesday – 30/10/2013

Oral Communications Morning I

Chair: Stefan Thurner

10:30h **Coffee Break**

Oral Communications Morning II

Chair: Andrea Rapisarda

12:30h **LUNCH**

Oral Communications Afternoon I

Chair: Henrik J. Jensen

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Day II – Wednesday – 30/10/2013

15:00h Georgios P. Pavlos – DUTH/Thrace/Greece
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15:30h Leonidas P. Karakatsanis – DUTH/Thrace/Greece
Earth's climate complexity **39**

16:00h **Coffee Break and POSTER SESSION**

Oral Communications Afternoon II

Chair: Allbens P. F. Atman

17:00h Alberto Robledo – UNAM/Mexico City/Mexico
Incidence of Tsallis statistics in rank distributions **19**

17:30h G. Cigdem Yalcin – Istanbul University/Turkey
Environmental aspects of superstatistics: Temperature **33**

Day III – Thursday – 31/10/2013

Oral Communications Morning I

Chair: Jeferson J. Arenzon

09:00h Henrik Jeldtoft Jensen – Imperial College London/UK

09:30h Jan Naudts – University of Antwerp/Belgium

10:00h Sabir Umarov – UNH/Connecticut/United States

10:30h **Coffee Break**

Oral Communications Morning II

Chair: Angel R. Plastino

11:00h Paul Bourgine – École Polytechnique/Paris/France

11:30h Nikos Kalogeropoulos – WCMC-Q/Doha/Qatar

12:00h Jesús Sánchez-Dehesa – UGR/Granada/Spain

12:30h **LUNCH**

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Day III – Thursday – 31/10/2013

Oral Communications Afternoon

Chair: Marcia C. Barbosa

16:00h **Coffee Break and POSTER SESSION**

Special Talk

Chair: Evaldo M. F. Curado

20:00h **Dinner**

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Oral Communications Morning I

Chair: José S. Andrade Jr.

10:30h **Coffee Break**

Oral Communications Morning II

Chair: Benedito Cabral

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Oral Communications Afternoon I

Chair: Ronald Dickman

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15:30h Osvaldo A. Rosso – UFAL/Alagoas/Brazil & UBA/B. Aires/Argentina
Distinguishing noise from chaos: an Information Theory approach **45**

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Oral Communications Afternoon II

Chair: Ugur Tirnakli

16:30h Roseli S. Wedemann – UERJ/Rio de Janeiro/Brazil
Some properties of memory retrieval in an associative memory neural network for conscious and unconscious mental behavior **52**

17:00h Marcia C. Barbosa – UFRGS/Rio Grande do Sul/Brazil
Enhancement flow in nanoconfined water **44**

17:30h **Closure**

POSTER SESSION

Day II – Wednesday – 30/10/2013

Chair: Luciana A. Rios

POSTER SESSION

Day III – Thursday – 31/10/2013

Chair: Ernesto P. Borges

Abstracts: Oral Communications

Non-extensive self-consistency in hadronic medium

Airton Deppman

Universidade de São Paulo (USP) – São Paulo – Brazil

The high energy experiments have provided us with many data which has confirmed that a tail-like distribution, as that which follows from the Tsallis statistics, can describe the transversal momentum, p_T, distributions. Nonetheless, the use of non-extensive statistics remains a rather controversial subject.

The non-extensive self-consistent theory recently proposed [**1**] predicts that hot hadronic matter should present a limiting effective temperature and a limiting entropic index. Also, it predicts that the p_T-distribution at high energy collision should be described by the expression

$$\frac{d^2N}{dp_T\,dy} = gV\frac{p_T m_T \cosh y}{(2\pi)^2}\left(1+(q-1)\frac{m_T\cosh y-\mu}{T}\right)^{-\frac{q}{q-1}}, \qquad (1)$$

which is somewhat different from the most used expression for fitting experimental data [**2**], and that the cumulative hadron mass spectrum should be given by [**3**]

$$\begin{aligned} r(m) &= \int_o^m \rho(m')dm' = \\ &= \frac{-2\gamma}{3}m^{-3/2}\,{}_2F_1\left(-\frac{3}{2},-\frac{1}{q-1};-\frac{1}{2};-(q-1)\beta m\right)+k\,. \end{aligned} \qquad (2)$$

It will be shown that existing experimental data for p_T distributions and for observed hadron states give support to the theory [**4**], and therefore show that the non-extensivity passes the restrictive test mentioned above. With these results one can obtain a complete description of the thermodynamics for hadronic systems at high temperatures. Some thermodynamical functions are calculated and compared with lattice-QCD results.

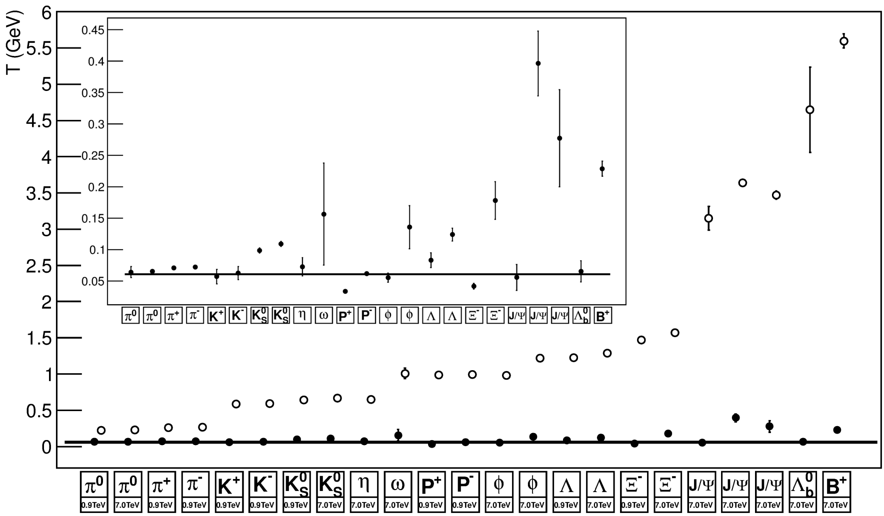

Figure 1: Effective temperature, T, resulting from the fittings of Eq. (1) (full symbols) and from the usual expression for fittings **[2]** (open symbols). The inset shows the effective temperature obtained through the use of Eq.(1) in more details. Full lines indicate the constant value, T_o, which best fits the data obtained with Eq. (1) assuming $y = 0$ and $\mu = 0$.

[**1**] A. Deppman, *Physica A* **391** 6380–6385 (2012);
[**2**] J. Cleymans, D. Worku, *J. Phys. G: Nucl. Part. Phys.* **39**, 025006 (2012);
[**3**] L. Marques, E. Andrade-II, A. Deppman, arXiv:1210.1725;
[**4**] I. Sena, A. Deppman, accepted for publication in *Eur. Phys. J. A* (2013) – arXiv:1208.2952v1.
Email address: `adeppman@gmail.com`.

Incidence of Tsallis statistics in rank distributions

G. Cigdem Yalcin[1] & Alberto Robledo[2,†]

[1]Department of Physics, Istanbul University – Istanbul – Turkey

[2]Instituto de Física, Universidad Nacional Autónoma de México (UNAM) – Ciudad de México – Mexico

We show that both size-rank and frequency-rank distributions observed in a limitless number of instances in a widespread family of systems, astrophysical, geophysical, ecological, biological, technological, urban, social, and human, obey Tsallis statistics. The theoretical framework for these distributions is analogous to that of a nonlinear iterated map near a tangent bifurcation for which the Lyapunov exponent is negligible or vanishes. The relevant statistical-mechanical expressions are derived from a maximum entropy principle and the resulting duality of entropy indexes is seen to portray physically relevant information. †Email address: `robledo@fisica.unam.mx`.

Noise, synchrony and correlations at the edge of chaos

Alessandro Pluchino[1,2] & Andrea Rapisarda[1,2] & Constantino Tsallis[2,3]
[1]Dipart. di Fisica e Astronomia, Università di Catania (UNICT) & INFN sezione di Catania – Catania – Italy
[2]Centro Brasileiro de Pesquisas Fisicas (CBPF) & National Institute of Science and Technology for Complex Systems (INCT-SC) – Rio de Janeiro – Brazil
[3]Santa Fe Institute (SFI) – New Mexico – USA

Since the nonlinear phenomenon of synchronization was first observed and discussed in the 17th century by Huygens, it has become of fundamental importance in various fields of science and engineering. It is frequently observed in complex systems such as biological ones, or single cells, physiological systems, organisms and even populations. Synchrony among coupled units has been extensively studied in the past decades providing important insights on the mechanisms that generate such an emergent collective behavior [**1,2,3**]. In this context coupled maps have often been used as a theoretical model [**4**]. Actually, many biological complex systems operate in a noisy environment and most likely at the edge of chaos [**5**]. Therefore studying the effect of a weak noise in this kind of coupled systems could be relevant in order to understand the way in which interacting units behave in rea l complex systems like for example living cells [**6,7**]. In previous studies [**8,9**] the effect of a small noise on globally coupled chaotic units was presented for several kind of systems and a universal behavior related to the Lyapunov spectrum was found to be a common feature. Power-law correlations and intermittent behavior have also been observed in lattices of logistic maps when some kind of global coupling exist among them [**10,11**]. In this talk we consider the effect of a weak random additive noise in a linear chain of N locally-coupled logistic maps at the edge of chaos [**12**]. Maps tend to synchronize for a strong enough coupling, but if a weak noise is added, very intermittent fluctuations in the returns time series are observed. This intermittency tends to disappear when noise is increased. Considering the pdfs of the returns, we observe the emergence of fat tails which can be satisfactorily reproduced by q-Gaussians curves typical of nonextensive statistical mechanics. Interoccurrence times of these extreme events are also studied in detail. Similarities with recent analysis of financial data are also discussed.

[**1**] S. H. Strogatz, *Sync: The Emerging Science of Spontaneous Order*, (Hyperion Books, 2004);
[**2**] A. Pikovsky, M. Rosenblum, J. Kurths, *Synchronization. A Universal Concept in Nonlinear Sciences*, (Cambridge University Press, Cambridge, 2001);
[**3**] Y. Kuramoto, *Chemical Oscillations, Waves and Turbulence*, (Springer, New York, 1984);
[**4**] K. Kaneko, *Simulating Physics with Coupled Map Lattices*, (World Scientific, Singapore, 1990);
[**5**] C. Langton, *Physica D* **42**, 12 (1990);
[**6**] D. Stokic, R. Hanel, S. Thurner, *Phys. Rev. E.* **77**, 061917 (2008);
[**7**] R. Hanel, M. Pöchacker, M. Schölling, S.Thurner, *Plos One* **7**, e36679 (2012);
[**8**] T. Shibata, T. Chawanya and K. Kaneko, *Phys. Rev. Lett.* **82**, 4424 (1999);
[**9**] J. Teramae, Y. Kuramoto, *Phys. Rev. E* **60**, 036210 (2001);
[**10**] N.B. Ouchi, K. Kaneko, *Chaos* **10**, 359 (2000);
[**11**] C. Li, J. Fang, *IEEE* 0-7803-8834-8/05 (2005);
[**12**] A. Pluchino, A. Rapisarda, C. Tsallis, *Phys. Rev. E* **87**, 022910 (2013).

Ergodic transition in partially self-avoiding stochastic walks

Juliana M. Berbert & Rodrigo S. Gonzalez & Alexandre S. Martinez
Universidade de São Paulo (USP) – São Paulo – 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 transition from local to global exploration is present 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 transition, obtained computationally, between exploration schemes, characterized yet, by the trajectory size (N_p) (aging effect). For an analytical approach, we consider the modified stochastic version in d dimensions, where the parameter T plays the role of a maximum hopping distance. This modification allows us to obtain a general analytical expression for the transition, as function of the parameters μ, T and N_p. These results have been validated by numerical experiments and may be of great use fixing optimal parameters in search algorithms.

Coin state properties in quantum walks

André M. C. Souza[1,3] & Roberto F. S. Andrade[2,3]
[1]Universidade Federal de Sergipe (UFS) – Sergipe – Brazil
[2]Universidade Federal da Bahia (UFBA) – Bahia – Brazil
[3]National Institute of Science and Technology for Complex Systems (INCT-SC) – Rio de Janeiro – Brazil

Recent experimental advances have measured individual coin components in discrete time quantum walks, which have not received the due attention in most of the theoretical studies on the theme. Properties of M, the difference between square modulus of coins states are investigated for a particle undergoing a discrete walk on a finite linear chain. Local expectation values are evaluated in terms of the real and imaginary part of the Fourier transformed wave function. A simple expression is found for the average difference between coin states in terms of an angle θ gauging the coin operator and its initial state. These results are corroborated by the numerical integration of the dynamical equations in real space. The local dependence is characterized both by large and short period modulations. The richness of the revealed patterns suggests that the amount of information stored and retrieved from quantum walks is signicantly enhanced if M is taken into account.

The beneficial role of random strategies in social and financial complex systems

Alessio Emanuele Biondo[1] & Alessandro Pluchino[2] & Andrea Rapisarda[2] & Dirk Helbing[3]

[1]Dipart. di Economia e Impresa, Universitá di Catania (UNICT) – Catania – Italy

[2]Dipart. di Fisica e Astronomia, Università di Catania (UNICT) & INFN sezione di Catania – Catania – Italy

[3]Eidgenössische Technische Hochschule Zürich (ETH Zürich) – Zürich – Switzerland

In physics, noise and randomness are usually restricted to be as low as possible in order to avoid any influence on the phenomena under examination. Actually, this is not often possible and one has to live with noise, but, random noise is not always so annoying as one might think intuitively. In fact there are many examples where randomness has been proven to be extremely useful and beneficial. On the other hand, in the last years, there has been an increasing interest in social complex phenomena by the physics community. In this talk we focus our attention on the beneficial role of random strategies in social sciences by means of simple mathematical and computational models. We briefly review recent results obtained by two of us in previous contributions for the case of the Peter principle [**1,2**] and the efficiency of a Parliament [**3**]. Then, we address a new application of random strategies to the case of financial trading and dis cuss in detail our findings about markets dynamics. Our results clearly show that the performance of random strategies in predicting the evolution of the markets is, on average and in the long term, quite similar to that of traditional approaches, but its variability on a small time scale is much lower. On the other hand, random strategies, used not only at an individual level but also at a global scale, may also be able to avoid herding effects among investors and, consequently, can reduce the probability of dangerous "avalanche effects" that have been among the main causes of the dramatic recent collapses of financial markets [**4,5**].

[**1**] A. Pluchino, A. Rapisarda, C. Garofalo, The Peter principle revisited: a computational study, *Physica A* **389**, 467 (2010),
see also `http://oldweb.ct.infn.it/cactus/peter-links.html`;

[**2**] A. Pluchino, A. Rapisarda, C. Garofalo, Efficient promotion strategies in hierarchical organizations, *Physica A* **390**, 3496 (2011);
[**3**] A. Pluchino, C. Garofalo, A. Rapisarda, S. Spagano, M. Caserta, Accidental politicians: how randomly selected legislators can improve Parliament efficiency, *Physica A* **390**, 3944 (2011),
see also `http://www.pluchino.it/Parliament.html`;
[**4**] A. E. Biondo, A. Pluchino, A. Rapisarda, The beneficial role of random strategies in social and financial systems, *J. Stat. Phys*, **151**, 607 (2013);
[**5**] A. E. Biondo, A. Pluchino, A. Rapisarda, D. Helbing, Are random trading strategies more successful than technical ones?, *PLOS ONE* **8**(7), e68344 (2013), see also `http://www.pluchino.it/financial-markets.html`.

MaxEnt and von Bertalanffy's growth processes

Angel Plastino
Universidad Nacional de La Plata (UNLP) – La Plata – Argentina

In this communication show how to introduce dynamical information into the MaxEnt principle so as to deal with von Bertalanffy's growth processes, thus extending results concerning power-laws with exponential cutoffs. von Bertalanffy's is the most widely used growth curve, being especially important in fisheries studies.

Aspects of the NRT nonlinear Schroedinger equation

Angel Ricardo Plastino
Universidad Nacional Noroeste (UNNOBA) – Buenos Aires – Argentina

We explore various aspects of the nonlinear Schrodinger equation recently advanced by Nobre, Regio-Montero, and Tsallis (NRT), based on Tsallis q-thermo-statistical formalism. We investigate some symmetries of this equation, leading to new analytical solutions. A pilot-wave approach to the NRT equation is also discussed.

Cell theory for the glass transition

Antonio Coniglio
University of Naples "Federico II" – Naples – Italy

Many theories have been proposed in the past years to explain the phenomenology associated to the glass transition. These include, among others, the free volume theory, the cooperative rearranging regions, the mode coupling theory, inherent structures, random first order transitions. These theories are not necessarily in contradiction with each other, but each catches some aspect of the glass transition. Here I will present a new approach, recently developed with Tomaso Aste, that combines some ideas of these previous theories, together with new concepts, originally introduced by Costantino Tsallis in his novel extension of the statistical mechanics entropy. The consequences of the theory will be discussed and compared with experimental and numerical results.

A scale-invariant probabilistic model based on Leibniz-like pyramids

Antonio Rodríguez Mesas[1] & Constantino Tsallis[2]
[1]Dpto. de Matemática Aplicada y Estadística, Universidad Politécnica de Madrid (UPM) – Madrid – Spain
[2]Centro Brasileiro de Pesquisas Físicas (CBPF) & National Institute of Science and Technology for Complex Systems (INCT-SC) – Rio de Janeiro – Brazil

We introduce a family of probabilistic *scale-invariant* Leibniz-like pyramids and (d)-dimensional hyperpyramids ($d = 1, 2, 3, ...$), with $d = 1$ corresponding to triangles, $d = 2$ to (tetrahedral) pyramids, and so on. For all values of d, they are characterized by a parameter $\nu > 0$, whose value determines the degree of correlation between N (d)-valued random variables ($d = 1$ corresponds to binary variables, $d = 2$ to ternary variables, and so on). There are $(d)^N$ different events, and the limit $\nu \to \infty$ corresponds to independent random variables, in which case each event

has a probability $1/(d)^N$ to occur. The sums of these N (d)-valued random variables correspond to a $d-$dimensional probabilistic model, and generalizes a recently proposed one-dimensional ($d = 1$) model having $q-$Gaussians (with $q = (\nu - 2)/(\nu - 1)$ for $\nu \in [1, \infty)$) as $N \to \infty$ limit probability distributions for the sum of the N binary variables [A. Rodríguez *et al*, *J. Stat. Mech.* P09006 (2008); R. Hanel *et al*, *Eur. Phys. J. B* **72**, 263 (2009)]. In the $\nu \to \infty$ limit the $d-$dimensional multinomial distribution is recovered for the sums, which approach a $d-$dimensional Gaussian distribution for $N \to \infty$. For any ν, the conditional distributions of the $d-$dimensional model are shown to yield the corresponding joint distribution of the $(d-1)$-dimensional model with the same ν. For the $d = 2$ case, we study the joint probability distribution, and identify two classes of marginal distributions, one of them being asymmetric and scale-invariant, while the other one is symmetric and only asymptotically scale-invariant. The present probabilistic model is proposed as a testing ground for a deeper understanding of the necessary and sufficient conditions for having q-Gaussian attractors in the $N \to \infty$ limit, the ultimate goal being a neat mathematical view of the causes clarifying the ubiquitous emergence of q-statistics verified in many natural, artificial and social systems.

Self-organised fractal corrosion in heterogeneous solids

Apiano Morais

Universidade Regional do Cariri (URCA) – Ceará – Brazil

In this study I investigated through a new mathematical model and computer simulations the generalized corrosion process in which a solid is in contact with an agressive solution. In this model the solid is identified in a rectangular lattice with L sites in width and infinity in length, with periodic conditions in width. Each site is assigned a property of resistance to corrosion r that in this work is distributed randomly $[0, 1]$, where the unitary value stands for maximum resistance. In an initial step the agressive particles, Q, of the solution are distributed over a volume V_0 and I assume the agressiveness p is proportional to the concentration of

particles. The portion of the solid in contact with the solution may be corroded if $p(t) > r_i$. As many sites are corroded the volume of the solution increases and the concetration decreases. The agressiveness is obtained as $p(t) \equiv \left[1\frac{\gamma}{L}N(t)\right]^{-1}$ with N standing for the number of corroded sites. The dynamics of the system evolves until a spontaneous stop. An infinity cluster emerges and we identify it as the final corrosion front. The final fronts present fractal dimensions in the range 1.33 to 1.75. The average width of the final front depends on γ in a power-law fashion, as well as the final agressiveness. Also, we found a hardening of the final front as γ decreases.

Hydrogen bond networks and electronic properties of complex systems

Benedito J. C. Cabral†

Grupo de Física Matemática, Universidade de Lisboa (ULisboa) – Lisboa – Portugal

The structure and electronic properties of the hydrogen bond (HB) networks of polar liquids are investigated by carrying out sequential quantum mechanics/Born-Oppenheimer molecular dynamics (BOMD). Emphasis is placed on liquid hydrogen fluoride (HF) [**1**] and hydrogen cyanide (HCN) [**2**]. These systems may form HB networks with a rich topological structure consisting of polymerized chains, ramified, and cyclic aggregates. HCN is also a prebiotic and extraterrestrial species closely related to the origin of life. The theoretical approach relies on the calculation of the electronic properties using configurations generated by BOMD. We put some emphasis on the possibility to carry out ab initio calculations for the electronic properties in the liquid phase by coupling many-body energy decomposition schemes [**3**] to BOMD configurations.

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Theoretical physics: Crossroads of truth and beauty

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Stock market variations by means of information theory

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Information theory has proven to be useful to understand different phenomena. In particular data compressor techniques have allowed to recognize and characterize magnetic transitions [**1**]. In the present contribution we consider the use of these techniques in econophysics, to explore the variations, or degree of agitation, of the stock markets indicators showing that information theory can help to recognize different regimes. Actually the onset of the different regimes can be established after some time measured in minutes which could allow to prevent extreme loses in the market. We begin by introducing improvements to data compressor wlzip reported in the reference above. On one hand, we recognize that wlzip allows for two different and simultaneous measurements: *a) diversity,* which accounts for the number of visited states during the evolution of the system in any time window; b) *mutability,* which measures the agitation of the system changing among the possible states. On the other hand we introduce a mechanism for rounding off truncations while doing the compression which allows to concentrate on the significant digits for each different application. We illustrate the technique with the well known ferromagnetic to paramagnetic transitions of the Edwards-Anderson model in 2D and in 3D. Then we move onto the main Chilean stock market, namely, Bolsa de Comercio de Santiago (BCS). The main indicator here is IPSA, whose values are reported every minute. We choose for this study the year 2010 because on February

10, 2010 a huge earthquake of magnitude 8.8 in the Richter scale, the sixth largest earthquake ever recorded by human instruments, followed by a large tsunami, shook most of Chilean territory and flooded several cities at the sea shore. Hundreds of lives were lost and the impact in the economy was large. How was this detected by the BCS? Our results include the report on the daily closing values of IPSA, daily values for mutability, diversity and profitability, possible correlations among these variables, average tendencies of mutability along the hours of the day (not all hours are the same), dependence on foreign stock markets, dynamic behavior of mutability for different time windows, definition of a new indicator (*sensitivity*) capable of anticipating large changes in the stock markets and possible criteria to tune sensitivity as a tool for stock market operations.

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A non-phenomenological model to explain population growth behaviors

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Will be proposed a non-phenomenological model for population growth based on the interaction between the individuals which compose the system. Will be considered that the individuals interacting by cooperation and competition. As consequence of this interaction will be showed that some well-known phenomenological population growth (as Malthus, Verhulst, Gompertz, Richards, Von Foerster, and power-law growth models) are reached as particular cases. Moreover other ecological behaviors can be seem as an emergent behavior of such interaction. For instance the Allee effect, which is the characteristic of some population to increase the population growth rate at small population size. While the models presented in the literature explain the Allee effect by phenomenological ideas, the model that will be presented explain such effect by the own interaction between the individuals. The model will be confronted

with empirical data in order to justify its formulation. Other interesting macroscopic emergent behavior from the model proposed is the observation of a regime of population divergence at finite time. It is interesting that such characteristic is observed in the human global population growth. Will be shown that in regime of cooperation, the model fit very well to the human population growth data since year 1000 A.D. up to the nowadays.

Universality of Tsallis non-extensive statistics and time series analysis: Theory and applications

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Near thermodynamic equilibrium statistics and dynamics are two separated but fundamental elements of the physical theory. Also, at thermodynamical equilibrium, nature reveals itself as a Gaussian and macroscopically uncorrelated process simultaneously with unavoidable or inevitable and objective deterministic character. However, modern evolution of the scientific knowledge reveals the equilibrium characteristics of the physical theory as an approximation or the limit of a more synthetic physical theory which is characterized as complexity. The new physical characteristics of complexity theory can be manifested as a physical system is driven in far from equilibrium states. Generally, the traditional scientific point of view is the priority of dynamics over statistics. That is dynamics creates statistics. However for a complex system the holistic behaviour does not permit easily such a simplification or division of dynamics and statistics. From this point of view Tsallis statistics and fractal or strange kinetics are two faces of the same complex and holistic (non-reductionist) reality. As Tsallis statistics is an extension of Boltzmann-Gibbs statistics, we can support that the thermal and the dynamical character of a

complex system are the manifestation of the same physical process which creates extremized thermal states (extremization of Tsallis entropy), as well as dynamically ordered states. From this point of view the Feynman path integral formulation of the statistical physical theory and of the quantum probabilistic theory indicates the indivisible thermal and dynamical character of physical reality. After Heisenberg's revolutionary subst itution of physical magnitudes by operators and the following probabilistic interpretation of Heisenberg operationalistic concepts and Schrodinger wave functions done by Max Born, probability obtained clearly a new realistic and ontological character concerning the foundation of physics. Moreover, the development of complexity theory caused the extension of the probabilistic character of dynamics from microscopic (quantum theory) to macroscopic (classical theory) level of reality. This showed the deeper meaning of the Boltzmann entropy principle through the fractal extension of dynamics, as well as the q-extension of statistics according to Tsallis non-extensive entropy theory. Modern evolution of physical theory, as it was described previously, is highlighted in Tsallis q-generalization of the Boltzmann-Gibbs (B-G) statistics which includes the classical (Gaussian) statistics, as the $q = 1$ limit of thermodynamical equilibrium. Far from equilibrium, the statistics of the dynamics follows the q-Gaussian generalization of the B-G statistics or other more generalized statistics. At the same time, Tsallis q-extension of statistics is related to the fractal generalization of dynamics. However, for complex systems, their holistic behaviour does not easily permit such a simplification and division of dynamics and statistics. The Tsallis extension of statistics and the fractal extension of dynamics as strange kinetics are two faces of the same complex and holistic (non-reductionist) reality. Moreover, the Tsallis statistical theory including the Tsallis extension of entropy to what is known as q-entropy principle and the fractal generalization of dynamics parallely to the scale extension of relativity theory, are the cornerstones of modern physical theory related to non-linearity and non-integrability as well as to the non-equilibrium ordering and the self-organization principle of nature. The theoretical concepts underlying Tsallis statistical theory and fractal dynamics can be used for the study of experimental time series extracted by complex systems observations. For this we apply concerning theoretical concepts of Tsallis non-equilibrium statistical mechanics to analyze and predict statistical and dynamical parameters of signals corresponding to novel algorithms concerning theoretical concepts of non-equilibrium dynamics to analyse signals corresponding to: a) cosmic stars and cosmic rays, b) space plasmas dynamics such as magnetospheric and solar systems, c) atmospheric dynamics and klima, d) earthquake dynamics and e) cardiac and brain dynamics.

Towards a large deviation theory for statistical-mechanical complex systems

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The theory of large deviations constitutes a mathematical cornerstone in the foundations of Boltzmann-Gibbs statistical mechanics, based on the additive entropy $S_{BG} = -k_B \sum_{i=1}^{W} p_i \ln p_i$. Its optimization under appropriate constraints yields the celebrated BG weight $e^{-\beta E_i}$. An elementary large-deviation connection is provided by N independent binary variables, which, in the $N \to \infty$ limit yields a Gaussian distribution. The probability of having $n \neq N/2$ out of N throws is governed by the exponential decay e^{-Nr}, where the rate function r is directly related to the relative BG entropy. To deal with a wide class of complex systems, nonextensive statistical mechanics has been proposed, based on the nonadditive entropy $S_q = k_B \frac{1-\sum_{i=1}^{W} p_i^q}{q-1}$ ($q \in \mathcal{R}$; $S_1 = S_{BG}$). Its optimization yields the generalized weight $e_q^{-\beta_q E_i}$ ($e_q^z \equiv [1+(1-q)z]^{1/(1-q)}$; $e_1^z = e^z$). We numerically study large deviations for a strongly correlated model which depends on the indices $Q \in [1,2)$ and $\gamma \in (0,1)$. This model provides, in the $N \to \infty$ limit ($\forall \gamma$), Q-Gaussian distributions, ubiquitously observed in nature ($Q \to 1$ recovers the independent binary model). We show that its corresponding large deviations are governed by $e_q^{-Nr_q}$ ($\propto 1/N^{1/(q-1)}$ if $q > 1$) where $q = \frac{Q-1}{\gamma(3-Q)} + 1 \geq 1$. This q-generalized illustration opens wide the door towards a desirable large-deviation foundation of nonextensive statistical mechanics.

Environmental aspects of superstatistics: Temperature

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Superstatistical techniques are powerful tools to describe general classes of complex systems. The applicability of these techniques to real-world problems is the prominent property of the superstatistics concept. Some of these numerous interesting applications are turbulence [**1–4**], defect turbulence [**5**], share price dynamics [**6,7**], random matrix theory [**8,9**] random networks [**10**], wind velocity fluctuations [**11,12**], hydro-climatic fluctuations [**13**], the statistics of train departure delays [**14**], models of the metastatic cascade in cancerous systems [**15**] scattering processes in high-energy physics [**16**] and complex systems of solid state physics [**17**].

More recently we have shown that superstatistical techniques could be also successfully applied to environmental aspects of surface temperature distributions [**18**]. In this presentation, we will discuss that superstatistical distributions $f(\beta)$ are very different at different geographic locations, and typically exhibits a double-peak structure for long- term data. For some of our data sets we also find a systematic drift due to global warming.

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Fluids in curved space

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By inserting the spatial metric into the equations of motion of a fluid and using contravariant coordinates it becomes possible to obtain the velocity field of the flow in an arbitrarily curved geometry by just solving the Lattice Boltzmann equations in Euclidean space on a cubic grid. This allows for instance to obtain Taylor-Couette rolls between concentric cylinders, spheres or tori in a rectangle with a metric tensor describing constant curvature. A "campylotic" medium consisting of randomly distributed curved patches gives a non-monotonic dependence on the density of patches. Also relativistic fluids can be canonically treated by the Lattice Boltzmann method by considering two distribution functions and identifying the physical and the numerical maximal velocities. This allows studying very efficiently shock waves in the quark-gluon plasma and supernova explosions. The ultrarelativistic limit can be achieved by developing the Jüttner distribution in polynomials. Also a treatment of the q-generalization of the relativistic Navier-Stokes equation becomes feasible in this way.

Restricted random walk model as a new testing ground for the applicability of q-statistics

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We present exact results obtained from Master Equations for the probability function $P(y,T)$ of sums $y = \sum_{t=1}^{T} x_t$ of the positions x_t of a discrete random walker restricted to the set of integers between $-L$ and L. We study the asymptotic properties for large values of L and T. For a set of position dependent transition probabilities the functional form of $P(y,T)$ is with very high precision represented by q-Gaussians when T assumes a certain value $T^* \propto L^2$. The domain of y values for which the q-Gaussian apply diverges with L. The fit to a q-Gaussian remains of very high quality even when the exponent a of the transition probability $g(x) = |x/L|^a + p$ with $0 < p \ll 1$ is different from 1, although weak, but essential, deviation from the q-Gaussian does occur for $a \neq 1$. To assess the role of correlations we compare the T dependence of $P(y,T)$ for the restricted random walker case with the equivalent dependence for a sum y of uncorrelated variables x each distributed according to $1/g(x)$.

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Combinatorial basis for Tsallis entropy and its applications

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The combinatorial basis for Tsallis entropy is presented along the line of Boltzmann's original approach, starting from the fundamental nonlinear differential equation $dy/dx = y^q$. The most general combinatorial expression for Tsallis entropy recovers the four typical structures: (i) additive duality "$q \leftrightarrow 2-q$"; (ii) multiplicative duality "$q \leftrightarrow 1/q$"; (iii) q-triplet; (iv) multifractal triplet. In the presentation, new results associated with the combinatorial basis are also presented.

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Statistical mechanics from the point of view of information geometry

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The Boltzmann-Gibbs distribution is an exponential family of probability distributions. As a consequence it has a dual Legendre structure. The latter is well-known to physicists as the duality between energy and entropy. The exponential family forms a differentiable manifold which is the object of study in information geometry [**1**]. The natural metric is that of Fisher. It can be obtained from the matrix of second derivatives of the relative entropy.

The traditional approach to non-extensive statistical mechanics starts from the maximum entropy principle. In our alternative approach [**2–5**] the notion of a deformed exponential family is the central concept. A characteristic property of an exponential family is that the Fisher information matrix is constant along fibers of minimal relative entropy [**6**].

In non-extensive statistical mechanics two types of relative entropies are in use [**6**,**7**]. In the mathematics literature they are called divergences of the Csiszár type and of the Bregman type, respectively. We use our characterization to argue that the Bregman type relative entropy is preferable in the context of the Tsallis distribution [**6**].

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Tsallis' entropy for central potentials: Improved bounds and uncertainty relations

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Further properties of inequality type for the Tsallis entropy of D-dimensional physical systems associated with their position and momentum probability distributions are encountered in terms of various density-functional-based observables which are described by power-like positon and momentum expectation values. Then, the results are used to find uncertainty relations, which are later compared with the elegant general expressions of Rajagopal and Maassen-Uffink. Later, the improvement of corresponding uncertainty relation is shown and discussed for systems with spherically-symmetric potentials in terms of the quantum numbers of the physical states and the dimensionality of the system. Applications to some prototypic and real specific quantum systems (Rydberg atoms, oscillator-like systems, ?) will be given. Finally, if time allows it, a large class of D-dimensional central potentials will also be shown to have ground states of the q-Gaussian form, either in position space or in momentum space.

Optimal synchronizability of bearings

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Bearings are mechanical dissipative systems that, when perturbed, relax toward a synchronized (bearing) state. Here we find that bearings 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. We show that, 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, $m \sim r^{\alpha}$, with an optimal exponent $\alpha = \alpha_{\times}$ 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 composing the mechanical system, the average participation per disk is maximized and the energy dissipation rate is homogeneously distributed among elementary rotors.

Information fusion and metrics using coupled states

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The methods of nonextensive statistical mechanics and information geometry are interpreted to define a nonlinear coupling between statistical states. The weighted coupled-product of probabilities is used as both a method for information fusion and shown to be equivalent to the normalized Tsallis entropy. Numerical experiments demonstrate that one coupling parameter can replace tens of thousands of linear correlation parameters in fusing the inferences from individual image pixels. Performance comparisons with a full covariance matrix and the naïve bayes utilize a risk profile which shows the spectrum of the generalized mean for the true class probabilities. This probability-based performance metric is a transformation of the generalized entropy measure.

Earth's climate complexity

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In this study we apply the Tsallis theory as concerns the estimation of q-triplet for the geopotential height (GH) time-series, by analyzing temporal and spatial components of the global distribution of month average values, during the period (1948-2012), reveal the presence of strong non-extensive character for both spatial and temporal components. Also noticeable differences of the q-triplet estimated at distinct local or temporal regions where found. Moreover theoretical interpretation of our results are presented. The results indicate the existence of spatiotemporal long range correlations and fractal dynamics underlying to the GH signal. This can be understood as a fractal Fokker-Plank process corresponding to far from thermodynamic equilibrium stochastic process including anomalous diffusion (non-Gaussian diffusion) character. This is in contrast to the near equilibrium Gaussian stochastic process. Especially, we summarize the estimation per decade of q-triplet. It is noticeable the complementary character of the q-triplet values between the north and south hemisphere, while the values of the q-triplet for the global planet correspond approximate for the mean value, especially for the q-stat and q-rel values. Also during the first three decades we can observe simultaneously degrease at the south hemisphere and increase at the north hemisphere of the q-stat values. The global q-triplet presents clearly degreasing profile, especially after 1970. We can support that the degreasing of the q-stat value especially after 1970 indicates the tendency of the homogenization of the dynamics (approach to Gaussian profile) loss of complexity and long range correlations.

Wavelet coherency in complex systems

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When we analyze complex networks and other complex systems it is important to know if two elements or sub-systems are linked or strongly correlated. In other words we need to investigate if they are part of the same group or cluster. If we don't have this information a priori, we try to infer it from cross correlations between time series (or data series) measured in these sub-systems. Although the standard statistical cross correlation methods may fail in giving an unambiguous result because of their global nature and possible fortuitous coincidences, there are cross-correlation quantities defined in wavelet space that provide a high degree of confidence for evaluating the similarity between the two parts. They are able to quantify the degree of cross-correlation in every scale (time-frequency or distance-wavelenght data intervals). They act as coherence tools capable to identify regions with identical properties, corresponding to the situations in which high cross-correlations are observed simultaneously in all scales. We have applied this approach to study physical quantities registered in well logs, searching for the continuity and extension of geological structures and trying to find connections between petroleum reservoirs.

The general preferential attachment growth model and nonextensive statistical mechanics

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In this work we revisit the model of Soares et al (2005) [**1**] in which they take into account Euclidean distances in between sites of a Network instead of topologic distances as in the Barabasi-Albert traditional model. Then numerically it is determined that the probability distribution of a site to have k links is asymptotically given by $P(k)$ proportional to $\exp_q(-k/\kappa)$, where $\exp_q(x) = [1 + (1-q)x]^{1/(1-q)}$ is the function naturally emerging within nonextensive statistical mechanics. In the work of Soares et al they established a connection in between the area of Networks and the Tsallis nonextensive statistical mechanics approach. The previous work is done for $d = 2$ and here we revisit the model including $d = 1$ and $d = 3$ dimensions.

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Are there dissipative structures in UEFA competition team ranking?

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Measures of primacy in ranking are presented with application to the 445 soccer teams, as ranked by UEFA. The analysis is based on considerations about complex systems, i.e. searching whether power law fits are appropriate to describe some internal non-linear dynamics. It can be so observed that major classes emerge, - surprisingly two in this UEFA case. Whence it seems of interest to raise the question whether a ranking method, like that of UEFA, implicitly induces some inner structure in the ranking distribution. In so doing, several subclasses can be found in particular when the notion of primacy index, as imagined by Sheppard is envisaged. To better perform, several additional indices are discussed, like those of Vitanov. (N.B. These measures can be used to sort out peer classes in more general terms.) Numerical illustrations, through the so called "length ratio", are illuminating, suggesting *dissipative structures* implication, as introduced by Nicolis and Prigogine. Thus a hierachical (open space) model, yet with boundary constraints, is suggested. A note on "soccer *country* ranking" is introduced for further discussion. Connection to Tsallis q-entropy is searched for. †Previously at GRAPES, ULG, Liège, Belgium, now at Rés. Beauvallon, rue de la Belle Jardiniere, 483/0021 B-4031, Liège Angleur, Wallonia-Brussels Federation, still in Belgium, Euroland. Email address: `marcel.ausloos@ulg.ac.be`.

Testing the Goodwin growth-cycle macroeconomic dynamics in Brazil

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This paper discusses the empirical validity of Goodwin's (1967) macroeconomic model of growth with cycles by assuming that the individual income distribution of the Brazilian society is described by the Gompertz-Pareto distribution (GPD). This is formed by the combination of the Gompertz curve, representing the overwhelming majority of the population ($\sim$ 99%), with the Pareto power law, representing the tiny richest part ($\sim$ 1%). In line with Goodwin's original model, we identify the Gompertzian part with the workers and the Paretian component with the class of capitalists. Since the GPD parameters are obtained for each year and the Goodwin macroeconomics is a time evolving model, we use previously determined, and further extended here, Brazilian GPD parameters, as well as unemployment data, to study the time evolution of these quantities in Brazil from 1981 to 2009 by means of the Goodwin dynamics. This is done in the original Goodwin model and an extension advanced by Desai et al. (2006). As far as Brazilian data is concerned, our results show partial qualitative and quantitative agreement with both models in the studied time period, although the original one provides better data fit. Nevertheless, both models fall short of a good empirical agreement as they predict single center cycles which were not found in the data. We discuss the specific points where the Goodwin dynamics must be improved in order to provide a more realistic representation of the dynamics of economic systems.

Reference: *Physica A* **392**, 2088-2103 (2013) (arXiv:1301.1090).

Enhancement flow in nanoconfined water

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We investigate through non-equilibrium molecular dynamic simulations the flow of core-softened fluids inside nanotubes. Our results reveal a anomalous increase of the overall mass flux for nanotubes with sufficiently smaller radii. This is explained in terms of a transition from a single-file type of flow to the movement of an ordered-like fluid as the nanotube radius increases. The occurrence of a global minimum in the mass flux at this transition reflects the competition between the two characteristics length scales of the core-softened potential. Moreover, by increasing further the radius, another substantial change in the flow behavior, which becomes more evident at low temperatures, leads to a local minimum in the overall mass flux. Microscopically, this second transition results from the formation of a double-layer of flowing particles in the confined nanotube space. These special nano-fluidic features of core-softened particles closely resemble the enhanced flow behavior observed for liquid water inside carbon nanotubes. Email addresses: [†]`bordin@if.ufrgs.br`, [⋆]`soares@fisica.ufc.br`, [‡]`diehl@ufpel.edu.br`, [▷]`marcia.barbosa@ufrgs-.br`.

Tsallis entropy composition: a geometric view

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Probably the biggest formal difference between the Tsallis and the BGS entropies, lies in their composition properties, as it can be seen through

a comparison of their axiomatic formulations. We explore aspects of the Tsallis entropy composition. We take a geometric viewpoint in our treatment. In addition to the differential, we also stress the synthetic approach as the latter may be of some use in quantum gravity.

Distinguishing noise from chaos: an Information Theory approach

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Deterministic chaotic systems share with truly stochastic processes several properties that make them almost undistinguishable. In this communication we introduce a two representation space in which, its horizontal and vertical axis are suitable functionals of the pertinent probability distribution. These planes, to be called: *a)* causality statistical complexity - entropy plane, $\mathcal{H} \times \mathcal{C}$ and *b)* causality Fisher information - Shannon entropy plane, $\mathcal{H} \times \mathcal{F}$; allow to quantifies the global-global and global-local characteristic of the corresponding associated probability distribution to the time series generated by the dynamical process under study. These three functionals (normalized Shannon entropy, $\mathcal{H}$; Fisher information measure, $\mathcal{F}$; and statistical complexity $\mathcal{C}$) are evaluated using the Bandt and Pompe permutation recipe to assign a probability distribution function to the time series generated by the system. Several stochastic

(noises with f^{-k}, $k \geq 0$, power spectrum, fBm and fGn) and chaotic processes (27 chaotic maps) are analyzed so as to illustrate the approach. The main achievement of this communication is the system's localization in a causal entropy-complexity plane and causal Shannon-Fisher plane displays typical specific features associated with its dynamics' nature, allowing a clearly distinguishing between stochastic and nonlinear low dimensional chaotic dynamics in our two representation spaces, something that is rather difficult otherwise. Additive noise contamination (noises with f^{-k}, $k \geq 0$, power spectrum) of chaotic time series planar localization effects are also reported.

Phenomenological and theoretical reconstruction in the framework of information geometry science is the process of reconstructing theory from data

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Complex systems must be observed in vivo, providing multilevel data collection protocols. And they require formalisms to reconstruct their intra-level and inter-level dynamics, and their capacity to adapt to perturbations from their changing environments. A first way to think a required formalism for reconstructing the multi-level dynamics of a complex systems is through assimilation of multi-level data by a nonparametric model as done by the brain. This way leads to phenomenological reconstructions and measurement of quality of phenomenological reconstruction of the data can be done inside the information geometry framework. The most elegant way is to require formalisms that provide the littlest possible formulation of the integrated model of the multi-level stochastic dynamics of a complex system. This way leads to theoretical reconstructions and measurement of quality of theoretical reconstruction can again be done inside the information geometry framework. If we consider the shortest model for a given quality, the size of the best model will increase with the quality. But for better understanding of a class of complex systems, shorter models can be required to capture the most important qualitative and theoretical features. And two common ones are

long term memory and path dependency as well as adaptation to their environmental constraints at the border of chaos. Long term memory will be exemplified through the projection theorem in statistical physics and its link with information theory. The border of chaos will be exemplified through the class of systems having a strong capacity to treat information.

Generalized entropic measures of quantum correlations

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We discuss a general measure of nonclassical correlations for bipartite quantum systems, based on general concave entropic forms [**1**]. Defined as the minimum information loss due to a local measurement in one of the systems, in the case of pure states it reduces to the generalized entanglement entropy, i.e., the generalized entropy of the reduced state. However, in the case of mixed states it can be nonzero in non-entangled (separable) states, vanishing just for classically correlated states with respect to the measured system, like the quantum discord. For the von Neumann entropy, the present measure becomes the so-called one-way information deficit, whereas for the $q = 2$ Tsallis entropy, it reduces to the geometric discord. The general stationary condition for the minimizing local measurement is also provided. Moreover, closed analytic expressions for this quantity, valid for general states of two-qubit systems, are derived for the $q = 2$ and $q = 3$ Tsallis entropies. As appli cation, we analyze the case of states with maximally mixed marginals, where a general evaluation is provided, as well as X states and the mixture of two aligned states. Comparison with the corresponding entanglement monotones is also shown.

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Data analysis of elections

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Recent results of data analysis of elections are reviewed. More specifically, power law distribution of votes, efforts aiming to model this behavior, distribution of votes when considering the weight of the parties, polarization of the voters, electoral turnout rates, detection of fraud, and allometric behavior of the number of candidates and of member of political parties as function of population of voters are discussed.

Thermodynamical consequences of the effective-temperature concept: heat, work, Carnot cycle, Clausius theorem, and entropy definition

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The concept of effective temperature θ in a pure mechanical model has been discussed within the framework of the non-extensive statistical mechanics [**1**]. In such case, it has been proven that this parameter, which is directly related to the density as well as to the interactions among vortices, plays the role of the actual temperature when generalized quantities such as entropy, internal energy, free energy, and heat capacity are conveniently and consistently defined. Now we explore further consequences of this definition. Particularly, we investigate the properties of an analogous to a Carnot cycle in terms of isothermal and adiabatic paths. They correspond, respectively, to processes where $\theta = constant$ and entropy $S = constant$. By direct evaluation of the heat and work

in the process, we show that the efficiency of such cycle is given only in terms of the effective temperatures θ_1 and θ_2 of the operating heat reservoirs. Next we consider a thermodynamical definition of work and heat transfer, and consider the hypothesis that the analogous Clausius statement to the second law is valid. Under this hypothesis, we prove the Clausius theorem for this system in terms of effective temperature concept, which leads to thermodynamical entropy expression. The obtained analytical expression is coincident to that derived within the framework of non-extensive statistical mechanics.

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Imaging in complex media: Recent progresses

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The Cancho i Ferrer - Solé model does not explain Zipf's Law

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We examine the cost-minimization problem posed by Ferrer i Cancho and Solé in their information-theory based communication model [**1**], proposed in efforts to explain Zipf's Law (that is, a power-law frequency-rank relation for words in written texts). Using a simple inequality, we obtain the exact minimum-cost solution as a function of the parameter

λ, as obtained previously via other methods [**2–4**] (λ defines the relative weights of speaker's and listener's costs). We show that at the phase transition, the minimum-cost solutions do not correspond to a power law except for a vanishingly small subset, even if we impose the additional condition of equal costs to speaker and listener [**5**]. Finally we consider the model at finite temperature using mean-field theory and entropic Monte Carlo simulation, and find a line of *discontinuous* phase transitions in the λ-T plane. The simulations yield no evidence for a power-law frequency-rank distribution.

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An Information-based tool for inferring the nature of deterministic sources in real data

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The scope of the paper is to find signatures of the forces controlling complex systems modeled by Langevin equations, by recourse to information-theory quantifiers. We evaluate in detail the permutation entropy (PE) and the permutation statistical complexity (PSC) measures for two similarity classes of stochastic models, characterized by either drifting or reversion properties, and employ them as a reference basis for the inspection of real series. New relevant model parameters arise as compared to standard entropy measures. We determine the normalized PE and PSC curves according to them over a range of permutation orders n and infer the limiting measures for arbitrary large order. We found that the PSC measure is strongly scale-dependent, with systems of the drifting class showing crossovers as n increases. This result gives warning signs

about the proper interpretation of finite-scale analysis of complexity in general processes. Conversely, a key n-invariant outcome arises, that is, the normalized PE values for both classes of models keep complementary for any n. We argue that both PE and PSC measures enable one to unravel the nature (drifting or restoring) of the deterministic sources underlying complexity. We conclude by investigating the presence of local trends in stock price series.

From multiplicity to entropy

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Shannon and Khinchin built their foundational *information theoretic* work on four axioms that completely determine the information-theoretic entropy to be of Boltzmann-Gibbs type, $S_{BG} = -\sum_i p_i \log p_i$. For non-additive systems the so called separation axiom (Shannon-Khinchin axiom 4) is not valid. It can be shown that whenever this axiom is is replaced by the requirement that entropic forms are of *trace-form*, $S = \sum_i s(p_i)$, then S takes a more general form, $S_{c,d} \propto \sum_i^W \Gamma(d+1, 1-c\log p_i)$, where c and d are characteristic scaling exponents.

As a consequence non-additive systems, i.e. systems where S_{BG} is non-extensive (scales linearly with system size), can possess assymptotically extensive generalized trace-form entropies $S_{(c,d)}$. The exponents (c, d) parametrize equivalence classes which precisely characterize *all* interacting and non interacting (statistical) system in the thermodynamic limit [**1**], comprizing systems typically exhibiting power laws or stretched exponential distributions.

However, the generalized *extensive* entropy is not necessarily identical with the generalized entropy *functional* required in a *maximum entropy principle*. Both concepts are closely related but distinct from each other. The generalized entropy functional in fact derives directly from Boltzmann entropy, i.e. the multiplicities of states. In particular, while Boltzmann entropy takes the form of the Shannon entropy for independent or weakly correlated systems, Boltzmann entropy can take different functional forms for *strongly* correlated systems. Whether a system is weakly or strongly correlated depends on whether or not a system breaks a certain invariance property.

We show that the entropy and the constraints a systems requires are determined by the *multiplicity* structure of phase-space. In particular it is the first Shannon-Khinchin Axiom that allows to properly distinguish between entropy and constraints. Systems that require generalized entropies have phase-spaces growing non-exponentially with system size. This is relevant e.g. for aging systems and non-Markovian systems with long-term memory, as e.g. random walks [**2**,**3**] where agents cross over from making random choices to making persistent choices over time depending on the history of the agent (or other forms of self-reinforcing Dirichlet-processes). Also self-organized critical systems such as sand piles or particular types for spin systems with densifying interactions may be found in this classes of strongly correlated sytems.

In this contribution we largely follow the lines of thought presented in [**1**–**3**] and recent work together with Murray Gell-Mann, soon to be published.

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Some properties of memory retrieval in an associative memory neural network for conscious and unconscious mental behavior

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We study properties of the topologies and dynamics of neuronal systems, to understand brain and mental processes, based on connexionist models [**1–6**]. It is possible to study how global emergent behavior arises from the interactions among neurons of the parallel processing neuronal networks, with computer simulations. We will present a neural network model, whereby some interplay of conscious and unconscious activities may be described by associative memory mechanisms [**3**].

In our model, memory retrieval can be achieved through simulated annealing, which is a phase space sampling technique. We analyse the behavior of the network under different assumptions on the way simulated annealing is performed on the model [**7,8**]. We will show some properties of the dynamics of memory access, obtained from measurements of quantities such as frequencies of access of memory traces and avalanche sizes in computer simulations. We found that when generalized statistical mechanics is used in the annealing procedure, instead of the Boltzmann machine, there is a power-law behavior for the avalanche size distribution, which is similar to fMRI data of cluster activation in the brain [**9**].

Knowledge from areas such as neurophysiology, psychiatry, psychology, computer science, mathematics and statistical mechanics can be combined, so we can better understand mechanisms which underlie brain and mental processes [**1–9**]. This knowledge may contribute to the understanding of therapeutic procedures and to the development of models of artificial machines and cognitive devices [**1**].

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Beyond the triangle – Brownian motion, Itô stochastic calculus, and Fokker-Planck equation: fractional generalizations

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One of Albert Einstein's *Annus Mirabilis* 1905 papers, titled "Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen" ("On the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat"), was devoted to the theoretical explanation of Brownian motion. A little earlier (in 1900) Bachelier published his doctoral dissertation "Théorie de la spéculation" ("The Theory of Speculation") modeling Brownian motion from the economics point of view. In 1908 Langevin published his work with a stochastic differential equation which was "understood mathematically" only after a stochastic calculus was introduced by Itô in 1944-48. The Fokker-Planck equation, a deterministic form of describing the dynamics of a random process in terms of transition probabilities, was invented in 1913-17. Its complete "mathematical understanding" become available after the appearance of the distribution (generalized function) theory (Sobolev (1938), Schwartz (1951)) and was embodied in Kolmogorov's backward and forward equations. Today the triple relationship between Brownian motion,

Itô stochastic differential equations driven by Brownian motion and their associated Fokker-Planck-Kolmogorov (FPK) partial differential equations is well known. The talk will be devoted to fractional generalizations of this triple relationship between the driving process, corresponding SDEs, and associated deterministic fractional order pseudo-differential equations. In the last few decades, fractional FPK type equations have been used in modeling various complex processes in physics, finance, hydrology, cell biology, etc. Complexity includes phenomena such as weak or strong correlations, different sub- or super-diffusive modes, memory and jump effects. For example, experimental studies of the motion of proteins or other macromolecules in a cell membrane show apparent subdiffusive motion with several simultaneous diffusive modes. The driving process of a stochastic differential equation plays a key role in the dynamics and evolution of the solution to that SDE. The processes associated with fractional order FPK equations are usually driven by complex processes. Even in the simplest case of the fractional equation $\partial^{\beta} u = \Delta u$, where Δ is the Laplace operator, and ∂^{β} is a fractional derivative of order $0 < \beta < 1$, the driving process is not even a Lévy process. We will briefly discuss that the driving processes related to fractional FPK equations are limit processes of continuous time random walks (CTRW).

Interplay between forest fire distribution and forest age structure

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We investigate via a cellular automata model the interplay between the distribution of long-term and large-scale forest fires and the forest age distribution. Particularly, we associate the age of the trees (or acres of forest) with the local heterogeneity existing in forested environments to determine their degree of flammability.

Mean-field theories and quasi-stationary simulations of epidemics models on complex networks

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In this communication, we will present a quenched mean-field (QMF) theory for the dynamics of the susceptible-infected-susceptible (SIS) epidemic model on complex networks where dynamical correlations between connected vertices are taken into account by means of a pair approximation [**1**]. This approach is an extension of the one-vertex QMF theory where the actual structure of network is explicitly included. We will present analytical expressions for the epidemic thresholds for the star and wheel graphs and for random regular networks. For random networks with a power law degree distribution, the thresholds were numerically determined via an eigenvalue problem. The pair and one-vertex QMF theories yield the same scaling for the thresholds as function of the network size. However, comparisons with quasi-stationary simulations [**2**] of the SIS dynamics on large networks show that the former is quantitatively much more accurate than the latter. Our results demonstrate the central role played by dynamical correlations on the epidemic spreading. Finally, we will discuss the effects of outliers and cutoffs of the degree distribution in the epidemic thresholds. Our numerical results show the presence of a localized epidemics, which is sustained by outliers, and an endemic phase associated to the bulk of the network. For scale-free networks (degree exponent $\gamma < 3$), we observed that the pair QMF theory predicts the correct scaling of the threshold against network size for both natural and structural cutoffs. However, for $\gamma > 3$ a hard-cutoff leads to the failure of the QMF theories. The numerical results are in better accordance with the mean-field recently theory proposed in Ref. [**3**].

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On generalisations of the log-Normal distribution by means of a new product definition in the Kapteyn process

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In this presentation, I will discuss the modification of the Kapteyn multiplicative process using the q-product of Borges [*Physica A* **340**, 95 (2004)], which emerged within the Tsallis statistics framework. Depending on the value of the index q a generalisation of the log-Normal distribution is yielded. Explicitly, the distribution increases the tail for small (when $q<1$) or large (when $q>1$) values of the variable upon analysis in relation to the standard log-Normal distribution, which is retrieved when $q=1$ and one has to the traditional Kapteyn multiplicative process. I will also introduce the main statistical features of this distribution as well as related random number generators. Lastly, I will illustrate the worthiness of this proposal by describing a set of variables of biological, namely the distribution of the chemical potential in metabolic networks and the capacity for distinguishing aerobic from anaerobic systems depending on the value of q.

Entropy for complex and non-ergodic systems, a derivation from first principles

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In their seminal works, Shannon and Khinchin showed that assuming four information theoretic axioms the entropy must be of Boltzmann-Gibbs

type, $S = -\sum_i p_i \log p_i$. For non-ergodic systems the so called separation axiom (Shannon-Khinchin axiom 4) is not valid. We show that whenever this axiom is violated the entropy takes a more general form, $S_{c,d} \propto \sum_i^W \Gamma(d+1, 1-c\log p_i)$, where c and d are characteristic scaling exponents that exist for all systems that obey Shannon-Khinchin axioms 1-3. $\Gamma(a,b)$ is the incomplete gamma function. The exponents (c,d) define equivalence classes for *all!*, interacting and non interacting, systems and unambiguously characterize any statistical system in its thermodynamic limit. The proof is possible because of newly discovered scaling laws which any entropy has to fulfill, if the first three Shannon-Khinchin axioms hold [**1**]. (c,d) can be used to define equivalence classes of statistical systems. A series of known entropies can now be classified in terms of these equivalence classes. We show that the corresponding distribution functions are special forms of Lambert-$\mathcal{W}$ exponentials containing – as special cases – Boltzmann, stretched exponential, and Tsallis distributions (power-laws).

We show how the dependence of phase space volume $W(N)$ on its size N, uniquely determines the exponents (c,d), [**2**]. We give a concise criterion when this entropy is not of Boltzmann-Gibbs type but has to assume a *generalized* (non-additive) form. We show that generalized entropies can only exist when the dynamically (statistically) relevant fraction of degrees of freedom in the system vanishes in the thermodynamic limit [**2**]. These are systems where the bulk of the degrees of freedom is frozen and is practically statistically inactive. Systems governed by generalized entropies are therefore those whose phase space volume effectively collapses to a lower-dimensional 'surface'. We explicitly illustrate the situation for binomial processes and argue that generalized entropies could be relevant for self-organized critical systems such as sand piles, for spin systems which form meta-structures such as vortices, domains, instantons, etc., and for problems associated with anomalous diffusion[**2**]. In this contribution we largely follow the lines of thought presented in [**1**–**3**].

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production 2013).

Dielectric constant at the critical point

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The behavior of the dielectric constant around the critical point has been of interest for many years, with particular interest in the possible existence of singularities [**1–3**]. In this work we use first-principle electronic structure calculations combining classical Monte Carlo simulations and density-functional quantum mechanical calculations to analyze the behavior of the dielectric constant both at the critical point and around it. This combined use of molecular modeling and quantum mechanics (QM/MM) allows an accurate description giving numerical results for the static dielectric constant at the critical point in very good agreement with experiment, leading credence to the behavior of the calculated values obtained around the critical density. Work supported by FAPESP, CNPq, CAPES and INCT-FCx.

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Central limit behaviour of dynamical systems: Emergence of q-Gaussians and scaling laws

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For deterministic dynamical systems, a central limit theorem is valid only if the system is sufficiently mixing. However, due to strong temporal correlations, a standard central limit theorem is not valid when the system is in the vicinity of chaos threshold. We have shown [**1,2**] that the probability distribution of sums of iterates of the logistic map in the

vicinity of chaos threshold can be well approximated by a q-Gaussian. Then, recently, a generalized Huberman-Rudnick scaling law has been obtained for all periodic windows of the logistic map and robustness of the q-Gaussian probability distributions in the vicinity of chaos threshold has been shown [**3**]. Finally, relationships among correlation, fractality, Lyapunov divergence and q-Gaussian distributions have been numerically introduced [**4**]. The scaling arguments possessing the critical exponents between the size of the q-Gaussian and correlation, fractality, Lyapunov divergence are obtained for periodic windows (i.e., period 2, 3 and 5) of the logistic map as chaos threshold is approached [**4**]. All these findings can be though as new evidences supporting that the central limit behavior at the chaos threshold is given by a q-Gaussian.

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Abstracts: Poster Sessions

No trivial extinctions transition in a two species population dynamics model

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The two-species population dynamics model is the simplest paradigm of inter- and intra-species interaction. Here, we present a generalized Lotka-Volterra model with intraspecific competition, which retrieves as particular cases, some well known models. We identify the model generalization parameter with the environmental fractal dimension and the individuals near and far con-specifics interaction range. The species inter-specific interaction parameters are not constrained and represent different ecological regimes. The asymptotic solutions stability analysis leads to a phase diagram in the parameter space representing the ecological regimes. In this diagram we call the attention to: a forbidden region in the mutualism regime and to the region with dependence on initial conditions, in the competition regime. Also, we have shed light on two types of predation and competition: weak, if there are species coexistence, or strong, otherwise.

Non-Gaussian behavior in jamming / unjamming transition in dense granular materials

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Experiments of dense and disordered granular media were reported recently showing the jamming / unjamming transition. In the present work,

we perform molecular dynamics simulations in order to assess both kinematic and static features of jamming / unjamming transition. We study the statistics of the particles velocities and displacements to evince that both experiments and simulations present the same qualitative behavior. We observe that the probability density functions (PDF) of velocities deviate from Gaussian depending on the packing fraction of the granular assembly. In order to quantify these deviations we consider a q-Gaussian (Tsallis) function to fit the PDF's. The q-value can be an indication of the presence of long range correlations along the system. We compare the fitted PDF's obtained with those obtained using the stretched exponential, and sketch some conclusions concerning the nature of the correlations along a granular confined flow.

Non extensive H-Theorem in general relativity

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In this paper we have showed the nonextensive H-theorem in general relativity. For this purpose, we consider the prerrogatives of quantum statistics in the nonextensive formalism and relativistic kinetic theory in a scenario composed of a quantum gas isolated on a specific volume in the presence of a gravitacional field. We also determined, by equilibrium condition, the generalized stationary distributions of this gas.

Generalized complexity and classical-quantum transition

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We investigate the classical limit of the dynamics of a semiclassical system that represents the interaction between matter and a given field. On

using as a quantifier the q-Complexity, we find that it describes appropriately the quantum-classical transition, detecting the most salient details of the changeover. Additionally the q-Complexity results a better quantifier of the problem than the q-entropy, in the sense that the q-range is enlarged, describing the q-Complexity, the most important characteristics of the transition for all q-value. **Keywords:** Generalized entropy; Semiclassical theories; Quantum chaos; Statistical complexity. Email address: `kowalski@fisica.unlp.edu.ar`.

The transformation groupoid structure of the q-Gaussian family

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Groupoid theory plays an important role in physics since the beginnings of quantum mechanics. Recent developments in understanding symmetries in complex dynamical systems underpin the growing importance of groupoid theory also for statistical mechanics. The q-Gaussian function is observed as the distribution function of many physical and biological systems and emerges naturally in the statistical mechanics of non-ergodic and complex systems. A number of dynamical systems are characterized by pairs and triples of q-Gaussians. The aim of this work is to relate these triples of q-Gaussians with different q-values, representing intrinsic symmetries of the dynamical system at hand, such that that any value of q can be mapped uniquely to any other value q'. We present a complete set of transformations of q-Gaussians by deriving a general map $\gamma_{qq'}$ that transforms normalizable q-Gaussian distributions into one another. We show that the action of $\gamma_{qq'}$ is a transformation groupoid.

Classical and quantum harmonic oscillator with position-dependent mass

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Systems consisting of particles with position-dependent mass (PDM) have been discussed by several researchers since past few decades. Applications of such systems may be found in semiconductor theory, ^{4}He impurity in homogeneous liquid ^{3}He, nonlinear optics, studies of inversion potential for NH_3 in density functional theory (DFT), particle physics and astrophysics. Recently, Costa Filho *et al.* [EPL **101**, 10009 (2013)] have introduced a generalized translation operator which produces infinitesimal displacements related to the q-algebra, *i.e.*, $\hat{T}_q(\varepsilon)|x\rangle \equiv |x+\varepsilon+\gamma_q x\varepsilon\rangle$, where $\gamma_q \equiv (1-q)/\xi$, q is a dimensionless parameter, and ξ is a characteristic length. This operator leads to a generator operator of spatial translations corresponding to a position-dependent linear momentum given by $\hat{p}_q = (\hat{1}+\gamma_q\hat{x})\hat{p}$, and consequently a particle with position-dependent mass. Through the inclusion of a q-exponential factor in the expression of $\hat{T}_q(\varepsilon)$, we re-obtain the deformed linear momentum operator in a symmetrical form: $\hat{p}_q = \frac{(\hat{1}+\gamma_q\hat{x})\hat{p}}{2} + \frac{\hat{p}(\hat{1}+\gamma_q\hat{x})}{2}$. The deformed position operator $\hat{x}_q = \gamma_q^{-1}\ln(1+\gamma_q\hat{x})$ is introduced so that it is canonically conjugated with respect to $\hat{p}_q$. These operators $\hat{x}_q$ and $\hat{p}_q$ was originally used to solve problems of particles with position-dependent mass in the quantum formalism. Particularly, the canonical transformation $(\hat{x},\hat{p}) \to (\hat{x}_q,\hat{p}_q)$ leads a particle with position-dependent mass $m(x) = m/(1+\gamma_q x)^2$ in a harmonic potential to a particle with constant mass in a Morse potential. Furthermore, since the operators $\hat{x}_q$ and $\hat{p}_q$ are Hermitian and canonically conjugated, we can analyze the classical analogue of quantum systems involving these dynamical variables. We revisit the problem of a position-dependent mass in a harmonic potential in both classical and quantum formalisms. The equations of motion in phase space (x,p) are expressed

in terms of the generalized dual q-derivative $\tilde{D}_{\gamma_q,t}x(t) = \frac{1}{1+\gamma_q x}\frac{dx}{dt}$. Specifically, this oscillator with position-dependent mass is related to non-linear differential equations $\tilde{D}^2_{\gamma_q,t}x(t) = -\omega_0^2 x(t)$ and $\tilde{D}_{\gamma_q,t}x(t) = \pm\omega_0\sqrt{A^2 - x^2}$, similar to the usual case, however, with the usual derivative replaced by deformed derivative. The analytical solution of these NLE led us to define new deformed trigonometric functions $\mathrm{Sin}_q(u)$ and $\mathrm{Cos}_q(u)$, such that $\widetilde{D}_{\gamma_q,u}\mathrm{Sin}_q u = \mathrm{Cos}_q u$ and $\tilde{D}_{\gamma_q,u}\mathrm{Cos}_q u = -\mathrm{Sin}_q u$, which preserve the Pythagorean theorem $\mathrm{Sin}^2_q u + \mathrm{Cos}^2_q u = 1$. The trajectories in phase spaces (x, p) and (x_q, p_q) are analyzed for different values of γ_q. Lastly, we compared the results of the problem in classical and quantum formalisms through the principle of correspondence and the WKB approximation.

Scaling functions for systems with finite range of interaction

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We present a numerical determination of the scaling functions of the magnetization, the susceptibility, and the Binder's cumulant for two nonequilibrium model systems with varying range of interactions. We consider Monte Carlo simulations of the block voter model (BVM) on square lattices and of the majority-vote model (MVM) on random graphs. In both cases, the satisfactory data collapse obtained for several system sizes and interaction ranges supports the hypothesis that these functions are universal. Our analysis yields an accurate estimation of the long-range exponents, which govern the decay of the critical amplitudes with the range of interaction, and is consistent with the assumption that the static exponents are Ising-like for the BVM and classical for the MVM.

A nonextensive approach to the stellar rotational evolution for F- and G-type stars

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The pioneering study by Skumanich (1972) showed that the rotational velocity of G-type Main-Sequence (MS) stars decreases with stellar age according to $\langle v \sin i \rangle \propto t^{-1/2}$. This relationship is consistent with simple theories of angular momentum loss from rotating stars, where an ionized wind is coupled to the star by a magnetic field. The present study introduces a new approach to the study of stellar rotational braking in unsaturated F and G type stars limited in age and mass, connecting angular momentum loss by magnetic stellar wind with Tsallis nonextensive statistical mechanics. As a result, we show that the rotation-age relationship can be well reproduced using a nonextensive approach from Tsallis nonextensive models. Here, the index q, which is related to the degree of nonextensivity, can be associated to the dynamo process and to magnetic field geometry, offering relevant information on the level of stellar magnetic braking for F- and G-type Main-Sequence stars.

A Comparison between methods for analyzing physiological time series

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Physiological registers, like EEG, ECG and blood pressure has been analysed using differents statistical technique, many of them developed for time series. Recently this set of tools has been expanded by the inclusion

of physical concept like chaos, complexity, criticality and others [**1,3**]. The use of these concepts has allowed a better understanding of the dynamical aspects behind the system originating the corresponding registers. A very significant example is the association of chaotic behavior in ECG registers with some kind of cardiac disease [**4**]; or the application of wavelets entropies in the study of EEG register of epileptic patients [**5**]. We investigate different method of analysis in physiologic register, based on theoretical information quantities (entropy, Jensen-Shannon divergence), Band and Pompe permutation entropy [**6**] and the Lempel-Ziv complexity [**7**]. These methods have been applied in EEG registers, continuous monitoring Blood pressure and respiration registers. Even thought our results are preliminary we can arrive to some significant conclusions about the ad-vantage of one method over the others, and we investigate the extraction of information clinically relevant from this analysis.

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A Kramers-Moyal expansion approach to time series of the atmospheric temperature – A contribution to the discussion of the global weather change

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We investigate in an unified description, the dynamics of long and short time range of the fluctuation of the environment temperature presented by their statistics. We do that analyzing a real temperature time series, in a wide range of temporal scales to encompass both regimes. By means of Kramers-Moyal (KM) coefficients evaluated from empirical time series, we obtain the evolution equation for the probability density function (PDF) of temperature fluctuations. We also present asymptotic solutions for the timescale dependent equation that emerges from the empirical analysis.

Reactive strategies: The establishment of cooperation

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Individuals in nature, in many different populations, exhibit cooperative behaviour. The so called Prisoner's dilemma is a game which is widely used to model this phenomena. Players in this game have two options: cooperation (C) or desertion (D). If there is only one round, deserting is the best option. But once the individuals meet each other several times, cooperative behaviour can emerge. Being p and q the probabilities of cooperating given that the opponent had cooperate and deserted in the last encounter, respectively, an infinity number of strategies is available. The time evolution of the fractions of individuals playing a given strategy is governed by the replicator equation. Since we have distinct versions for

this equation and different ways to solve it (using continuous or discrete time approaches) we can obtain discordant outcomes. In this wor k we show that the usual results which is presented in literature (GTFT's victory) is found only when we use the discretized version of the Maynard Smith's replicator equation. In order to investigate the establishment of cooperation, we also analyse the flux diagram of initial conditions for a few strategies and study what happens when new strategies are added in the game, starting from the point in which all strategies are equally populated.

Generalized space and linear momentum operators in quantum mechanics

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We propose a generalized space operator $\hat{x}_q$ for which it is valid the canonical commutation relation with the generalized momentum operator $\hat{p}_q$ recently introduced by Costa Filho *et al.* [*Phys. Rev. A* **84**, 050102(R) (2011)]. These operators are related to infinitesimal translations $|x\rangle \to |x + \varepsilon + \gamma_q x\varepsilon\rangle$, where $\gamma_q \equiv (1-q)/\xi$, q is a dimensionless parameter, and ξ is a characteristic length. This generalized linear momentum operator is position-dependent and, accordingly, corresponds to a position-dependent mass particle. Furthermore, $(\hat{x}, \hat{p}) \to (\hat{x}_q, \hat{p}_q)$ is a canonical transformation with the classical analogue that leads the Hamiltonian $K(x_q, p_q)$ of a particle with constant mass m in a conservative force field of a deformed phase space (x_q, p_q) into the Hamiltonian $H(x, p)$ of a position-dependent mass particle with effective mass function $m(x) = m/(1+\gamma_q x)^2$. Time evolution of the deformed position x_q may be conveniently expressed in terms of the generalized dual q-derivative acting upon the usual position x, according to $\frac{dx_q}{dt} = \tilde{D}_{\gamma_q,t}x$, with the dual q-derivative operator defined as $\tilde{D}_{\gamma_q,u} f(u) = \frac{1}{1+\gamma_q u}\frac{df}{du}$. A position-

dependent mass confined in an infinite square potential well is shown as an instance. Uncertainty and correspondence principles are analyzed.

Fractional diffusion equation, surface effects and anomalous diffusion

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We investigate time dependent solutions for a system in a semi-infinite region and governed by a fractional diffusion equation. We also consider that the surface which delimit the system can adsorb and desorb particles with determinate rates. This process of adsorption-desorption is simulated by using integro-differential time dependent boundary condition on this surface. The solutions are obtained by using the Green function approach and shows an anomalous spreading which can be related to an anomalous diffusion.

Scaling exponents of rough surfaces generated by damage spreading in the Ising model

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We carry out a study of the phase transitions in the damage spreading in the one-dimensional Ising model under a dynamic introduced by Hinrichsen and Domany (HD) and mapping of the spin configurations to a solid-on-solid growth model, resulting in an aggregate which is compact (no vacancies) and without surface overhangs. A system is said to exhibit

damage spreading (DS) if the "distance" between two of its replicas, that evolve under the same thermal noise but from slightly different initial conditions, increases with time. The dynamic introduced by Hinrichsen and Domany exhibit nondirected percolation universality class continuous phase transitions to absorbing states, exhibit parity conservation (PC) law of kinks. The kinks (00's and 11's) of these models exhibit mod 2 parity conservation and the absorbing state is doubly degenerated. They are characterized by different exponents which are related to the PC universality class. We have obtained such exponents through M onte Carlo smilulations, variating the lattice size at critical probability. We estimated the growth exponent betaw at short times, such as, other critical exponents associated to the surface growth (teta and z). Our results are in good agreement with those expected for PC universality class. The critical roughening exponents, expected to belong to the PC universality class, were measured using power law relations valid at criticality. Supported by Capes, CNPq and Fapemig.

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Permutation quantifiers and the fine structure on the chaotic attractors.

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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.

Free energy evaluation in polymer translocation via Jarzynski equality

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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 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, U, by a Legendre transform $F = U - TS$, where T is the temperature and 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 $F = U - TS$, solely depends on the final and initial states without regard to the particular process connecting them. In contrast, the work W done on the system and the heat Q exchanged with the environment are process-dependent. Yet, their sum yielding the change in internal energy, $U = W + Q$, 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. **Keywords:** Free Energy, Jarzynski Equality, Polymer Translocation. Email address: `fmondaini@if.ufrj.br`.

Growing jackpot and persistence in lottery winners

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Historically, lottery seems to be the most famous branch among all the games of chances playing a relevant role in the behaviour of many individuals. In this work, we analyze data from Mega-Sena, the major lottery in Brazil. We show that while the size of the expected jackpot is growing, the demand for lottery tickets may grow exponentially. In addition, we find that the number of winners exhibits temporal persistent behavior despite unbiased draws. We propose a straightforward model grounded on the rolling-over feature of lottery that exhibits a persistent behaviour similar to those observed in the empirical data. Our results are consistent with the fact that the expectation of being awarded with money may drive human actions. In this framework, the desire for the jackpot (related to the increase in the sales of tickets) could be a mechanism to generate correlations in an apparently random scenario. **Keywords:** Autocorrelation, Human Behaviour, Rollover, Jackpot. Correspondence and requests for materials should be addressed to F.J.A. (`fja@dfi.uem.br`).

First passage time for a diffusive process under a geometric constraint

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We investigate the solutions, survival probability, and first passage time for a two dimensional diffusive process subjected to the geometric constraints of a backbone structure. We consider this process governed by a

fractional Fokker-Planck equation by taking into account the boundary conditions $\rho(0,y;t) = \rho(\infty,y;t) = 0$, $\rho(x,\pm\infty;t) = 0$, and an arbitrary initial condition. Our results show an anomalous spreading and, consequently, a nonusual behavior for the survival probability and for the first passage time distribution that may be characterized by different regimes. In addition, depending on the choice of the parameters present in the fractional Fokker-Plack equation, the survival probability indicates that part of the system may be trapped in the branches of the backbone structure.

Alternative measures for biospeckle image analysis

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Biospeckle is a technique whose purpose is to observe and study the underlying activity of some material. It has its roots in optical physics, and its first step is an image acquisition process that produces a video sequence of the reflection of a laser. The video content can be analyzed to have an interpretation of the activity of the observed material. The literature on this subject presents several different measures for analyzing the video sequence. Three of the most popular measures are the generalized difference (GD), the weighted generalized difference (WGD), and Fujii's method. These measures have drawbacks such as high computation time or limited visual quality of the results. In this paper, we propose (i) an alternative O n algorithm for the computation of the GD, (ii) an alternative measure based on the GD, (iii) an alternative measure based on the WGD, and (iv) a generalized definition of the Fujii's method with better visual quality. We discuss the similarities between the new measures and the existent ones, showing when they are applicable. We prove the gain in time computation. The proposed measures will help researchers to gain time during their research and to be able to develop faster tools based on biospeckle application.

Control of centrifugal fingering via a variable interfacial tension approach

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We study the centrifugal fingering instabilities that occur in rotating Hele-Shaw cells containing two different fluids. A weakly nonlinear analysis of the problem is performed, considering that the surface tension between the rotating fluids changes with the local curvature of the interface. It is shown that the coupling between the contact angle and the variable interfacial tension permits the control of the interface disturbances. As a result, linear perturbations and nonlinear finger competition phenomena can be properly controlled, and suppressed.

Interfacial elastic fingering in Hele-Shaw cells: A weakly nonlinear study

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We study a variant of the classic viscous fingering instability in Hele-Shaw cells where the interface separating the fluids is elastic, and presents a curvature-dependent bending rigidity. By employing a second-order mode-coupling approach we investigate how the elastic nature of the interface influences the morphology of emerging interfacial patterns. This is done by focusing our attention on a conventionally stable situation in which the fluids involved have the same viscosity. In this framework, we show that nonlinear effects significantly affect the ultimate shape of the pattern-forming structures.

Entropy production in systems described by a master equation

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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 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. **Keywords:** Entropy Production, Master Equation, Nonextensive Thermostatistics.

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Finite baths for Tsallis statistics: a rigorous approach

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Radial viscous fingering in yield stress fluids: Onset of pattern formation

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We report analytical results for the development of interfacial instabilities in a radial Hele-Shaw cell in which a yield stress fluid is pushed by a Newtonian fluid of negligible viscosity. By dealing with a gap averaging of the Navier-Stokes equation, we derive a Darcy-law-like equation for the problem, valid in the regime of high viscosity compared to yield stress effects. A mode-coupling approach is executed to examine the morphological features of the fluid-fluid interface at the onset of nonlinearity. Within this context, mechanisms for explaining the rising of tip-splitting, side-branching and competition events are proposed for lifting and injecting Hele-Shaw flow.

Nonextensive thermostatistic properties of compact stars

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In this work we discuss relevant aspects of the δ-thermostatistical treatment for an Fermi system in the context of generalized entropy proposed

recently by C. Tsallis and L.J.L. Cirto (*Eur. Phys. J. C* **73**, 2487 (2013)). After that, we analyzed properties of neutron and white dwarf stars in the framework of nonextensive δ-statistical mechanics. We show that nonextensive statistical effects could play a interesting role in the structure and in the evolution of the compact stars for small deviations from the standard Boltzmann-Gibbs statistics.

Anomalous g-factors for charged leptons in a fractional coarse-grained approach

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In this work, we investigate aspects of the electron, muon and tau gyromagnetic ratios ($g - factor$) in a fractional coarse-grained scenario, by adopting a Modified Riemann-Liouville (MRL) fractional calculus. We point out the possibility of mapping the experimental values of the specie's $g - factors$ into a theoretical parameter which accounts for fractionality, without computing higher-order QED calculations. We wish to understand whether the value of $(g-2)$ may be traced back to a fractionality of space-time.The justification for the difference between the experimental and the theoretical value $g = 2$ stemming from the Dirac equation is given in the terms of the complexity of the interactions of the charged leptons, considered as pseudo-particles and "dressed" by the interactions and the medium. Stepwise, we build up a fractional Dirac equation from the fractional Weyl equation that, on the other hand, was formulated exclusively in terms of the helicity operator. From the fractional angular momentum algebra, in a coarse-grained scenario, we work out the eigenvalues of the spin operator. Based on the standard electromagnetic current, as an analogy case, we write down a fractional Lagrangian density, with the electromagnetic field minimally coupled to the particular charged lepton. We then study a fractional gauge-like invariance symmetry, formulate the covariant fractional derivative and propose the spinor field transformation. Finally, by taking the non-relativistic regime of the

fractional Dirac equation, the fractional Pauli equation is obtained and, from that, an explicit expression for the fractional $g - factor$ comes out that is compared with the experimental CODATA value. Our claim is that the different lepton species must probe space-time by experiencing different fractionalities, once the latter may be associated to the dressing of the particles and, then, to the effective interactions of the different families with the medium. Email addresses: †`josewebe@ufrrj.br`, *`helayel@cbpf.br`.

Controlling the range of interactions in the classical inertial Heisenberg model

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Numerical results on the ferromagnetic Heisenberg model characterized by interactions with a variable range are presented. The system is defined as an ensemble of N localized classical Heisenberg rotators, coupled through interactions that decay with distance as $1/r^{\alpha}$ ($\alpha \geq 0$). By introducing a kinetic term, the total energy becomes a sum of the interaction and kinetic terms, in such a way to present its own dynamics, through a Hamiltonian formulation. The Hamiltonian is given by

$$\mathcal{H} = \frac{1}{2}\sum_{i=1}^{N} \mathbf{L}_i^2 + \frac{1}{2\widetilde{N}}\sum_{i=1}^{N}\sum_{j\neq i}^{N} \frac{1 - \mathbf{S}_i \cdot \mathbf{S}_j}{r_{ij}^{\alpha}} \qquad \left(\widetilde{N} = \frac{1}{N}\sum_{i=1}^{N}\sum_{j\neq i}^{N}\frac{1}{r_{ij}^{\alpha}}\right),$$

where we are assuming a unit moment of inertia, $\mathbf{L}_i$ represents the angular momentum, and $\mathbf{S}_i$ is a classical Heisenberg spin variable (defined in a sphere of unit radius). The spins are disposed along a ring, such that r_{ij} measures the minimum distance between rotators i and j, whereas the parameter α allows one to control the interaction range. The particular case $\alpha = 0$ (the fully coupled limit) has been previously studied in Ref. [**1**], and in the $\alpha \to \infty$ limit one recovers the well-known one-dimensional nearest-neighbour-interaction model. Herein we will be interested in the cases $\alpha > 0$. We carried out microcanonical molecular-dynamics simulations using the above Hamiltonian, focusing mainly in the study of metastable, or quasi-stationary states (QSS). Our results suggest that, for $\alpha < 1$ (long-range interactions), the order in which the $N \to \infty$ and $t \to \infty$ limits are considered becomes important. Specifically, if we let $N \to \infty$ first, the system remains trapped in the QSS, never reaching the final Boltzmann-Gibbs equilibrium state.

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Synchronization as a mechanism for protein folding

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Biochemical reactions in cells require that proteins adopt a specific conformation in their native state. Experimental and theoretical studies conducted over recent decades have not fully explained the folding phenomena, despite significant advances in structural biology. Different models such as diffusion-collision and nucleation-condensation have been used to unravel how secondary and tertiary structures form during protein folding. Although such models enhance our understanding of the problem, we have still not identified a simple mechanism based on physical principles that provide an accurate description of kinetics and thermodynamics for such phenomena. In this study, we introduce the hypothesis that the synchronization of the amino acids dynamics through the cooperative movements of the peptide planes along the backbone is a mechanism that adequately explains how a protein rapidly adopts a specific three-dimensional structure. Synchronization is the ability for self-organization, wherein two or more self-sustaining dynamic systems adjust their rhythms to adopt coordinated behaviour through a low-intensity mutual influence. Such non-linear phenomena are widespread in nature and are applied in different fields of study, such as modelling cardiac cell behaviour in biology, and superconductors in physics, through Josephson junction arrays Proteins are chains of 20 different types of amino acids. Each amino acid has two degrees of freedom, and the angles of rotation around the N-Cα and Cα-C bonds are ϕ and ψ, respectively. Conversely, the peptide bond has a partial double bond character, which restricts free rotation around the N-C bond and causes H-N-C-O atoms to arrange in a conformation that defines the peptide or amide plane. The individual behavior of the peptide plane is expressed by the variation in the angles ψ of the i^{th} amino acid and ϕ of the $i{+}1^{th}$ amino acid, which identifies such a structure as an oscillating system. Therefore, we adopted a simplified representation of a protein backbone to describe its conformational dynamics, where the N peptide planes were idealized as oscillators. We draw a parallel between the folding process and dynamics for a network of coupled oscillators described by the Kuramoto model to illustrate the inherent concepts of the new proposed model. Based on the Kuramoto model, the stimulus for synchronization over a specific amino acid is not pre-determined because it arises from the interactions between the set of amino acids, constituting a typical case of self-organization. Thus, the native protein structure forms due to the mean-field forces acting on a specific amino acid sequence. Defining such forces can improve the prediction of the protein structure from sequence alone. In that sense, equivalent forces generated by homologous proteins, which evolved from a common ancestor, may explain the success of homology structural modeling. Likewise, changes in the composition of the forces caused, for example, by binding could explain the protein conformational changes seen in distant parts of the polypeptide chain, associated with the allosteric effect. We further expected that thoroughly understanding synchronization may facilitate control over the folding process and help to predict a protein's native structure from its amino acid sequence.

Ion-acoustic double-layers in magnetized plasmas with nonthermal electrons

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A double layer (DL) consists of a positive/negative Debye sheath, connecting two quasineutral regions of a plasma. These nonlinear structures can be found in a variety of plasmas, from discharge tubes to space plasmas. It has applications to plasma processing and space propulsion [**1**], and its concept is also important for areas such as applied geophysics.

The best known of these structures is the strong Langmuir DL, which is characterized by two counterstreaming plasmas, carrying a large electric current across the DL. The current-free double layer (CFDL) constitutes a different group, for which there is no trapped ion population. A DL may be regarded as a BGK equilibrium in some cases, for which certain conditions must be fulfilled. It is worth mentioning that in general the plasma distributions near a DL are strongly non-Maxwellian [**2**], with long tails observed in some cases [**3**].

In the present work we investigate a different class of double layers, the ion-acoustic double layers (non-BGK). It is believed that these structures are responsible for the acceleration of auroral electrons, for exa mple [**4**]. Considering that the plasma distributions near a DL are usually strongly non-Maxwellian, as mentioned before, we assume that the hot electron population is modeled via a κ distribution function [**5**]. The family of κ distributions has been proved to be appropriate for modeling non-Maxwellian plasmas. In its reduced form, the standard κ distribution is equivalent to the distribution function obtained from the maximization of the Tsallis entropy, the q distribution [**6**]. The parameters κ and q measure the deviation from the Maxwellian equilibrium ('nonthermality') and are related by the expression $-\kappa = 1/(1-q)$.

Here the existence of ion-acoustic double layers in magnetized two-electron plasmas is investigated. The influence of the magnetic field on the existence and structure of small amplitude DLs is analyzed, as well as the effects of quasineutrality and nonthermality. A comparison with previous works is also presented.

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Scaling laws in the dynamics of crime growth rate

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The increasing number of crimes in areas with large concentrations of people have made cities one of the main sources of violence. Understanding characteristics of how crime rate expands and its relations with the cities size goes beyond an academic question, being a central issue for contemporary society. Here, we characterize and analyze quantitative aspects of murders in the period from 1980 to 2009 in Brazilian cities. We find that the distribution of the annual, biannual and triannual logarithmic homicide growth rates exhibit the same functional form for distinct scales, that is, a scale invariant behavior. We also identify asymptotic power-law decay relations between the standard deviations of these three growth rates and the initial size. Further, we discuss similarities with complex organizations. Email addresses: [†]`lgaalves@dfi.uem.br`, [⋆]`hvr@dfi.uem.br`, [‡]`rsmendes@dfi.uem.br`.

Nonlinear diffusion equation, solutions and Tsallis framework

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We investigate the solutions of a generalized diffusion equation which contains nonlinear terms in presence of external forces and reaction terms. The solutions found here are expressed in terms of the q-exponentials functions present in the Tsallis framework and can have a compact or long tail behavior. For the last case, in the asymptotic limit, these solutions can be connected with the Lévy distributions. In addition, from the results presented here a rich class of diffusive processes, including normal and anomalous ones, can be obtained.

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

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A Boolean dynamical system integrating the main signaling pathways involved in cancer is constructed based on the currently known protein-protein interaction network [**1–3**]. 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.

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[**2**] R. Weinberg, *The Biology of Cancer* (Garland Science, New York, 2007);
[**3**] KEGG Pathway database, `http://www.genome.jp/kegg/pathway.html`.
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Classical field theory for a nonlinear Schroedinger equation

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An exact classical field theory, for a recently proposed nonlinear generalization of the Schroedinger equation, is presented. In this generalization, a nonlinearity depending on an index q appears in the kinetic term, such that the free-particle linear Schroedinger equation is recovered in the limit $q \to 1$. It is shown that besides the usual $\Psi(x,t)$, a new field $\Phi(x,t)$ must be introduced, which becomes $\Psi^*(x,t)$ only when $q \to 1$. In analogy to the linear case, $\rho(x,t) = 1/(2V)[\Psi(x,t)\Phi(x,t) + \Psi^*(x,t)\Phi^*(x,t)]$ is interpreted as the probability density for finding the particle at time t, in a given position x inside an arbitrary finite volume V, for any q. The possible physical consequences are discussed, and in particular, the important property that the fields $\Psi(x,t)$ and $\Phi(x,t)$ do not interact with light.

Overdamped motion of interacting particles in general confining potentials: Time-dependent and stationary-state analyses

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By comparing numerical and analytical results, it is shown that a system of interacting particles under overdamped motion is very well described by a nonlinear Fokker-Planck equation, which can be associated with nonextensive statistical mechanics. The particle-particle interactions considered are repulsive, motivated by three different physical situations: (i) modified Bessel function, commonly used in vortex-vortex interactions, relevant for the flux-front penetration in disordered type-II superconductors; (ii) Yukawa-like forces, useful for charged particles in plasma, or colloidal suspensions; (iii) derived from a Gaussian potential, common in complex fluids, like polymer chains dispersed in a solvent. Moreover, the system is subjected to a general confining potential, $\phi(x) = (\alpha|x|^z)/z$ $(\alpha > 0, z > 1)$, so that an stationary state is reached after a sufficiently long time. Recent numerical and analytical investigations, considering interactions of type (i) and a harmonic confining potential ($z = 2$), have shown strong evidence that a q-Gaussian distribution, $P(x, t)$, with $q = 0$, describes appropriately the particle positions during their time evolution, as well as in their stationary state. Herein we reinforce further the connection with nonextensive statistical mechanics, by presenting numerical evidence showing that: (a) In the case $z = 2$, different particle-particle interactions only modify the diffusion parameter D of the nonlinear Fokker-Planck equation; (b) For $z \neq 2$, all cases investigated fit well the analytical stationary solution $P_{\rm st}(x)$, given in terms of a q-exponential (with the same index $q = 0$) of the general external potential $\phi(x)$. In this later case, we propose an approximate time-dependent $P(x, t)$ (not known analytically for $z \neq 2$), which is in very good agreement with the simulations for a large range of times, including the approach to the stationary state.

q-Statistics modelling NMR decay of unconsolidated porous media

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The knowledge of hydrogen spin relaxation in porous media is of great interest in the oil industry and science. In this work we propose a analytical statistical function for pore size distribution, such that we can predict the T_2 distribution for a theoretical model of porous media. Applying this model to NMR transverse relaxation data, for real unconsolidated porous media, we can estimate the statistical parameters and derive the T_2 and pore size distribution. Our model with two q-exponential proved to be superior to Tikhonov inversion with one thousand of exponential functions mostly for long relaxation time and computational cost.

A representation of the Dirac delta based on the q-exponential function

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It is known that the Dirac delta function, $\delta(x)$, can be represented by $(1/2\pi)\int_{-\infty}^{\infty} e^{ikx}dk$. This representation is closely related to the definitions of the Fourier transform and its inverse. With the development of the nonextensive statistical mechanics, generalisations of the logarithm and the exponential function were conveniently done, resulting in the so-called q-logarithm and q-exponential function. These 'q-generalised' functions can be used to generalise other definitions and theorems. Thus we already have the q-Fourier transform and the q-central limit theorem. We show here that there exists a 'q-generalised' version of the representation of the Dirac delta shown above, which is based on the q-exponential function [**1**]. Moreover, we use this fact to find a formula that enables us to find a

function $f(x)$ from the q-Fourier transform of $f(x+y)$, where y is an arbitrary value of the domain of f [**2**]. This formula can be useful since the q-Fourier transform is not invertible as was shown by Hilhorst (2010).

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Generalized information deficit and quantum discord in spin chains

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We examine the quantum correlations of spin pairs in spin 1/2 chains in an applied transverse field B, through the analysis of the quantum discord and the generalized information deficit based on general entropic forms. The latter contains, as particular cases, the von Neumann based one-way information deficit, the geometric discord and the q-discord. It is shown [**1**] that all these quantities provide the same qualitative information. In the case of Heisenberg-type XY chains, they all reach full range for $|B| < B_c$, and decay smoothly with temperature. Moreover, they all exhibit a similar asymptotic behavior for high temperatures or large separation of the pair. Nonetheless, it is also shown that important differences arise in the minimizing local measurement that defines them. The information deficit exhibits a measurement transition, absent in the quantum discord, which reflects significant changes in the structure of the reduced pair state.

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Role of viscous friction in the reverse rotation of a disk

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The mechanical response of a circularly driven disk in a dissipative medium is considered. We focus on the role played by viscous friction in the spinning motion of the disk, especially on the effect called reverse rotation, where the intrinsic and orbital rotations are antiparallel. Contrary to what happens in the frictionless case, where steady reverse rotations are possible, we find that this dynamical behavior may exist only as a transient when dissipation is considered. Whether or not reverse rotations in fact occur depende on two parameters, one related to dissipation and inertia and the other related to the geometric configuration of the system. The critical value of this geometric parameter (separating the regions where reverse rotation is possible from those where it is forbidden) falls off in a q-exponential way.

Calculating the drag on a cylinder in a wind tunnel

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The Navier-Stokes equations describing the behavior of a fluid flowing. The solution of this equation for most of the problems can not be solved exactly. Therefore, in most cases the numerical approach is the best alternative to get accurate and reliable results. There are numerous methods developed exclusively to address the problem in a fluid flowing through. Recently [**1**] the method of finite differences to relaxation, was used to study the problem of a fluid flowing around a cylinder with different values of the Reynolds number. It was possible to verify the formation of mats Von Kármán. However, there was calculated the drag force on the cylinder. In this work, we use the finite difference method with relaxation

to compute the drag force on the cylinder.

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Statistical model of impact fragmentation in a disk

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In this work was 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 propagation, and the angles distribution of radial cracks was supposed to equal a uniform distribution, because of the system's simmetry.

Statistical complexity and pattern formation in cosmology

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We investigate two important questions about the use of the nonextensive thermostatistics formalism in the context of nonlinear galaxy clustering and pattern formation in cosmological scales. Firstly, we review a quantitative criterion for justifying nonextensivity at different physical cosmological scales [**1**]. Then, we discuss the physics behind the ansatz of the entropic parameter $q(r)$. Our results, from both observational and simulated data [**2**], suggest the approximate range where nonextensivity

can be justified and, hence, give some support to the applicability of $q(r)$ to the study of large-scale structures in cosmology.

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Scaling law and anti-persistent motion of annihilating defects in a lyotropic liquid crystal

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Topological defects can appear whenever there is some type of ordering. Its ubiquity in nature has been the subject of several studies, from early Universe to condensed matter. In this work, we investigated the annihilation dynamics of defects and antidefects in a lyotropic nematic liquid crystal (ternary mixture of potassium laurate, decanol and deionized-destilated water) using the polarized optical light microscopy technique for the experimental measures and statistical physics techniques for the data analysis. We analyzed *Schlieren* textures with topological defects produced due to a symmetry breaking in the transition of the isotropic to nematic calamitic phase after a temperature quench. As result, we obtained for the distance D between two annihilating defects (defect-antidefect pair), as a function of time t remaining for the annihilation, the scaling law $D \propto t^{\alpha}$, with $\alpha = 0.390$ and standard deviation $\sigma = 0.085$. This scaling law is in good quantitative agreement with previous investigations on the subject. We further present statistically significant evidence that the relative velocity between defect pairs is Gaussian distributed, anti-persistent and long-range correlated, by using DFA

analysis. Beyond that, we show that simulations of the Lebwohl-Lasher model reproduce quite well our experimental findings related to the anti-persistent behaviour. Our findings go in the direction to extend experimental results related to dynamics of defects in liquid crystals since only thermotropic and polymerics ones had been investigated. †Email address: `renatofisuem@gmail.com`.

Time-dependent Monte Carlo simulations for the refinement of critical points for extensive and non-extensive spin models

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We developed methods to determine critical parameters of the interacting spin systems based on optimization of power laws obtained under suitable initial conditions. For that, we considered the scaling relations obtained from relaxation of magnetic system initially at high temperature which is suddenly quenched to the critical temperature, which became known in statistical mechanics as “short time dynamics”. The difference of our methods in relation to the conventional short-time dynamics is to determine the critical parameters instead of only find the critical exponents when we already have an accurate estimate of the critical parameter from another method used in the equilibrium regime. We will show that our method covers not only extensive systems ($q = 1$) but also for the models under non-extensive regime ($q \neq 1$). We will present results for critical and multicritical points of the several models in Statistical Mechanics.

Bridging stylized facts in finance and data non-stationarities

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Employing a recent technique which allows the representation of nonstationary data by means of a juxtaposition of locally stationary paths of different length, we introduce a comprehensive analysis of the key observables in a financial market: the trading volume and the price fluctuations. From the segmentation procedure we are able to introduce a quantitative description of statistical features of these two quantities, which are often named stylized facts, namely the tails of the distribution of trading volume and price fluctuations and a dynamics compatible with the U-shaped profile of the volume in a trading section and the slow decay of the autocorrelation function. The segmentation of the trading volume series provides evidence of slow evolution of the fluctuating parameters of each patch, pointing to the mixing scenario. Assuming that long-term features are the outcome of a statistical mixture of simple local forms, we test and compare different probability density functions to provide the long-term distribution of the trading volume, concluding that the log-normal gives the best agreement with the empirical distribution. Moreover, the segmentation of the magnitude price fluctuations are quite different from the results for the trading volume, indicating that changes in the statistics of price fluctuations occur at a faster scale than in the case of trading volume.

Analytical solutions for a nonlinear diffusion equation: convection and reaction terms

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Exact analytical solutions are proposed for a family of nonlinear diffusion equations, which typically appears in nonlinear problems of heat and mass transfer and flows in porous media. A diffusion type solution based on a power law emerges from an ansatz useful to write a set of ordinary coupled equations that is easily solved, allowing to construct its exact solution. The result recovers its linear form as a special limit. Additionally, we apply to problems where it is considered as convection as reaction term. In this latter case, Velhurst growth and global regulation is added. Again, a power law solution is proposed to write a couple of ordinary differential equations that are easily solved, allowing to construct its exact solution. The equations admit an interpretation in terms of population dynamics and are related to the so-called conserved Fisher equation. In every case, it is possible to set the solution to the Tsallis q-exponentials. Email address: `scurilef@ucn.cl`.

On generalized entropic uncertainty relations for the quNit

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We present entropic formulations of the uncertainty principle satisfied by an arbitrary pair of quantum observables, say A and B, with discrete spectra on an N-dimensional Hilbert space (quNit). We use here the Rényi entropy H_λ to measure the ignorance or lack of information

associated to the probability distribution for the outcome of A and B eigenvalues (resp. p^A y p^B). In particular, we exhibit a non trivial minimal bound for the sum of the Rényi entropies $H_\alpha(p^A) + H_\beta(p^B)$ for any nonnegative couple of entropic indices (α, β). In the literature, such bounds are derived, using in general the Riesz-Thorin theorem, that imposes the indices to be Hölder conjugated $(1/\alpha + 1/\beta = 2)$; with our approach it is possible to go beyond the scope of the Riesz-Thorin theorem, allowing to cover all the quadrant for the couple of entropic indices. Our approach is based on two steps: (i) we first minimize the entropy of a probability vector subject to the maximum of this vector; (ii) then, we minimize the sum of the minimum entropies obtained in step (i) subject to the Landau–Pollak inequality that links the maximum of the distributions p^A and p^B. In this work we solve the problem geometrically, using mainly convexity properties (of the space of probability vectors subject to its maximal component, of the norm to optimize) and the decreasing property of the minimal entropy. It turns out that our bound only depends on the overlap c between the eigenvectors of the observables. Two situations are then distinguished versus c:

- When $c > \frac{1}{\sqrt{2}}$, the problem reduces to that of the qubit $(N = 2)$ we solved in a recent work [**1**]. The bound we obtain here is universal (state-independent), and optimal for c fixed; we exhibit pair of observables with this c so that the their exists at least one state that saturate the bound (minimizing state).

- When $c \leq \frac{1}{\sqrt{2}}$, the problem remains partially open:

  – With this procedure we show that it is not possible to improve the known sub-optimal bound evaluated by Maassen-Uffink [**2**] when α and β are Hölder-conjugated (and more generally for any couple of indices above the conjugation curve),

  – When β is larger than $\frac{\alpha}{2\alpha-1}$ (the Hölder-conjugated of α), we show that our bound improve the bound of Deutch [**3**], the only one known in this part of the plane (except in some special part of the plane [**4**]).

Recently Puchala et al. derived a bound for the sum of entropies with same index $(\beta = \alpha)$ that depends on the pair of observables [4]. Due to the optimality of our bound when $c > \frac{1}{\sqrt{2}}$ is fixed, it is obviously higher to the minimal bound of Puchala over the pairs of observables having the same overlap. When $c \leq \frac{1}{\sqrt{2}}$ this question remains open, but some, simulations seem to indicate that again our bound improve the minimal one Puchala when c is fixed.

Note finally that there exists a one-to-one mapping between the Rényi entropy and the Tsallis entropy. Thus, uncertainty inequalities satisfied by the Tsallis entropy can easily be deduced from our inequalities (the sum of the entropy being replaced by a deformed/non extensive sum). Note also that our procedure applies directly to the sum of the Tsallis entropy, allowing to derive uncertainty inequalities using the usual sum of Tsallis entropies.

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[**4**] Z. Puchala, L. Rudnicki, K. Zyczkowski, Entropic uncertainty relations and majorization, *Journal of Physics A* **46**(27), 272002 July (2013).

Deformed Pythagorean triples and Fibonacci sequences

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There are infinit solutions for the Pythagorean triples, (x, y, z) integers that satisfy $z^n = x^n + y^n$, with $n \leq 2$ ($n > 2$ has no solution, according to the celebrated Fermat's last theorem recently proved by A. Wyles). We use the deformed addition operator $\oplus_a$, defined as $x \oplus_a y = x + y + axy$ (deformed addition is frequent to appear as $a = 1 - q$), and computationally search for solutions for the Diophantine equation $z^n =$

$x^n \oplus_a y^n$. Despite the known result $a = 0$, we have observed that this generalized version, in each power n, has at least a trivial solution $(1, 1, 2)$ for the case $a = 2^n - 2$. Moreover we have found that the number of solutions, in each power n, is very scarce for $a > 0$. For instance, for $2 < n < 7$, we have found at most 1 or 2 triples for some particular values of a, for which x and y assume values limited by 10^6. Although these findings provide a negative answer for a possible generalization of Fermat's theorem, the very small number of triples indicates that $a = 0$ and $n > 2$ may correspond to a limiting case, for which, there are no triples. We have also introduced a deformation in the Fibonacci sequence as $F(n) = F(n-1) \oplus_a F(n-2)$, ($n > 1$, given $F(0)$ and $F(1)$). One particularly curious result is found with the Lucas numbers ($F(0) = 1$, $F(1) = 3$), and $a = 3$. Successive results have the number of the digit "3" that increases according to the Fibonacci's sequence. The integer part of the ratio of successive numbers $F(n)/F(n-1)$ for this instance obeys a recursive relation, and the number of digits "0" in the ratio also increases according to the Fibonacci's sequence. These investigations are rather preliminary, and up to this point they stand as a mathematical curiosity, but we suspect that there may be a more fundamental basis behind these findings.

A family of Leibniz triangles as models for correlated systems

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Many natural systems are well described by Gaussian probability distributions in the thermodynamic limit, provided that the N random variables are independent or weakly correlated. According with de Moivre-Laplace theorem, the distribution in a Bernouilli process is a Gaussian distribution in this limit. On the other hand, Leibniz triangles, also multiplied by Pascal coefficients, generate uniform distribution, that is

identified with a q-Gaussian as $q \to -\infty$. All triangles obey the Leibniz rule, for which the sum of successive elements $r_{N,n}$ at position n and $n+1$ of line N corresponds to the element n in line $N-1$ in order to ensure the total symmetry of micro-states. For triangles given by Bernoulli trials, $r_{N,0} = p^N$ and $r_{N,n} = p^{N-n}(1-p)^n$, with p and $1-p$ as the probability of independent variable. For Leibniz triangles, besides the Leibniz rule, the boundary conditions are $r_{N,0} = 1/(N+1)$. A generalization of Leibniz triangles was proposed to generate a family of correlated systems described by a q-Gaussian with $q < 1$ (A. Rodríguez, V. Schwämmle, C. Tsallis, *J. Stat. Mech.*, P09006 (2008)). For generalized Leibniz triangles with a parameter ν, such that the boundary conditions are $r^{(\nu)}_{N,n} = B(n+\nu, N+\nu-n)/B(\nu,\nu)$, in which $B(X,Y)$ stands for the Beta function, Rodriguez *et al.* have obtained analytically and numerically q-Gaussian distributions for $q = (\nu-2)/(\nu-1)$. Note that, when $\nu = 1$ and $n = 0$, the Leibniz triangles are recovered. In this work, we consider a family of Leibniz triangles to generate q-Gaussian distributions with $q > 1$ (R. Hanel, S. Thurner, C. Tsallis, *EPJ B* **72**, 263 (2009)). In this case, the boundary conditions are such that $\nu = 1/2, 3/2, \ldots$; for $\nu = 1/2$, we have $r^{(1/2)}_{N,0} = (2N-1)!/\{N[(N-1)!]^2 2^{2N-1}\}$. We expect to find q-Gaussian distributions with $q = (3+2\nu)/(1+2\nu)$ according to Hanel *et al.*.

Electronic transport through disordered wires using Stochastic Differential Equations

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Electronic transport through a disordered wire is one of the fundamental problems in mesoscopic physics. Dorokhov (1982) and (independently) Mello, Pereyra, and Kumar (1988) developed a theory to describe the evolution of the distribution function $P(\lambda_1, \lambda_2, ..., \lambda_N, L)$ with increasing wire length, where λ_i is related to the transmission eigenvalue T_i of the multimode wire through $\lambda_i = (1-T_i)/T_i$. The DMPK equation

$$l\frac{\partial P}{\partial L} = \frac{2}{\beta N + 2 - \beta} \sum_{n=1}^{N} \frac{\partial}{\partial \lambda_n} \lambda_n (1+\lambda_n) J \frac{\partial}{\partial \lambda_n} \frac{P}{J}$$

$$J = \prod_{i=1}^{N} \prod_{j=i+1}^{N} |\lambda_j - \lambda_i|^{\beta}$$

is a Fokker-Planck equation and an exact solution to that is only know for the case $\beta = 2$. The results for this equation, in most of the cases, have been obtained for the asymptotic cases $L \to \infty$ or $N \to \infty$. However, the transport properties of systems with a finite number of propagating modes are still not well understood. We also notice that there is a lack in the literature of a general approach to achieve the solutions for all the ten classes of DMPK equations.

Here we propose to rewrite the DMPK equation as an equivalent Itô Stochastic Differential Equation. With this approach we can achieve the metallic (diffusive) regime, the localised regime or the crossover (between metallic and localised) regime. We can also easily change among (at least) seven of the ten classes of DMPK equations. Using the SDE version of the DMPK equation, we numerically solved it and showed how $P(ln(\lambda_1), L)$ evolves with increasing wire length from a del ta peak around zero to a Gaussian distribution as we approach the localised regime. We also showed that the same does not happen for the BdG class without spin-reverse symmetry (as expected).

Cellular Automata simulation of people moving in confined space in the presence of obstacles

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The subject of our work is to study the behaviour os people trying to leave a confined space using some limits exits. In situations where panic took place, is it common to observe how this dynamic became extremely disorganized. Although such phenomena have many causes based in Human Nature, there are many others factors feasible to study. By physical methods including computer simulations. Many people moving and interacting themselves together is an exemple of a highly complex system,and, this way cannot be modelad as a sum of the Independent movements of single persons. The interaction among particles, in this case of people, is the main causes of the emergence of patterns that we are interested. In order to simulate such problem we discretized the room in cells and use cellular automata under some rules in order to establish the dynamic. Basically we model people as particles traped in a discretized container (i.e. A Room) and the rules of movements are taken under the influence of a "Floor Field" created using Manhattan distances to the exits. We apply the model in a case study of a seminar room located at ICEB/UFOP. We study then how the number, the disposition and the size of the exits affect the time necessary to take all the people out of the room. Supported by Capes, CNPq and Fapemig.

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Constantino Tsallis was born in Athens-Greece, grew up in Argentina, and acquired the Brazilian citizenship since 1981. He works in the area of statistical mechanics, and presently heads the National Institute of Science and Technology for Complex Systems of Brazil. He obtained his title of Docteur d'État ès Sciences Physiques from the University of Paris-France in 1974. He has worked in a variety of theoretical subjects in the areas of critical phenomena, chaos and nonlinear dynamics, economics, cognitive psychology, immunology, population evolution, among others. Since over two decades, he is focusing on the entropy and the foundations of statistical mechanics, as well as on some of their scientific and technological applications. Indeed, he proposed in 1987 and formally published in 1988 a generalization of the Boltzmann-Gibbs entropy and its associated statistical mechanics. This generalization is presently being actively studied around the world: a Bibliography containing more than 4,000 directly related articles, by more than 6,000 scientists from all over the world, is available at `http://tsallis.cat.cbpf.br/biblio.htm`. Prof. Tsallis' contributions have received over 13,000 ISI citations (more than 3,000 of them for his 1988 paper), which currently makes him one among the most cited scientists of all times in Latin America. He has received many international and national distinctions (Guggenheim Foundation Award, Mexico Prize for Science and Technology, Rio de Janeiro Prize of Science and Technology, among many others), and has been given in four occasions the title of Doctor Honoris Causa by Universities from Argentina (Cordoba), Brazil (Maringa and Natal) and Greece (the Thessaloniki Aristotelian University). He is member of the Academy of Sciences of Brazil, as well as of the Academy of Economical, Political and Social Sciences of Brazil. He received in 2012 the highest distinction from the Academy of Athens. He is main editor of Physica A – Elsevier (Amsterdam), and has supervised close to 40 Doctor and Master Thesis. He has given regular undergraduate and graduate courses in Physics in Brazil, Argentina, USA, France and Germany, and has given over 900 invited lectures around the world. Prof. Tsallis is an external Professor of the Santa Fe Institute, New Mexico.

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