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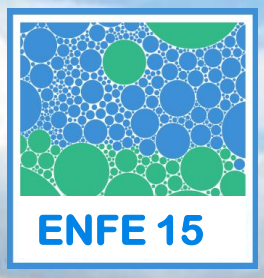

Encontro Nacional de Física Estatística

1-4 de Novembro de 2015
Vitória-ES

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Plenary talks (8:30 - 10:00)

PLENARY SESSION

[02/11/2015 - 09:00 - Room Vitória]
A random walk picture of basketball scoring and lead-change dynamics, Aaron Clauset, Marina Kogan, Sid Redner, *Santa Fe Institute* ■By analyzing recently available play-by-play data from all regular-season games from multiple seasons of the National Basketball Association (NBA), we present evidence that, basketball scoring during a game is well described by a continuous-time anti-persistent random walk. The time intervals between successive scoring events follow an exponential distribution, with essentially no correlations between different scoring intervals. We will also argue that the heterogeneity of team strengths plays a minor role in understanding the statistical properties of basketball scoring.
As intriguing applications of this random-walk picture, we show that: (i) the distribution of times when the last lead change occurs, (ii) the distribution of times when the score difference is maximal, and (iii) the distribution for the fraction of game time that one team is leading are all given by the celebrated arcsine law–a beautiful and surprising property of random walks. We also use the random-walk picture to construct the criterion for when a lead of a specified size is "safe"as a function of the time remaining in the game. This prediction generally agrees with comprehensive data on more than 1.25 million scoring events in roughly 40,000 games across four professional or semiprofessional team sports, and are more accurate than popular heuristics that are currently used in sports analytics.

[02/11/2015 - 09:30 - Room Vitória]
CLUSTER APPROACH TO GELS AND GLASSES, A. Coniglio, *CNR-SPIN, Department of Physics, University of Naples "Federico II", Via Cinthia, 80126 Napoli, Italy* ■A percolation theory is presented to describe the dynamics of the sol-gel transition[1]. The same approach at mean field level is shown to describe also the dynamical critical behavior predicted by mode coupling theory (MCT) for the continuous glass transition[2]. A similar approach is extended to MCT for the discontinuous glass transition, more appropriate to describe the standard molecular glass transition. It is shown that the relevant model now is given by Bootstrap Percolation. This approach will provide a geometrical and physical interpretation of the critical exponents, elucidating the scaling laws and the universal aspect of MCT.

[1] A. Fierro, T. Abete and A. Coniglio, J. Chem. Phys. 131, (2009) 194906.
[2] J..J. Arenzon, A. Coniglio A. Fierro, and M. Sellitto. Phys. Rev. 90, (2014) 020301(R)

Posters (10:00-11:00 / 16:05-17:05)

COMPLEXITY & INTERDISCIPLINARY TOPICS

[02/11/2015 - P001]
Spatial organization and mobility effects in collective hunting and defense strategies of predator-prey systems, Annette Cazaubiel, *École Normale Supérieure - International Center of Fundamental Physics, Paris - France*, Alessandra F. Lütz, Jeferson J. Arenzon, *Instituto de Física - UFRGS , Porto Alegre RS - Brasil* ■There is a myriad of strategies that predators utilize to increase their rate of success. Among them, preys may be attacked in a cooperative, coordinated way, these actions being correlated in space and time. The number of known examples of coordinated hunting, whether intra or interspecies, has increased in the last years and examples include hawks, crocodiles, spiders, etc. Although there are some additional costs, hunting or defending in group may bring several benefits for predators and preys, respectively, what have been widely studied. Despite these mounting evidences, much less attention has been dedicated to model such behavior.
This problem has been recently considered within a game theoretical framework in which the abundances of preys and predators were assumed constant and only the fraction of those populations using either an individual or collective strategy evolves. Lett et al (2004 Theor. Pop. Biol. **65** 263) considered a mean field approach in which these densities are described by Lotka-Volterra-like equations, taking into account some of the advantages and disadvantages for both preys and predators choosing a grouping strategy. More specifically, it is assumed that grouping lowers the risk of predation at the cost of increasing the competition for resources, while predators have a greater probability of success at the expense of having to share the prey with others.
We present a spatial version of this model that locates individuals or groups on a lattice and study it in the limits of both low and high population viscosity (with or without diffusion, respectively), and compare these results with the mean field predictions. Of particular interest is the coexistence region with both grouped and individual predators and prey persist within the population. When compared with the mean field case, fundamental differences appear and are strongly affected by finite size effects.

[02/11/2015 - P002]
Density classification performance of the Gacs-Kurdyumov-Levin four-states cellular automaton model IV and related automata, J. Ricardo G. Mendonça, Rolf E. O. Simões, *EACH/USP* ■Almost four decades ago (in 1978), Gacs, Kurdyumov, and Levin (GKL) introduced three different cellular automata (CA), which they called models II, IV, and VI, to investigate whether nonequilibrium interacting particle systems are capable of displaying phase transitions. Their objective was to examine the "positive probabilities conjecture," according to which one-dimensional particle systems with short-range interactions and positive transition probabilities are always ergodic. This conjecture has been disproved—much

to the awe of the practicing community—many times since then, with the introduction of several models that have become archetypal models in theoretical computer science and nonequilibrium statistical mechanics.
As a by-product of their investigations, GKL introduced the density classification problem in the cellular automata literature. The density classification task consists in classifying arrays of symbols according to their initial density of symbols using local rules, and is completed successfully if a correct verdict as to which was the initial majority state is obtained in time at most linear in the size of the input array. Density classification is a nontrivial task for CA in which cells interact over finite neighbourhoods, because then the cells have to achieve a global consensus cooperating locally only. Ultimately, that means that information should flow through the entire system, be processed by the cells, and be not destroyed or become incoherent in the process—entropy must loose to work in the task, a relevant property in the theoretical analysis of data processing and storage under noise. For one-dimensional locally interacting systems of autonomous and memoryless cells, emergence of collective behavior is required in these cases. In this context, GKL model II has been extensively scrutinized as a model system related with the concepts of emergence, communication, efficiency, and connectivity. The other two GKL models, however, did not receive much attention.
Here we characterize the density classification performance of Gacs, Kurdyumov, and Levin's "model IV," a four-states cellular automaton with three absorbing states, by Monte Carlo simulations. We show that model IV compares well with its sibling model II in the density classification task, the additional states being barely relevant for its performance. We also investigate the performance of model IV under the influence of noise and show that it cannot perform the density classification task reliably at any nonzero level of noise, an indication that, most probably, it becomes ergodic in this case.

[02/11/2015 - P003]
Discrete Scale Invariance in Self-Organized Criticality Systems, André Luis Brito Querino, *Universidade de São Paulo USP* ■Recently, studies have shown evidence of log-periodic behavior in non-hierarchical systems. A known case of log-periodicity or discrete scale invariance are systems that have a geometric hierarchy, for example the model Potts on the diamond structure. The usual solutions of the renormalization group show that such systems have power laws $\frac{1}{x^b}$ with complex exponents $b \in \mathbb{C}$ when near a critical point. An interesting fact is the emergence of such properties in real systems, for instance rupture and breakdown of complex materials and financial crashes. These may be examples of complex systems with self-organized criticality (SOC).
The detection of discrete scale invariance, or log-periodicity in non-hierarchical systems presents numerous difficulties. Parametric estimates using log-periodic functions can be flawed due to large fluctuations in values, beyond the problem of degeneracy and multiple local minima in parametric regression estimation. For these reasons most research focuses on the use of nonparametric methods in detecting discrete scale invariance. A method widely used for the study of log-periodic data is to make a change of variable t for a new log-time $\tau \equiv \ln(t_c - t)$, then to study the power spectrum of the new series thus generated. A consequence of this method is the non-uniformity of the sample data, i.e. unequal spacing between data points. The FFT-based techniques are not applicable, but one solution is to use the *Lomb periodogram of Scargle*, which is suitable for unevenly sampled points.
We applying this method to study the Brazilian financial market, with the aim of detecting discrete scale invariance in the Bovespa (Bolsa de Valores de São Paulo) stock market index. Some historical price series have been selected for the periods in 1999, 2001 and 2008. We report evidence of detection of possible log-periodicity before breaks.

[02/11/2015 - P004]
Study of String-Like Excitations in Artificial Spin Ice Through Linear Chains of Magnetic Dipoles, Denis da Mata Oliveira, Lucas Alvares da Silva Mól, *UFMG* ■In this work we study a system of classical magnetic Ising-like dipoles (spins) on the square lattice interacting exclusively by magnetic dipolar interaction. The spins are positioned in sequence, forming linear chains on the lattices links (strings), parallel to its plane. These strings are constructed by Self-Avoiding Walks (SAW's). For each string length, we generate all reachable microstate the system in order to make the accurate analysis of the system through the canonical ensemble. Our purpose is to better understand the behavior of excitation type strings in artificial spin ice, since the studied chains are similar to those excitations, which present as remarkable feature the presence of magnetic monopole quasi-particles associated to its extremes. The studied system is similar to the homopolymers in network-based SAW's. We observed signs of phase transition which are analyzed by such quantities as the end-to-end distance and the radius of gyration. Among the phase transition signs observed, the compact-extended transition of strings is well identified, such as the θ-transition of homopolymers. We also present some results for the hexagonal lattice. We observed that the low temperature properties of the square lattice are determined by configurations that satisfy a rule of alternation in the direction of the walk, while in the hexagonal lattice the minimum end-to-end distance is the key factor.
Thanks financial support: CNPq e FAPEMIG.

[02/11/2015 - P005]
Role of dimensionality of complex networks with metrics: Connection with nonextensive statistical mechanics, S.G.A. Brito, L.R. da Silva, *Departamento de Física Teórica e Experimental - UFRN*, C. Tsallis, *Centro Brasileiro de Pesquisas Físicas - CBPF and Santa Fe Institute* ■The study of networks is perceived in several fields of the science since many real systems can be modeled as networks. The networks are everywhere from social science to physics, biology, economics and other areas. Over the last decade a large number of empirical studies has been identifying peculiar properties in very different networks, for instance, the Internet and Online Social Networks (e.g. Facebook) to citation networks and networks of neurons. Over the past years the concept of nonextensive statistical mechanics has been extremely successful in applications of the

complex systems, in particular, on the complex networks. Deep connections are known to exist between scale-free networks and non-Gibbsian statistics. For example, the typical degree distributions at the thermodynamical limit are of the form $P(k) \propto e_q^{-k/\kappa}$, where the q-exponential form $e_q^z \equiv [1 + (1-q)z]^{\frac{1}{1-q}}$ optimizes the nonadditive entropy S_q, basis of nonextensive statistical mechanics (which recovers Boltzmann-Gibbs statistical mechanics at the $q \to 1$ limit). We introduce and study here d-dimensional growing networks with preferential attachment involving Euclidean distances through $r_{ij}^{-\alpha_A}$ ($\alpha_A \geq 0$). Reinforcing the connection with q-statistics we numerically verify that the q-exponential degree distributions exhibit, for both q and κ, universal dependences on the ratio α_A/d. Moreover, the $q = 1$ limit is exponentially achieved by increasing α_A/d to infinity.

[02/11/2015 - P006]
Contribution to the study of complex networks: Affinity model with metrics, S.G.A. Brito, L.R. da Silva, *Departamento de Física Teórica e Experimental - UFRN* ■Currently the interest in large-scale systems with a high degree of complexity has been much discussed in the scientific community in various areas of knowledge. As an example, the Internet, protein interaction, collaboration of film actors, among others. To better understand the behavior of interconnected systems, several models in the area of complex networks have been proposed. Barabási and Albert proposed a model in which the connection between the constituents of the system could dynamically and which favors older sites, reproducing a characteristic behavior in some real systems: connectivity distribution of scale invariant. However, this model neglects two factors, among others, observed in real systems: homophily and metrics. Given the importance of these two terms in the global behavior of networks, we propose in this dissertation study a dynamic model of preferential binding to three essential factors that are responsible for competition for links: (i) connectivity (the more connected sites are privileged in the choice of links) (ii) homophily (similar connections between sites are more attractive), (iii) metric (the link is favored by the proximity of the sites). Within this proposal, we analyze the behavior of the distribution of connectivity and dynamic evolution of the network are affected by the metric by α_A parameter that controls the importance of distance in the preferential binding) and homophily by η (characteristic intrinsic site). We realized that the increased importance as the distance in the preferred connection, the connections between sites and become local connectivity distribution is characterized by a typical range. In parallel, we adjust the curves of connectivity distribution, for different values of α_A, the equation $P(k) = P_0 e_q^{-k/\eta_q}$ from the statistical non-extensive Tsallis.

[02/11/2015 - P007]
Sympatric multiculturalism or how distrust polarizes societies of Bayesian agents into groups, Felippe Alves, Nestor Caticha, *IF Universidade de São Paulo* ■While social interactions tend to decrease differences in opinions, multiplicity of groups and individual opinion differences persist in human societies. Axelrod identified homophily and social conformity seeking as basic interactions that can lead to multiculturalism in spatial scenarios in models under certain special conditions. We follow another route, where the social interactions between any two agents is given by the descent along the gradient of a cost function deduced from a Bayesian learning formalism. The cost functions depends on a hyperparameter that estimates the trust of one agent on the information provided by the other. If the expected value of the total cost function is relevant information, Maximum Entropy permits characterizing the state of the society. Furthermore we introduce a dynamics on the trust parameters, which increases when agents concur and decreases otherwise. We study the resulting phase diagram in the case of large number of interacting agents on a complete social graph, hence under sympatric conditions. Simulations show that there is evolution of assortative distrust in rich cultural environments measured by the diversity of the set of issues under discussions. High distrust leads to antilearning which leads to multiple groups which hold different opinions on the set of issues. We simulate conditions of political pressure and interaction that describe the House of Congress of Brazil and are able to qualitatively replicate voting patterns through four presidential cycles during the years of 1994 to 2010.

[02/11/2015 - P008]
Spectral analysis of complex network with tunable degree distribution and clustering, Roberta Pires Lins Machado, Josué Xavier de Carvalho, *Universidade Federal do Rio de Janeiro - Campus Xerém* ■Network models provide a natural way to describe real data set in diverse fields as for example biology, sociology, ecology, internet, global economy and many others. Real networks display topological features, such as heavy tail degree distribution, high clustering coefficient and assortativity or disassortativity, that can not be modeled by a totally regular or random graphs. Many random network models has been proposed with the aim to capture features regularly found in empirical networks. Two of most studied classes of such models are the Scale-free network model (SF) and the Small-world network model (SW). The original SF model display power law degree distribution and vanishing clustering coefficient in the limit of large networks. The SW model interpolates between regular and random network by means a parameter p, that characterizes the disorder in the system. For small values of p the model exhibits high clustering coefficient. Since each graph/network can be represented by a matrix (adjacency, laplacian or normalized laplacian) its spectra (eigenvalues and eigenvectors) encodes information about its topology. The fluctuations of networks spectra can be analysed through the framework of Random Matrices Theory (RMT). Results for SW model have revealed that as the disorder level increases (decreasing clustering coefficient) the spectral fluctuations follows the description of a transition between two different ensemble of RMT (Poisson-GOE transition). The main focus of this work is to clarify the effects of clustering on the spectral properties of complex networks. The clustering quantifies the likelihood that two neighbors of a vertex are neighbors themselves and it is related to number of triangles in the network (the vast majority of real networks display a high density of triangles). The spectra of totally random networks (no correlation between vertices) is well descri-

bed by GOE ensemble of RMT. According to RMT it is expected that network models with high clustering (correlation) deviates from GOE prediction. Here we analyse under the RMT framework the spectral properties of different classes of random networks where both the degree-dependent clustering coefficient and the degree distribution are tunable with special attention to the Scale-free networks.

[02/11/2015 - P009]
A resource based model for the competition of two species with different metabolic pathways, André Amado[†], Jorge Lenin[†], Weini Huang[‡], Paulo R. A. Campos[†], Fernando F. Ferreira[§], [†]*Evolutionary Dynamics Lab, Department of Physics, Federal University of Pernambuco, 50670-901, Recife-PE, Brazil* [‡]*Department Evolutionary Theory, Max Planck Institute for Evolutio* ■The evolution of cooperation is one of the most intriguing conundrum in evolutionary biology. Natural selection favours traits that increase individuals ability to reproduce or survive. One individual is said to be cooperative if it provides a benefit to another individual or to a group at the expense of its own relative fitness. According to evolutionary theory, such cooperative behaviour is detrimental to the individual and should be counter-selected. Instead, the selfish behaviour is expected to rise and invade in a group of cooperators. However, cooperation is observed everywhere. Despite the greater attention the issue has received in the last decades our understanding about the underlying mechanisms that explain the emergence and maintenance of cooperation is still poor. Here we combine the frameworks of resource-based modeling and evolutionary game theory to study the conditions under which cooperative strains can thrive in the context of metabolic pathways.
Heterotrophic organisms can produce adenosine triphosphate (ATP) from two different mechanisms: inefficient (high rate) in which high amount of resources is consumed or efficient (high yield) with less resource consumption. Despite cells with a higher rate but lower yield of ATP production may have a selective advantage compared with high yield cells, the latter is abundant in nature. To be well succeeded the high yield cells behave as a cooperative organism while high rate cells are non-cooperative. This problem can be posed in terms of competition between cooperative and selfish cells. Here we investigate the probability that a cooperative trait can invade a population of defectors (high rate of consumption, but low yield of conversion of research into energy) by using multilevel selection, where individuals (cells) are organised into groups. Selection occurs at both individual and group levels. Selection at the group level stems from differentiated growth rates that vary according to the group's composition. We show in what conditions high yield cells can invade a population of high rate metabolic cells. One of the motivation to study this problem is understanding the transition of unicellular organism (high rate) to multicellular (high yield).

[02/11/2015 - P010]
Slow relaxation dynamics and aging in random walks on activity driven temporal networks, Angélica Sousa da Mata, *Universidade Federal de Lavras*, Romualdo Pastor-Satorras, *Universitat Politècnica de Catalunya* ■The heterogeneous topology of a complex network can have a very relevant impact on the properties of dynamical systems running on top of it. Already classical studies in network science have thus shown that a heterogeneous connectivity pattern can lead to a null percolation threshold, set a strong resilience against random failures, as well as to induce a vanishing epidemic threshold for disease propagation. Similar and additional remarkable effects have been observed in a wide variety of dynamical processes. Such dynamical effects, originally reported for static networks, in which nodes and edges are fixed and do not change over time, can take a different, more complex turn when one considers the intrinsic time-varying, temporal nature of many real networks. Indeed, networked systems are often not static, but show connections which appear and disappear with some characteristic time scales. Social networks represent the prototypical example of this behavior, being defined in terms of a sequence of social contacts that are continuously established and broken. This mixing of time scales can induce new phenomenology on dynamics on temporal networks, in stark contrast with what is observed in static networks. Moreover, the bursty nature of the time evolution of temporal network contacts, characterized by long stretches of inactivity, interspersed by bursts of intense activity, can complicate the picture, inducing for example a dynamical slowing down in dynamical processes as varied as epidemic spreading, diffusion or synchronization. The random walk is one of the simplest dynamical processes, although still underlying many practical realistic applications such as diffusion, searching, community detection and spreading dynamics. Even in this simplest of cases, a time-varying substrate can induce very noticeable differences with respect to the behavior expected in static networks. In this work, we investigate the dynamic relaxation of random walks on temporal networks by focusing in the recently proposed activity driven model [N. Perra, *et. al.* Sci.Rep. 2, 469 (2012)]. For realistic activity distributions with a power-law form, we observe the presence of a very slow relaxation dynamics compatible with aging effects. A theoretical description of this processes in achieved by means of a mapping to Bouchauds trap model. The mapping highlights the profound difference in the dynamics of the random walks according to the value of the exponent γ in the activity distribution. Acknowledgements and Financial Support: FAPEMIG, CAPES and CNPq.

[02/11/2015 - P011]
Nonequilibrium phase transitions in a model of tax evasion dynamics, Rafael Mynssem Brum, Nuno Crokidakis, *Instituto de Física, Universidade Federal Fluminense, Niterói/RJ, Brazil* ■The agent-based modeling of social interactions is one of the most interesting problems in statistical physics and it has been extensively explored due to its high degree of applicability (opinion dynamics, spreading of diseases, systems with competing dynamics, rumor spreading, etc). Its results are also very important from the point of view of an organized society (stationary behavior of a disease, epidemic cycles, predominance of a certain political position and many others).
In this work, we study the tax evasion dynamics in a artificial society. In this case, we consider three types

of individuals in relation to tax compliance: honest, tax evaders and undecided individuals. We analyze the social interactions that may occur among these individuals and autonomous decisions, and we consider our population as a fully-connected network of N nodes, that characterize a mean-field-like approach. Through analytical and numerical results, we found that even if initially there are no tax evaders in the population, these individuals may emerge in the society, and its fraction may stabilize in the population, depending on certain socio-economic parameters (efficiency of the influence of certain individuals over others, autonomous decisions, punishment rules, etc). We show that this emergency of tax evaders is associated with a nonequilibrium phase transition.

COMPLEXITY & INTERDISCIPLINARY TOPICS

[02/11/2015 - P012]
On a connection between a class of q-deformed algebras and the Hausdorff derivative in a medium with fractal metric, José Weberszpil, *Universidade Federal Rural do Rio de Janeiro, UFRRJ-IM/DTL, Av. Governador Roberto Silveira s/n, Nova Iguaçú, Rio de Janeiro, RJ, Brazil*, Matheus Jatkoske Lazo, *Universidade Federal do Rio Grande-FURG, Instituto de Estatística e Física, Rio Grande, RS, Brazil*, José Abdalla Helayël-Neto, *Centro Brasileiro de Pesquisas Físicas-CBPF-Rua Dr Xavier Sigaud 150, 2290-180, Rio de Janeiro, RJ, Brazil* ■Over the recent decades, diverse formalisms have emerged that are adopted to approach complex systems. Amongst those, we may quote the q-calculus in Tsallis version of Non-Extensive Statistics with its undeniable success whenever applied to a wide class of different systems; Kaniadakis approach, based on the compatibility between relativity and thermodynamics; Fractional Calculus (FC), that deals with the dynamics of anomalous transport and other natural phenomena, and also some local versions of FC that claim to be able to study fractal and multifractal spaces and to describe dynamics in these spaces by means of fractional differential equations. The question we might ask is whether or not there are common aspects that connect these alternative approaches. In this short communication, we discuss a possible relationship between q-deformed algebras in two different contexts of Statistical Mechanics, namely, Tsallis framework and Kaniadakis scenario, with local form of fractional derivative operators defined in fractal media, the so-called Hausdorff derivatives, mapped into a continuous medium with a fractal measure. This connection opens up new perspectives for theories that satisfactorily describe the dynamics for the transport in media with fractal metrics, such as porous or granular media. Possible connections with other alternative definitions of FC are also contemplated. Insights on complexity connected to concepts like coarse-grained space-time and physics in general are pointed out.

[02/11/2015 - P013]
Critical aspects of bifurcations in a geometrical approach, A. Mihara, *Universidade Federal de S. Paulo* ■Bifurcation is a qualitative change that occurs in the behavior of a dynamic system when the value of a (control) parameter undergoes a small and smooth change. In complex systems bifurcations can be associated with phase transitions in many different contexts: from ecosystems to models of information traffic on the Internet, and from epidemic to social models.
But if a complex system undergoes a phase transition when the control parameter reaches some critical value, which are the critical aspects (in the sense of thermodynamics / statistical mechanics) of such a transition? Trying to answer this question, it is presented an exploratory study, based on Thermodynamic Geometry (TG), of the critical aspects of some common bifurcations (e. g. transcritical, saddle-node, etc.).
Thermodynamic Geometry (TG), also called Information Geometry, is an approach based on Riemannian geometry for the study of thermodynamical systems in equilibrium. The main idea is that the space of equilibrium states of a system is described by a metric, which is proportional to the Hessian matrix of entropy (or another thermodynamic potential) of the system with respect to the thermodynamic parameters. In this context, the notion of "distance" between two states is associated with probability of fluctuation between them: the less likely the fluctuation between the states, more distant they are. From the metric one can obtain the corresponding geodesic equations and curvature scalar R, which in turn is proportional to the correlation volume ξ^d and therefore closely related to phase transitions.
In order to study the critical aspects of bifurcations in such a geometrical approach, the normal form (described by a nonlinear first-order differential equation) of each bifurcation is regarded (after some appropriate transformations) as a geodesic equation of some hypothetical model. With this we obtain the corresponding metric, curvature scalar and also the exponent α, analogous to the critical exponent of specific heat in a typical thermodynamical system.

[02/11/2015 - P014]
Mean-field approximation for the Sznajd model in complex networks, Maycon S. Araújo, André M. Timpanaro, Carmen P. C. do Prado, *USP - SP - Brazil*, Fábio S. Vannucchi, *UNESP - SP - Brazil* ■We will present a work in which we revisited mean fied approximations to the Sznajd model for opinion formation in a population connected through a general network. A master equation describing the time evolution of opinions is presented and solved in a hybrid approach. Based in a mean-field approximation, we were able to include some features of the underling structure of the network though the estimate of some network parameters. Although quite simple, this approximation allows us to capture the most important features regarding the steady states of the model. When spontaneous opinion changes are included, a discontinuous transition from consensus to polarization can be found as the rate of spontaneous change is increased. The main point in this work is the presentation of a hybrid mean-field approach, that includes interactions between second nearest neighbors, that are necessary to estimate correctly the critical point of the transition. The analytical prediction of the critical point is also compared with numerical simulations in a wide variety of networks, in particular Barabási-Albert networks, finding reasonable agreement despite the strong approximations involved. The same hybrid

approach that made it possible to deal with second-order neighbors could just as well be adapted to treat other problems such as epidemic spreading or predator-prey systems. The work has been published in PRE 91, 022813 (2015).

[02/11/2015 - P015]
Interspike intervals in neuronal networks with self-organized criticality, Osame Kinouchi, Ariadne A. Costa, Lézio Bueno, Geraldine Bosco, *Universidade de São Paulo*, Mauro Copelli, *Universidade Federal do Pernambuco* ■The distribution of interspike intervals (ISI) for individual neurons is a standard measure in neuroscience. Recently the idea that neuronal networks works near the critical point of an absorbing state transition has been explored, with a lot of theoretical and experimental results. Surprisingly, it appears that the distribution of ISI for neurons pertaining to a critical network has not been measured yet. Here, we model the generation of interspike intervals in neuronal systems with self-organized criticality by two methods. First, we use a simple stochastic model where interavalanches intervals (IAI) are generated from a power law distribution, and interspike intervals are sums of IAI between two times where a neuron spikes because it pertains to an avalanche (modeled by a neuronal size avalanche distribution $P(S) = cS^{-3/2}$). Second, we perform a full simulation in a network of excitable elements (neurons) with dynamical synapses which presents well behaved self-organized criticality. In this simulation we define avalanches as sequential activity above some threshold level of active sites. This enables us to define interavalanches (IAI) and interspikes intervals (ISI) and construct histograms for them. We compare these results with ISI distributions that present power law tails from real neurons from cortical and thalamic areas of freely behaving rats. We find that self-organized criticality can explain power laws in the tail of ISI distributions of neurons and that such power laws in single neurons could suggest the presence of criticality at the network level.

[02/11/2015 - P016]
Cooperation in two-dimensional mixed-games, Marco Antonio Amaral, Jafferson Kamphorst Leal da Silva, Lucas Wardill, *Universidade Federal de Minas Gerais - MG - Brasil, University of British Columbia - Vancouver Vancouver, BC, Canada* ■Evolutionary game theory is a common mathematical framework to study the evolution of cooperation in selfish systems, specially using the Prisoners Dilemma game, where it is usually assumed that the same game is played in all interactions. Here, we investigate a model where the game that is played by two individuals is uniformly drawn from a sample of two different games at each iteration. Using the master equation approach we show that the random mixture of two games is equivalent to play the average game when (i) the strategies are statistically independent of the game distribution and (ii) the transition rates are linear functions of the payoffs. This result still holds using Pair-Approximation for a small cluster of 8 sites arranged in a square lattice. We also use Monte-Carlo simulations in a two dimensional lattice to investigate the scenario when the two above conditions do not hold, i.e. we use the Fermi-Dirac distribution for the transition rates. We find that even outside of such conditions, several quantities characterizing the mixed-games are still the same as the ones obtained in the average game when the two games are not very different. Also we find interesting results regarding how the heterogeneity of the games played can increase the final fraction of cooperators above the usual mean game limit. We would like to thanks FAPEMIG and CNPq for the financial support given.

[02/11/2015 - P017]
Differences between quenched and annealed neuronal networks with self-organized criticality, Ariadne de Andrade Costa, Osame Kinouchi, *FFCLRP - USP - SP - Brasil*, João G. F. Campos, Mauro Copelli, *UFPE - PE - Brasil* ■In a recent work, mean field analysis and computer simulations were employed to analyze critical self-organization in an annealed network of excitable cellular automata (SIRS) neuronal networks, where randomly chosen synapses are depressed after each neuron spike. Calculations agree with simulations of the annealed version, showing that the nominal branching ratio (σ) converges to the critical value $\sigma_c = 1$ and fluctuations vanish in the thermodynamic limit, as expected of a self-organized critical system. However, the question remains whether the same results occurs to the quenched version of the model (which is biologically more plausible) where neighborhoods are fixed and only the acting synapses are depressed. We have seen that simulations of the quenched model yield a stationary value $\sigma(t \to \infty) = 1.105$ which is a significant deviation from $\sigma = 1$, due to spatio-temporal correlations produced by avalanches. However, the model is shown to be critical, as the largest eigenvalue λ of the synaptic matrix is shown to approach $\lambda_c = 1$, with fluctuations vanishing in the thermodynamic limit. We also study the influence of the recovery and decay synaptic parameters in both types of models, as well the influence of the number of neighbors. As a future work, we intend to study the distribution of interspike intervals in this kind of neuronal networks.

[02/11/2015 - P018]
Real genomic representation for topopatric speciation, Camilo Rodrigues Neto, Sergio Candido de Oliveira Junior, *EACH, University of Sao Paulo, Brasil* ■The evolutionary theory for speciation has produced several models to explain the diversity of life. Four of these models are called alopatric, peripatric, parapatric and sympatric, named after the predominant kind of genetic flux disturbance acting among the population. Physical barriers and ecological interactions are the two usual factors.
Recently, a new kind of speciation was proposed [Aguiar, 2009]. The model is based in selective mating determined by genetic affinity and spatial proximity. The model does not include any kind of geographical barrier, ecological interaction or natural selection. This new kind of speciation is named topopatric, as it emphasize the role of the spatial auto organization of the species origin and distribution. The usual approach is to represent a specimen as a binary string, and defying usual genetic algorithm with crossover and mutation operators, but without the selection phase. Differences between individuals reproductive rates are randomly attributed at reproduction time, rather than being due to any special ability.

We present a modified model with a real-coded genetic algorithm, where the specimens are represented by real numbers, with modified crossover and mutation operators. The reproductive rates are similar to the previous binary model. We studied the number of new species, the abundance of the species, and the distribution of the species over space in function of the genomic distance tolerance, the searchable radius for mating, the migration and the random reproductive rate. All simulations start with an initially uniform population, with the same real coded genetic algorithm crossover and mutation operators, and were performed in torus and ring like spatial setups. The results resemble the ones already reported in the literature, but are not strictly equivalent. We attribute this difference mainly to topological differences in the space of the genome representation.

Aguiar, M. A. M., et al. "Global patterns of speciation and diversity."Nature 460.7253 (2009): 384-387.

[02/11/2015 - P019]

Long-range correlations of the wind velocity in Salvador-BA, José Vicente Cardoso Santos, Davidson Martins Moreira, Marcelo A. Moret, *SENAI CIMATEC* ■The use of wind energy has been increasingly adopted worldwide. In Brazil, the Northeast has been a strong investment option in the industry because recent wind maps have been made and show high attendance rates winds around its coastline and in some cases inside. Notwithstanding this great wind potential scenario, Brazil has this alternative source of energy with a low representation in its energy mix. Thus, in order to justify an increase in interest and reliability in this alternative source of energy, is presented in this paper a preliminary analysis of time series representing the intensity records and wind direction in fixed unit of data collection on the drive SENAI / CIMATEC in Salvador, Bahia. This analysis is done by Destrended Fluctution Analysis method (DFA). Using this method substantiates the viability of wind farms installations in the areas of collection, because it indicates the possibility of long-range correlation in the distribution of magnitudes analyzed what may prove the function of the constancy of the wind flow, and, with this, enable the facilities of wind turbines more efficiently and effectively. Preliminary results indicate that the number of local data is persistent in direction, speed and related thermodynamic quantities, which corroborates the feasibility of wind participation in local energy matrix.

Keywords: Renewable Sources. DFA. Complexity. Wind Energy.

FUNDAMENTAL ASPECTS OF STATISTICAL MECHANICS

[02/11/2015 - P020]

Chaos and relaxation to equilibrium in systems with long-range interactions, Felipe L. Antunes, Fernanda P. C. Benetti, Renato Pakter, Yan Levin, *Universidade Federal do Rio Grande do Sul* ■In the thermodynamic limit, systems with long-range (LR) interactions do not relax to equilibrium, but become trapped in non-equilibrium stationary states. Once a system is trapped in a non-equilibrium state, two outcomes are possible: if the system has a finite number of particles N, residual correlations will eventually drive it to thermodynamic equilibrium (if such equilibrium exists, which is not the case for 3d gravitational systems) after a time $t_\times$ which scales with N as $t_\times \sim N^\delta$, where δ is a system specific exponent. On the other hand, in the thermodynamic limit, $N \to \infty$, the system will remain trapped in a stationary state forever. In this collisionless limit, the relaxation to stationarity is a result of Landau damping, which transfers the energy of collective oscillations to the individual particles. Once the oscillations of the mean-field potential die out, the particles will move in a static mean-field potential. If a system has sufficient symmetry, the motion of particles in a static potential will be integrable, and the ergodicity will be irrevocably broken. In this paper we will explore the role of chaotic dynamics on the time that a system with LR interactions remains trapped in a QSS. We discover that a small degree of chaos, measured by the Lyapunov exponents, favors a faster relaxation to equilibrium. Surprisingly, a larger degree of chaos hinders the relaxation to equilibrium.

[02/11/2015 - P021]

Entropic simulations of the spin-1/2 Baxter-Wu model., Lucas Nunes Jorge, Álvaro de Almeida Caparica, *Universidade Federal de Goiás - UFG* ■Among the various models used to describe spins systems the Baxter-Wu model is particularly interesting, since it considers triplets of spins, thus, it does not presents spin-reversal symmetry, as it occurs in the most know models. This model is defined in a triangular two-dimensional lattice, and the three-spin interaction is given by the Hamiltonian,

$$H_{BW} = -J \sum_{<i,j,k>} s_i s_j s_k, \qquad (1)$$

where the variables of spin are located at the vertices of the triangular lattice and take the values $s_i = \pm 1$, J is the coupling constant that defines the energy scale and the sum extends over all the triangular faces. For the spin-1/2 case, the model was exactly solved by Baxter and Wu, and presents the same critical temperature of the Ising model, but the critical exponents are those of the $q = 4$ Potts model, so, this model is an excellent object of study to test new Monte Carlo procedures. Monte Carlo simulations are an efficient tool to calculate critical temperatures and static critical exponents. In particular, the Wang-Landau sampling has become in last years more and more accurate and robust. In this work we present a simulational study of the pure spin-1/2 Baxter-Wu model using a modified Wang-Landau scheme to calculate the critical exponents γ, β and ν and the critical temperature T_c in the Baxter-Wu model. In this new procedure, instead of updating the density of states after every spin-flip we adopt the Monte Carlo sweep for updating the density of states, the microcanonical averages are accumulated only after a few Wang-Landau levels have already run out, and stop the simulations when a checking parameter, ε, which measures the fluctuation of the peak of the specific heat during the simulations, varies below 10^{-4} for a complete Wang-Landau level. As a result, different runs proceed up to different final modification factors. Moreover, the final results are obtained as averages over ten independent sets of finite size sca-

ling simulations. Our results are very consistent and we compare them with exact data available in literature.

[02/11/2015 - P022]
Mass segregation on Hamiltonian Mean Field model, J.R. Steiner, Zolacir T.O.Jr, *Universidade Estadual de Santa Cruz*, T.M. Rocha-Filho, *Universidade de Brasília* ■The dynamical evolution of young stellar clusters is thought to be entangled with that of the mass segregation. This is a common sense in the astrophysical community. In this work, mass segregation phenomena (MSP) is investigated, as a dynamical feature, using the Hamiltonian Mean Field (HMF) model. The study of MSP in the HMF model is justified by the fact that stellar and galaxies clusters are clearly examples of systems with long range interaction as the HMF itself and exhibits MSP. To achieve this aim, we introduce different masses in the Hamiltonian and perform computational simulations for that HMF model. We focus in looking for what happens over the mass distribution in the phase space for the system. A comparison with a short range version of HMF, with only first neighbours interaction, that is known as XY-model, also with different masses is made. The integration of the equations of motion is conducted using a fourth-order symplectic Omelyan integrator. We analyse what happens through the violent relaxation period and what stand for the quasi-stationary states (QSS) of this dynamics. The results obtained support the fact that MSP is observed already in the violent relaxation time and is maintained during the QSS's that come after that. Some structures are observed in the mass distribution function. Another result of this study is that the mass distribution is determined by the system dynamics and is independent of the dimensionality of the system. MSP occurs in a one dimensional system as a result of the long range forces that acts in the system.

[02/11/2015 - P023]
The BKT phase transition in the diluted XY Model, Tatiana Pena Figueiredo, Julio César Siqueira Rocha, Bismarck Vaz da Costa, *UFMG* ■The Berezinskii - Kosterliz - Thouless phase transition (BKT) in the diluted XY Model is studied in detail with Monte Carlo simulations using the Wang-Landau algorithm. The transition temperature, T_{BKT}, was found by the finite size scaling of the helicity modulus and the in-plane magnetic susceptibility, for various magnetics sites density. The spin-spin correlation function was calculated, for all spins, and for those who are within the cluster that percolates, in temperatures after and below the T_{BKT}, for various sizes lattices. We intend, using these results, discuss the mechanism of the unbinding of the vortices - antivortices pairs in the transition process. The position of this pairs and the vortices and antivortices density was calculated for various magnetics sites density. A well accepted theory suggests that this is the main mechanism responsible for the transition. However, we observed that vortices do not move for long distances through the lattice and in the vacancies neighborhood it can be pinned there for a long period of time, then if the transition occurs even with pinned vortices, these can not be responsible for the transition, and another mechanism should be observed. There is another theory which suggests such polymerizations walls domain is responsible for transition. We would like to thank the partial support of this project given by FAPEMIG and CNPq.

[02/11/2015 - P024]
The Cluster Expansion in Statistical Mechanics: Holder inequality, José André Lourenço, *UFES* ■In this review, the Glimm-Jaffe-Spencer cluster expansion from constructive quantum field theory is adapted to treat quantum statistical mechanical systems of particles interacting by finite range potentials. The Hamiltonian $H_0 + V$ need be stable in the extended sense that $H_0 + 4V + KN \geqq 0$ form some K. In this situation, with a mild technical condition on the potentials, the cluster expansions converge and infinite volume limit of the correlation functions existes, at low enough density. These infinite volume correlation functions cluster exponentially. Following the usual literature, we define a class of interacting boson and fermion particle theories with a matter-like potential, $1/r$ suitably truncated at large distance. This system would collapse in the absence of the exclusion principle. The potential is unstable, but the Hamiltonian is stable. This provides an example of a system for which this is method proves existence of the infinite volume limit, that is not covered by the classic work of Ginibre, which requires stable potentials. The main focus of this review is to discuss a key ingredient, a type of Holder inequality for the expectation values of spatially smeared Euclidian densities, a special interpolation theorem. The cluster expansion as developed here is purely a geometric analysis of the paths that realize the traces in path space. The total path space integral is split into subsets in which paths avoid certain regions and must hit other regions.

[02/11/2015 - P025]
Holographic considerations on non-gaussian statistics and gravothermal catastrophe, Everton M. C. de Abreu, *Universidade Federal Rural do Rio de Janeiro*, Jorge Ananias Neto, *Universidade Federal de Juiz de Fora*, Edésio M. Barboza Jr., *Universidade do Estado do Rio Grande do Norte*, Rafael C. Nunes, *Universidade Autonoma de Barcelona* ■The mechanism of gravothermal instability, discovered by Antonov is an important phenomena in gravitational thermodynamics. It has been very helpful for an extensive research concerning statistical mechanics of long range interactions systems in several fields in physics. This connection with thermodynamics and statistical mechanics has motivated us to investigate statistically the gravothermal catastrophe

At the same time, there are theoretical evidences that the understanding of gravity has been greatly benefited from a possible connection with thermodynamics. Pioneering works of Bekenstein and Hawking have described this issue. For example, quantities as area and mass of black-holes are associated with entropy and temperature respectively. Working on this subject, Jacobson interpreted Einstein field equations as a thermodynamic identity. Padmanabhan gave an interpretation of gravity as an equipartition theorem.

In this paper we have derived the equipartition law of energy using Tsallis formalism and the Kaniadakis power law statistics in order to obtain a modified gravitational constant. We have applied this result in the gravothermal collapse phenomenon. We have discussed the equivalence between Tsallis and the Kaniadakis statistics in the con-

text of Verlinde's entropic formalism. In the same way we have analyzed the negative heat capacities in the light of gravothermal catastrophe. The relative deviations of the modified gravitational constants are derived.

[02/11/2015 - P026]
Classical Origns of Frequency Probabilities, Guilherme Roncaratti Galanti, Osame Kinouchi, *Universidade de São Paulo* ■A classical open problem in probability theory concerns the so called three sided dice: suppose a cylinder with diameter d and height h, what should be the ratio h/d so that the frequency to obtain a face is 1/3 (where falling on the cylinder lateral side counts as a face). In a more general situation, we can ask for what is the frequency $P(S|d,h,H,\theta,\varepsilon)$ for obtaining a fall on the lateral side S given the cylinder diameter d and tallness h, the height H of its center of mass above a table at the moment of launching, the initial angle θ of the cylinder axis with the horizontal and the elastic coefficient of restitution ε, which depends on the materials of the table and the cylinder. We do not consider here initial conditions with translational or rotational velocities. We made experimental measures for $P(S|d,h,H,\varepsilon)$ varying h/d with H large (so that influences of initial conditions vanishes) and ε fixed. We also model numerically the system as a two dimensional "cylinder"of height h and d composed by four masses linked by springs. Given initial conditions, the numerical result is deterministic. However, for $H > 30cm$, the toss outcome depends strongly on initial conditions, so that we must average over a cell $\Delta H.\Delta\theta$ of initial conditions under control of the experimenter. This average furnishes a frequency $P(S|d,h,H,\varepsilon)$ to be compared to the experimental results. By using the unknown ε as a free parameter, we obtain a very good agreement between the full three-dimensional experiment and the two-dimensional simulation. The experimental data can also be fitted by a recently proposed "Gibbs curve".

[02/11/2015 - P027]
Efficient Wang-Landau Sampling for the Baxter-Wu Model, Maria Lúcia M. Costa, *Universidade Federal do Pará*, João Antonio Plascak, *Universidade Federal da Paraíba* ■This study analyzes the two-dimensional Baxter-Wu model of Spin-1/2 and Spin-1 through the revenue to improve the accuracy of the Wang-Landau sampling. This scheme of Wang-Landau was proposed by Caparica and Cunha-Neto[1]. Remembering that Wang-Landau simulation primordial [2] generates the density of states $g(E)$, i.e. the number of all possible states (or configurations) for any energy level E of the system, allowing determine the canonical average of any thermodynamic variable, as $< X >_T = \frac{\sum_E < X >_E g(E) e^{-\beta E}}{\sum_E g(E) e^{-\beta E}}$, where $< X >_E$ is the microcanonical average accumulated during the simulations and $\beta = 1/k_B T$, k_B is the Boltzmann constant and T is the temperature. Our analysis accomplish the two approaches of Wang-Landau: the conventional (WLS) and the improved precision (MWLS) for the Baxter-Wu model, where we observe the behavior of the temperature of the maximum of the specific heat and magnetic susceptibility as a function of the Monte Carlo sweeps (MCS) , where update the density of states only after every spin-flip (WLS), and update it after each Monte Carlo sweep (MWLS) and, in the case susceptibility, the MWLS shows that there is a limit to begin the accumulation the microcanonicas media. This study also showed the density of states for the Baxter-Wu Spin-1/2 and Spin-1, and perform a scale analysis of finite size for the model.

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[02/11/2015 - P028]
Classical dynamics of two electric charges, Rodrigo R. Silva, Annibal Figuereido, *Universidade de Brasília* ■From Liénard-Wiechert fields that describe the classical electromagnetic effect of a moving electric point charge, we construct the equations of motion for two particles. To build the equations of motion we use the Lorentz force $\frac{d\mathbf{p}}{dt} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$ where $\mathbf{E}$ and $\mathbf{B}$ are the Liénard-Wiechert fields and $\mathbf{p}$ is the relativistic momentum. Rescheduling to simplify this equations and thus get only one parameter, the ratio of masses. As the system depending only on the ratio of the masses and the boundary conditions we can simulate a electron-positron system, a electron-proton system and any two electric point charge system varying the ratio of mass. For each system we can analyze the position and velocity of each particle, the center of mass and the decay time. Analyzing the equations of motion in polar coordinates, and the results of the numerical solutions can be analytically deduce the decay time of the particles depends on the initial radius and the ratio of the mass. From the Langevin equation that is a stochastic differential equation we search the noise term that generates the stability of existing orbits on the electron-proton model.

[02/11/2015 - P029]
A study of Entropies and Non-linear Constraints in Long Range Interacting Systems, Moises F. Junior, Marco A. Amato, *Universidade de Brasília* ■The statistical basis for entropy has been laid by Boltzmann and Planck giving $S_N = k_B \ln \Omega$, where S_N is the total thermodynamic entropy of the system, N the number of entities, Ω the statistical weight or number of possible realisations (e.g., microstates) of the system, of equal probabilities, and k_B is the Boltzmann constant. For a discrete system one may also write $S = -k_B \sum p_i \ln p_i$. p_i is the probability of occurrence of the *i-th* distinguishable outcome or state, from a total of s such states. In a previous paper those authors provide a natural extension of the Boltzmann counting method in order to obtain generalized entropies, which leads to a statistical interpretation based on the occupational statistics of a stochastic process. In this paper we impose non-linear constraints to the entropy function. In particular we explore these in systems with long range interaction. The system studied is the Hamiltonian Mean Field (HMF) model. To study the behavior of this system, simulations using Microcanonical Monte Carlo (MMC) method was used. At first, we observed the behavior without non-linear constraints, only the conservation of energy and particles. Then, we study the behavior of the system with addition of the non-linear constraint. With addition of the non-linear constraint the system remained in the phase given by the initial conditions, i.e. if

the system began magnetized it remained magnetized at high energies and vice versa.

NON-EQUILIBRIUM

[02/11/2015 - P030]
Short-Time Dynamics for the Three-Dimensional O(4) Model, Wanderson Gonçalves Wanzeller, *UFFS*, Raquel dos Santos Marques de Carvalho, *UNIFESP* ■We perform a numerical study of the short-time dynamics for the O(4) spin model in three dimensions. Using a heat-bath time evolution algorithm we obtain the first and the second magnetization moments. With this quantities we estimate the dynamic critical exponents θ, θ_g and y. The θ exponent is related to the magnetization short-time anomalous behavior. Indeed, from dynamic scaling relation it is possible to observe universality and scaling behavior in the beginning of system evolution after quenching the system from high temperature to the Curie temperature. To measure the dynamic critical exponent θ we perform the simulations at $T_c = 1.0683$ for different (sharp) values of the m_0 initial magnetization. We fit a power law in the magnetization data. In order to avoid the extrapolation and the cumulative error in θ we use the time correlation function. Then we have the θ measure from two approaches. The results agree with literature's analytical calculations. The dynamic critical exponent for the magnetization second moment (y) is calculated from $m_0 = 0$ (not sharp). The dynamic critical exponent θ_g related with the magnetization probability does not change the signal of its initial value at time t. For a direct measurement of the z critical exponent we use the mix method.

[02/11/2015 - P031]
Transition under q noise in the Sznajd model on square lattice, F. W. S. Lima, *Universidade Federal do Piauí* ■In order to describe more realistically the formation of a consensus in human opinion dynamics, in this work we study the Sznajd model with probabilistic noise in two dimensions on square lattice. The time evolution of this system is performed via Monte Carlo simulations. This social behavior model with noise presents a well defined second-order phase transition. For small enough noise $q < 0.33$ most agents end up sharing the same opinion. We performed Monte Carlo simulation on the square lattice with various systems of size $L = 30$, 100, 300, 500, 1000, and 3000. We take 1.5×10^5 Monte Carlo steps per spin (MCS) to make the system reach the steady state, and then the time averages are estimated over the next 3×10^5 MCS. One MCS is accomplished after all the N spins are investigated whether they flip or not. The results are averaged over N_{run} ($20 \leq N_{run} \leq 100$) independent simulation runs for each lattice and for given set of parameters (q, N). In our study of the Sznajd model on square lattices with probabilistic noise q we found a phase transition when the initial concentrations p of spins up are different from $p = 0.5$ Our results show the introduction of a probabilistic noise ($0 < q < 1$) to produce a phase transition independent of the initial concentrations p of spins up and down. Therefore, we found out a strong second-order phase transition when the size lattice increases, at critical noise $q_c = 0.329(4)$. This means that strong noise, $q > q_c$, destroys the consensus found in deterministic Sznajd opinion dynamics, while for small noise nearly all agents share the same opinion.

[02/11/2015 - P032]
Role of pinning in temperature and conductance profile in a linear non-equilibiurm chain, Michael M. Cândido, Welles A. M. Morgado, *PUC-Rio*, Sílvio M. Duarte Queirós, *CBPF* ■Through years many physicists have been searching for a microscopical model to explain Fouriers Law correctly. One of the first attempts was the harmonic linear chain with heat reservoirs (with different temperatures) connected to its ends. This model, though does not leading to its main goal, has many intriguing features that give rise to many physical discussions.
Besides the well known infinite conductivity, which imply a constant conductance, linear harmonic chains display an awkward temperature profile for the particles composing them. In 1967, Lebowitz et al showed that particles in the bulk of the chain are thermalized with the same temperature,which is explained due to non scattering of phonons along the chain. When we turn attention to what happens near the extremities, the presence of cuspids adds one more strange characteristic to this model. In the present work we show that it is possible to change the cuspidal behavior near the extremities to a more smooth one, through proper combinations of border and bulk pinning values. We also show that for some choices of these pinnings the system shows two critical regimes, where the chains temperature is represented by a straight line (except for the particles connected to the thermal baths).
These critical regimes are attained to two curious characteristics: the first critical regime coincides with the maximum heat rate that the system reaches, while both regimes separates the temperature profile from a cuspidal to a non cuspidal one. Along the present work we show all the theoretical background that leads to the aforementioned results, in addition a discussion about what these results mean physically is also risen.

[02/11/2015 - P033]
Griffths phases of susceptible-infected-susceptible epidemic model on scale-free networks, Wesley F. C. Cota, Silvio C. Ferreira, *Universidade Federal de Viçosa - UFV - Brasil*, Géza Ódor, *MTA TTK MFA Research Institute for Natural Sciences - Hungary* ■Critical phenomena are drastically altered by the presence of quenched disorder, including systems with a transition between active and absorbing phases. Quenched disorder produces local supercritical rare regions, which can be active for exceedingly long times even if the system is globally in the absorbing phase. Conjunction of rare regions of considerable size R and the exponentially long lifetime in these regions produces a slow relaxation to the absorbing stationary state in the subcritical region, following power laws decays with non-universal exponents, a phenomenon called Griffiths Phase (GP). Epidemic models can be modeled in terms of reaction-diffusion processes with absorbing states representing a population rid from the disease. Since many substrates for epidemic spreading are well described by quenched complex networks with a highly heterogeneous structure, analogues of the GPs in epidemic spreading could be observed. However,

many complex networks are, theoretically, infinite dimensional systems, while GPs are expected for finite dimensions. It was recently observed Griffiths effects in the contact process (CP) on weighted heterogeneous networks in the form of slow relaxations. On the other hand, the fundamental susceptible-infected-susceptible (SIS) model, which have a null critical point for infinite networks, exhibit multiple transition involving localized configuration when investigated in a single finite-size network. In this work, we performed simulations of the SIS model on a large ensemble of $\mathcal{N}$ random networks with power-law degree distributions $P(k) \sim k^{-\gamma}$, with and without a hard upper cutoff, the latter rendering networks with outliers, which were pointed as the origin of multiple localized transitions. We observed that for a fixed and small infection rate many samples were in the inactive phase, but some exhibited quasistationary states with very long and highly fluctuating lifespans, analogously to the rare region effect. In the absence of cutoff, a logarithmic decay to the absorbing state was observed. For a hard cutoff we found power-law decays with non-universal exponents in agreement with a GP. Even being observable on very large networks ($N \sim 10^8$), a finite size scaling shows that the GP-like regime disappears in the infinite size limit. We acknowledge the financial support of CNPq and FAPEMIG.

[02/11/2015 - P034]

An study of the scaling of the dynamics of homogeneous states of one-dimensional gravitational systems, Lydiane F. Souza, M. A. Amato, T. M. Rocha Filho, *UnB* ■Quasi-Stationary States of long-range interacting systems have been studied at length over the last fifteen years. A pair interaction potential is said to be long ranged if it decays at long distances as $r^{-\alpha}$ with $\alpha \leq d$ where d is the spatial dimension. Kinetic equations for long-range interacting systems usually can be obtained from the BBGKY hierarchy [1] by taking into account contributions from the two-body correlation functions, which are of order $1/N$ [2] that result in a time scale of collisional relaxation proportional to N. The Balescu-Lenard equation for a one-dimensional homogeneous system vanishes identically due to the Dirac delta function. Therefore higher order terms must be kept when truncating the hierarchy, leading to a different scaling of the time evolution of a homogeneous state. It would be natural to expect that in the present case the predominant collisional corrections to the kinetic equation come from higher order terms proportional to $1/N^2$, this implies a relaxation scaling proportional to N^2. In a previous report [3] it is shown that the scaling from theoretical considerations for the HMF and Ring Model is proportional to the square of the number of particles and have also, in the former case, confirmed by computational calculations. In this report we propose an extension of the theoretical calculations given in Ref. [3] for a 1D gravitational system in order to provide a kinetic equation for such systems.

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[02/11/2015 - P035]

FRACTAL RESERVOIRS, Tawan Tayron de Andrade Carvalho, Valdemiro da Paz Brito, *Universidade Federal do Piauí*, Marcelo Andrade de Filgueiras Gomes, *Universidade Federal de Pernambuco* ■Since the 1980s, when the study of fractal structures quickly began to move forward, there are many unexplored aspects about how a fractal object interacts with certain types of environments. In some of these problems extensively studied in the area of out-of-equilibrium growth models, there is an interaction of a fractal surface with external fields, especially a diffusive field [1, 2, 3]. In another area, the study of the interaction of molecules with enzymes, proteins, or biological tissues is modeled by fractals, in catalytic processes or adsorption, an area known as chemistry between 2 and 3 dimensions [4]. More recently, Balankin and coworkers studied the kinetics of the water escape from aluminum crumpled surfaces [5]. This process occurs until the mass of water absorbed by the surface reaches the threshold of the water retained in the structure by surface tension forces. In the present work, we are interested to study experimentally the process of absorption and retention of water by crumpled wire balls, a much more effective system for the retention of water than the aluminum wrinkled surfaces. These balls were made with wire with 1.5 mm in diameter and had radii varying from 0.40 to 5.15 cm. Such structures are obtained in approximately spherical shapes by the use of nearly isotropic external compressing forces and have a high porosity and behave as fractals. The experiment consists of (1) generation and characterization of the balls, (2) immersion of the samples in water by following a fixed protocol, (3) evaluation of the retained water as a function of the size of the balls, the volume of pores, and the surface roughness, and (4) comparison of the experimental results with a simple mean-field model.

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[02/11/2015 - P036]

Analysis of the Shear Viscosity of Binary Gaseous Mixtures near from the Chemical Equilibrium, Adriano Willian da Silva, Kayk Bueno Martins, Atíria Sbrissia, *Instituto Federal do Paraná- Câmpus Curitiba* ■A binary gaseous mixture with reversible reaction of type A+A=B+B is studied with Boltzmann equation, assuming hard spheres cross sections for elastic collisions and two models for reactive interactions: line-of-centers model and modified line-of-centers model. The Chapman-Enskog method is used to obtain the solution of the Boltzmann equation in a chemical regime for wich the reactive interactions are of the same order as the elastic one, i.e. in the system is closed to the final stage of a chemical reaction where the affinity is considered to be a small quantity and the system tends to the chemical

equilibrium. This kind of reaction is known as fast reactions. The internal degrees of freedom of the particles of the gas are not taken into account. The value of the reaction heat distort the Maxwellian distribution function, for large values the effect becomes more importants. The resulting integral equation is solved with the expansion of the distribution function in Sonine polynomials. The aim of this paper is to evaluate the influence of the chemical reactions on the shear viscosity coefficient of the mixture. It was verified the reaction heat changes the shear viscosity and these change differ for exotermic and endotermic reactions. The change is bigger for endotermics reactions and reactive interactions of line-of-centers model.

[02/11/2015 - P037]
Anomalous temperature relaxation for polymeric chains, Rogelma M. S. Ferreira, *Universidade Federal do Recôncavo da Bahia - UFRB*, David L. Azevedo, Fernando A. Oliveira, *Universidade de Brasília - UnB* ■We analyse the temperature relaxation phenomena of small polymeric chains in contact with a thermal reservoir. We simulate the chains in a fluid [1], and we show that they reproduce a behaviour predicted by recent theoretical investigations [2]. The temperature decay reveals the existence of an anomalous cooling in which the temperature may oscillate [2]. This effect is a consequence of collective behaviour of the monomers in the chain, which builds up correlation [3,4]. This anomalous behaviour however, does not violated the second law of thermodynamics [5]. We analyse as well the scaling [4,6] dynamical properties of the chains.

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[02/11/2015 - P038]
Thermal Transport in a Higher-Order Generalized Hydrodynamics, Carlos A. B. Silva, *Instituto Tecnológico de Aeronáutica SP Brasil*, Clóves G. Rodrigues, *Pontifícia Universidade Católica de Goiás Departamento de Física Goiânia GO Brasil*, J. Galvão Ramos, R. Luzzi, *Institute of Physics Gleb Wataghin State University of Campinas 13083-859 Campinas SP Brasil* ■Thermal transport in classical fluids is analyzed in terms of a Higher-Order Generalized Hydrodynamics (or Mesoscopic Hydro-Thermodynamics) , that is, depending on the evolution of the energy density and its fluxes of all orders. Its derived in terms of a kinetic theory based on the Non-Equilibrium Ensemble Formalism. The general system of coupled evolution equations is derived. Maxwell times which are of large relevance to determine the character of the motion are derived. They also have a quite important role for the choice for the contraction of description (limitation in the number of fluxes to be retained) in the study of the hydrodynamic motion. Nowadays, new and elaborated experimental, technological , and industrial situations require new and advanced phisico-chemical theoretical formalisms. We consider here one such case, which appears to provide a good illustration: the so called Therma laser Stereolithography. This is a recent technological process that allows solid physical parts to be made directly and rapidly from computer data. In a description of order one it is presented an analysis of the conditions necessary for a satisfactory characterization of the technological process of thermal prototyping. We also consider the nonequilibrium thermodynamic aspects of the related techno-industrial process of thermal laser stereolithography.

[02/11/2015 - P039]
Nonlinear Ehrenfest's Urn Model, Gabriela A. Casas, Fernando D. Nobre, Evaldo M. F. Curado, *Centro Brasileiro de Pesquisas Físicas - CBPF* ■The Ehrenfest's urn model (sometimes also called Ehrenfest's flea model) has played an important role in clarifying the foundations of statistical mechanics, providing an interpretation of irreversibility in a statistical manner. The model is defined by N balls distributed in two urns (or boxes) 1 and 2, such that at each discrete instant of time s, a ball is chosen at random and moved from the box in which it is found to the other box. At the beginning of the 20th century, such a simple model was useful in explaining the heat exchange between two bodies at unequal temperatures, where the temperatures are mimicked by the number of balls in each box, and the heat exchange becomes a random process. In the present work the Ehrenfest's urn model is modified by introducing nonlinear terms in the associated transition probabilities. It is shown that these modifications lead, in the continuous limit, to a Fokker-Planck equation characterized by two competing diffusion terms, namely, the usual linear one, as well as a nonlinear diffusion term, typical of anomalous diffusion. By considering a generalized H-theorem, the associated entropy is calculated, resulting in a sum of Boltzmann-Gibbs and Tsallis entropic forms. It is shown that the stationary state of the associated Fokker-Planck equation satisfies precisely the same equation obtained by extremization of the entropy. Moreover, the effects of the nonlinear contributions on the entropy production phenomenon are also analyzed.

[02/11/2015 - P040]
Statistical Thermodynamics of the Fröhlich-Bose-Einstein Condensation of Non-Equilibrium Magnons, Fabio S. Vannucchi, *Campus do Litoral Paulista, Universidade Estadual Paulista - UNESP*, Roberto Luzzi, *Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas - UNICAMP* ■A non-equilibrium statistical-thermodynamic approach to the study of a Fröhlich-Bose-Einstein condensation of magnons under radio-frequency radiation pumping is presented. Such a system displays a complex behavior consisting in steady-state conditions leading to the emergence of a synergetic dissipative structure resembling the Bose-Einstein condensation of systems in equilibrium, due to a peculiar and fundamental contribution of a non-linear character related with the magnon-lattice interaction. A kind of "two fluid model" arises: the "normal" non-equilibrium structure and Fröhlich condensate or "non-

equilibrium"one, which is shown to be an attractor to the system. After a brief description of the system in terms of its Hamiltonian, the presentation of the relevant variables and the associated kinetic equations, and the study of stability of the steady-state solutions, we analyze some aspects of the irreversible thermodynamics of this dissipative complex system. At first, the informational entropy and its production is calculated, and an order parameter is introduced in terms of the scaled rate of pumping and the Fröhlich parameter. Then, Glansdorff-Prigogine criteria for evolution and (in)stability are verified, a generalized H-theorem is established, a Boltzmann-like relation for the non-equilibrium statistical entropy is derived, as well as expressions for the fluctuations in non-equilibrium conditions and the associated Maxwell relations.

[02/11/2015 - P041]
Critical properties of the susceptible-exposed-infected model on a square lattice, Alexander H. O. Wada, Tânia Tomé, Mário J. de Oliveira, *Instituto de Física da Universidade de São Paulo* ■The epidemiological model susceptible-infected-exposed (SEI) is studied on a square lattice. The SEI model is defined by its transition probabilities, in which only susceptible sites with at least one infected site on its near neighborhood are allowed to change its state. A susceptible site can change its state with probability equal the fraction of nearest infected neighbors, if so becomes infected with probability p or exposed with $1-p$. Infected and exposed sites remain forever in its states. Starting from the initial condition with only one infected in a lattice full of susceptibles, the dynamics of this model grows a single cluster of infected sites until the absorbing state, in which there is no pairs susceptible-infected and the cluster of infected sites is completely surrounded by exposed sites. By interpreting infected and exposed sites as occupied and vacant sites respectively, we show, by means of numerical simulations, that the clusters generated have the same critical properties of the percolation clusters, in other words , both the SEI model and the percolation problem have the same critical threshold and exponents. Furthermore, we analyze the time series of the SEI model up to a lattice of linear size $L = 2^{15}$ in the critical point, calculating the dynamical critical exponents with high precision and classifying the SEI as belonging to the Dynamical Percolation universality class.

[02/11/2015 - P042]
Thermal Rectification in Anharmonic Chains under Energy-Conserving Noise, Pedro Henrique Guimarães, Mário José de Oliveira, *IFUSP - SP - Brasil*, Gabriel T. Landi, *UFABC - SP - Brasil* ■Thermal rectification is the phenomenon in which the heat flux in a given system depends on the direction the flux is applied. This phenomenon has been widely investigated in recent years due to its great academic and technological relevance. In order to present thermal rectification, at least two main conditions are necessary to such systems: an inherent spacial asymmetry, which breaks the invariance under bath reversal and a temperature dependent thermal conductivity, which induces different phonon spectra when the baths are reversed. However, in disagreement with the results of experimental works, most results of theoretical models proposed in the literature have a rectification which decreases with increasing system size and thus vanishes in the thermodynamic limit. So, since these ingredients may not suffice to maintain a finite thermal rectification, we introduce a new ingredient, namely energy-conserving noise that randomly flips the sign of the velocity of the system's particles with a certain rate λ. With this new ingredient, we show that a finite and non-zero thermal rectification in the thermodynamic limit can be obtained. Our analysis is done numerically, with the simulation of a harmonic chain subject to a quartic local potential (pinning) and coupled at its ends to thermal reservoirs by Langevin equations.

[02/11/2015 - P043]
Geometrical relations during coarsening for the Potts model, Marcos Paulo de O. Loureiro, *Universidade Federal de Viçosa - Campus Rio Paranaíba*, Jeferson J. Arenzon, *Universidade Federal do Rio Grande do Sul*, Leticia F. Cugliandolo, *Université Pierre et Marie Curie* ■When taken out of equilibrium by an instantaneous temperature quench, from above to below the critical temperature, several systems form a time evolving complex pattern (coarsening) in which several equilibrium phases compete. The energy excess is concentrated at the interfaces (hulls) separating these several states while the curvature-driven dynamics attempts do decrease the total length of these interfaces. Despite the very different nature of these systems, many of them satisfy the dynamic scaling hypothesis that states that the behavior becomes universal when a proper rescaling is performed using the characteristic length $R(t)$ that increases in time as $t^{1/2}$ when the order parameter is not conserved. The study of the topological and geometrical properties in liquid crystals, soap froths, cellular tissues, magnetic materials, superconductors and polycrystalline microstructures has attracted attention for several decades. The morphology of the coarsening patterns in these experimental systems can be reproduced by the q-states Potts model. Several phenomenological laws have been proposed from the analysis of area and perimeter (e.g.,the Lewis and Fetham's laws) and confronted with data from two-dimensional biological tissues and metal grains. Here we follow the formation and evolution of patterns generated by Monte Carlo simulations of the two-dimensional Potts model for several values of q after a deep quench in order to check the validity of those empirical laws in less isotropic systems and the dependence on the order of the underlying phase transition and the amount of correlation present in the initial state.

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NONLINEAR DYNAMICS & CHAOS

[02/11/2015 - P044]
Exploiting the weakness of preferential attachment networks, Tiago M. Vieira, Gandhi M. Viswanathan, Luciano R. da Silva, *UFRN - RN - Brasil* ■We address the general problem of how to attack and destroy a network by node removal given limited or no prior information about the edges. Networks have been used to describe many kinds of systems. In general, nodes represent systems components and edges the interactions between them. How the edges are arranged in a network has great importance because quantities of interest depend on edge placement, e.g. connectivity distribution, clustering coefficient, resilence to node and edge removal, spreading processes, and small-world effects. The rules controlling edge placement define the network structure and they can be exploited by agents that wish to attack weaknesses of the networks. In our study, we consider a family of strategies in which nodes are randomly chosen, but not removed. Instead a random acquaintance (i.e., a first neighbour) of the chosen node is removed from the network. Our approach is a generalization of the strategy introduced by Cohen et. al. [Phys. Rev. Lett., 91 (2003)], in which the acquaintance of a randomly chosen node is promptly removed from the network as soon as it was chosen. Instead of the immediate removal, a given node needs to be pointed by other randomly chosen nodes more than once before being removed. As a result, we observe that our approach leads the network to be destroyed more quickly, i.e., it's necessary to remove a lower number of nodes, in comparison to the original strategy.

[02/11/2015 - P045]
Self-organization of periodicity hubs and spirals in a high resolution parameter space from the two-level model on semi-insulating GaAs, Samir Lacerda da Silva, *Instituto Federal do Espírito Santo - Campus Vitória*, Rodrigo Lacerda da Silva, *Instituto Federal Fluminense - Campus Bom Jesus do Itabapoana*, Emilson Ribeiro Viana, *Universidade Tecnológica Federal do Paraná* ■Semi-insulating Gallium Arsenide (SI-GaAs) samples experimentally show, under high electric fields and even at room temperature, negative differential conductivity in N-shaped form (NNDC). In recent work [1], we proposed a physical model, the two-valley model, which describes electrical conduction in SI-GaAs. The model is based on the minimal set of generation-recombination (g-r) equations for two valleys inside of the conduction band, and an equation for the drift velocity as a function of the applied electric field, that covers the physical properties of the nonlinear electrical conduction of the SI-GaAs system. The model generated theoretically the NNDC region for the first time and the nonlinear dynamics were investigated in this region by building of high-resolution parameter-space of the periodicity using a Periodicity-Detection routine [2]. In the parameter-space we observed too many self-organized periodic structures embedded in the chaotic regions, like as a "shrimp"shaped in a spiral form, that forms a "snail shell". This structure established a direct communication between the windows in order within chaotic regions, producing new routes of bifurcation. The snail structure show three regions where the shrimp shape rotated around a focal point, called periodicity hubs, with intricate connections between different shrimps.
The purpose of this work is to further develop our recent study and we focus on periodicity hubs. Such hubs shows focal points where your localization are associated with the generation recombination rate. In the present model the coefficients of g-r processes, like as impact ionization and field enhanced trapping, depend on the electric field. Our results shows the impact when a small variations on some parameter of the coefficients g-r can causes on position of the focal points and consequently over all self-organized periodic structure around them. Our results show that the position of the focal points and the structures of the periodic hubs have dependence with the change of the coefficients g-r. The stable and unstable hubs and many mergers between shrimps with different periodicity are presented.
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[02/11/2015 - P046]
Dynamical Properties of Soft Elliptical Billiard, Tiago Kroetz, *Universidade Tecnológica Federal do Paraná, Pato Branco - PR - Brasil*, Hercules Alves de Oliveira Junior, *Universidade Tecnológica Federal do Paraná, Ponta Grossa - PR - Brasil* ■Two-dimensional billiards can be considered as special cases of two-dimensional potentials. These potentials must be constant at the inner part of the billiard and present an abrupt variation of their values at the coordinates on the border of the billiard. Thus, the force exerted on a particle subjected to this kind of potential is null into the billiard area and is infinite at the border of the billiard. Also, the direction of the force (and thus the potential gradient) must be normal to the frontier of the billiard. In this work we obtained a soft version of a two-dimensional billiard. Differently from the hard billiard, the particle confined in the soft billiard suffers the influence of a force during a time interval greater than zero. Due to this reason, the particle trajectory is smooth at the reflections and differs from straight lines between consecutive reflections. The obtaining of the soft billiard was made considering a particle subjected to a two-dimensional potential with a parameter capable to change the values of gradient function without however alter the shape of equipotential curves. With this, we can investigate the continuous transition of the dynamics from soft two-dimensional potential to the corresponding hard two-dimensional billiard. We opt to perform this investigation considering the elliptical geometry of the equipotential curves, where the values of eccentricities are the same for each equipotential and can be controlled by a parameter in the potential expression. Using this procedure we can reveal the changes of the numerical results by varying the hardness of the border until recover the well known phase space of hard elliptical billiard. We investigate the two-dimensional space of parameters identifying the transitions order-chaos in there.

[02/11/2015 - P047]
Three unequal masses on a ring and soft triangular billiards, Hercules A. Oliveira, *Universidade Tecnológica Federal do Paraná, Ponta Grossa*, Marcus W. Beims, *Universidade Federal do Paraná* ■Collisions with hard (infinite) walls in billiards systems are usually described by instantaneous reversal of the particles linear momentum. From this, simple analytical relations of velocities and angles before and after the collisions with the walls are obtained. However, in order to analyze the transition to soft walls, which are more realistic, it is essential to have well defined equations of motion since, in general, no simple analytical solutions are obtained. The present work suggests that appropriated soft walls potentials are those for which the corresponding forces become "delta functions"in the limit of hard walls. This allows for better numerical investigation of the soft-hard transition. A general scaled Hamiltonian is derived for three unequal masses interacting particles on a frictionless ring, which nicely describes the transition and shows that the dynamics occurs inside a soft triangular billiard. The dynamics of three soft interacting particles on a ring is shown to correspond to the motion of one particle inside a soft triangular billiard. The dynamics inside the soft billiard depends only on the masses ratio between particles and softness ratio of the particles interaction. The transition from soft to hard interactions can be appropriately explored using potentials for which the corresponding equations of motion are well defined in the hard wall limit. Numerical examples are shown for the soft Toda-like interaction and the error function.

[02/11/2015 - P048]
Plasma Structures in Texas Helimak, F. A. C. Pereira, Z. O. Guimarães-Filho, I. L. Caldas, *Instituto de Física da Universidade de São Paulo*, D. L. Toufen, *Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Campus Guarulhos*, K. W. Gentle, *Institute for Fusion Studies of the University of Texas at Austin* ■Intermittent structures with extreme events (bursts) have been detected in the turbulence of the scrape of layer (SOL) of Tokamaks and these structures have a major role in plasma confinement. The Texas Helimak is a toroidal plasma device with one-dimensional equilibrium, magnetic curvature and shear, thus resembling closely a SOL of a Tokamak. The Texas Helimak vacuum vessel has a rectangular cross section with 0.6 m of internal radius, 1.6 m of external radius, and 2 m of height and the plasma is generated by electron cyclotron resonance heating. The Helimak has 16 bias plates, where a large set of Langmuir probes is mounted and from where is possible to impose an external electrical bias. This electrical bias can change the turbulence properties and even suppress the appearance of the intermittent structures. In this work, we study the statistical characteristics of bursts in the ion saturation current, and we show that a shot noise model can reproduce the signal statistics. We also characterize both the spacial and temporal profiles of the bursts and their propagation, as a function of the external imposed bias and the radial position inside the Helimak. Both profiles and the bursts propagation are analyzed by conditional analysis and the cross correlation between the probes signals. We acknowledge the financial support of FAPESP (grants 2014/07043-0 and 2011/19296-1).

[02/11/2015 - P049]
Chaos in 3D Brans-Dicke Model, Thiago Gilberto do Prado, Hércules Alves de Oliveira Junior, Marcos Cesar Vergès, *Universidade Tecnológica Federal do Paraná* ■The evidence of an accelerated expansion of the universe, observed by WMAP, opened the discussion of the general relativity eventual limits. There are many options for alternative theories of gravity, and among them wecan cite scalar-tensor theories like supergravity, Kaluza-Klein theories, dual string theories, M-Theory, etc . One particular kind of scalar-tensor theory to describe an accelerate expansion of the universe, called Brans-Dicke theory, was proposed in the early sixties. This theory uses the principle of Mach and the hypothesis of Dirac, considering an eventual variation in time of the Newton's gravitational constant, thus ensuring the universality of free fall (equivalence principle). Most of the works which have been published in this theory up to now consider four flat dimensions, and some of them have tried to associate the scalar field of the Brans-Dicke theory as quintessence field as a type of K-essence field. Others have tried to find a solution for the observed accelerated expansion using a dimensional reduction of the 5D Brans-Dicke theory without matter. Concerning 3 dimensions, a broad study has been done in gravitational theories since the publication of BTZ Black Hole, motivated by the fact that 3D theories avoid some complications found in higher dimensions. However, there are not as many results about 3D scalar-tensor theories, and it would be interesting to find some results in this subject, more specifically in 3D Brans-Dicke theory. For instance, we can see some problems like the association of the scalar field of the Brans-Dicke theory to K-essence fields which models the dark energy. The goal in this paper is study the dynamical behavior of a 3D Brans-Dicke model. For this we use tools such as calculation of the exponent Lyaponov and analysis of phase space for the study of this dynamic system. From the results we identified regions whose theory has chaotic behavior.

[02/11/2015 - P050]
Algebraic period 3 orbits: rotation on complex plane and statistical quantities., Antônio João Fidélis, *IFC - Campus Luzerna*, Luciano Camargo Martins, *UDESC - CCT* ■For the period-3 window of the logistic map $x_{n+1} = rx_n(1 - x_n)$ it is presented algebraic orbits, for both stable and unstable ones. From the solution of $x_{n+3} = x_n$ it is obtained the polynomial that rules the periodic orbits inside this window. The roots of this polynomial are the orbits, and they are functions of the fixed parameter value r. As r is increased, the value of the roots are modified: some increase and the others decrease. For the same branch of the three possible orbits, the value of the roots present opposite behavior with respect to stable and unstable orbits. The roots of the polynomial, i.e., the orbits, are presented in two different ways: a sum of complex numbers $x_i = a + bc + \overline{bc}$, and via Euler's formula $x_i = a + 2|b|\cos(\theta)$ – the overbar indicates complex conjugation. The algebraic orbits are obtained

for three different fixed control parameter values of r: at tangent bifurcation (birth), at super-stability and at ending pitchfork bifurcation (death). The algebraic expressions of the constants a, b, c, $|b|$ and θ are given for each r value for both stable and unstable orbits. It is shown that a and $|b|$ are statistical quantities of the orbits, again, both stable and unstable ones. Finally, the numerical values of the orbits and the constants obtained are summarized in a table and, numerically, it is shown the behavior of each orbit, constant and Lyapunov exponent for each orbit.

[02/11/2015 - P051]
Inelastic scattering of a structured particle: influence of the internal degrees of freedom on the scattering cross section, Kellen M. Siqueira, Marcus A. M. de Aguiar, *Instituto de Física Gleb Wataghin - UNICAMP* ■We studied the 2D classical scattering of a structured particle by a Gaussian well. The structured particle is composed of three point particles, each with a different mass ($m_1 = 1$, $m_2 = 2$, $m_3 = 3$), forming a linear chain. The interaction between the point particles was modelled as either a harmonic or a quartic spring. We assumed that there was no other interaction between these particles. The scattering of the composite particle was evaluated numerically for 5 different elastic constant for each type of spring including a case without interaction between the point particles. We found that there is a breakdown of the differential scattering cross-section for non zero elastic constant and initial energies at the same order or smaller than the depth of well. For these low energies the structured particle may get trapped in the Gaussian well. Depending on the impact parameter the particle may escape from the well after some time or it may remain trapped. Even if the particle escapes it can leave the well at any scattering angle. Therefore for this range of impact parameters the system behaves in a chaotic way and the differential scattering cross section cannot be properly defined. This effect was more evident for small values of spring constant. In the case without interaction between the particles, however, the scattering cross section was equivalent to the case of a single particle. We found that for larger values of energy the effect of the springs was less important and the "molecule" behaved in a similar way to a single point particle. The results for the harmonic and quartic spring were qualitatively and quantitatively similar. Therefore the chaotic behaviour seems to be mainly due to the interaction between internal and center-of-mass degrees of freedom and not to nonlinearities in the interaction potential.

[02/11/2015 - P052]
Elliptical Stadium Billiard: Classical Dynamics and Quantization, T. Araújo Lima, F. M. de Aguiar, *Universidade Federal de Pernambuco* ■Billiards are prototype models in the ergodic theory of Hamiltonian systems. They describe the classical dynamics of particle (unit mass and speed) free to move between specular reflections in a closed 2D domain; The dynamics can be regular, chaotic or may display a mixed phase space, depending only on the geometry of the border. The Elipitical Stadium Billiard (ESB) is composed by two half-ellipses (major axis $2a$ and minor axis $2b$) that bracket a rectangular sector of thickness $2t$ and height $2b$, as usual, we set $b = 1$ [1]. Here, we study numerically the vicinity of a particular line in the paramater space $a \times t$, namely $t_c = t_0(a) = \sqrt{a^2 - 1}$. If $t \geqslant t_c$, there is chaos almost everywhere[1]. If $t < t_c$, the billiard exhibits a mixed phase space. From the relative measure and Shannon entropy we define a order parameter and a billiard capacity respectively. By fixing a and variyng t, a phase transition is observed at $t_0(a)$, which is characterized by exponents $\beta = 0.34$ and $\alpha = -0.0127$. The results bear a remarkable resemblance to the famous λ transition in liquid ^{4}He, where the two-component (superfluid and normal fluid) phase of He-II is critically separated from the fully entropic normal-fluid phase of He-I by the so-called λ line in the pressure $\times$ temperature parameter space. The analogy adds support to a set of previous results by Markarian and coworkers, which indicate that the line $t_0(a)$ is a strong candidate for the bound for chaos in the ESB[2].

The quantized version of a given billiard corresponds to a 2D infinite quantum well with the same geometry, one hes to solve the Helmholtz equation $(\nabla^2 + k^2)\phi = 0$, where ϕ is the energy eigenfunction and $k^2 = 2mE/\hbar^2$, where E is the energy eigenvalue. For the quantization of the ESB, we are using a numerical method[3] to obtain the first 150,000 energy eigenvalues with great efficiency. Spectra are being statiscally characterized through the nearest neighbor spacing distribution, $p(s)$ and the Dyson-Mehta spectral rigidity, Δ_3.

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[02/11/2015 - P053]
A KINETIC THEORY FOR NONLINEAR QUANTUM TRANSPORT IN SEMICONDUCTORS, Clóves Gonçalves Rodrigues, *Escola de Ciências Exatas e da Computação, Pontifícia Universidade Católica de Goiás*, Roberto Luzzi, *Condensed Matter Physics Department, Institute of Physics Gleb Wataghin - Unicamp* ■As a general rule, in the study of transport phenomena analytical-type methods have been based on Boltzmann-like transport theories, which however have limitations when nonlinear effects become to have relevance. Thus, improved analytical methods, that is nonlinear quantum kinetic theories for studying physical phenomena in systems arbitrarily away from equilibrium, are desirable. An advantage over Monte Carlo computational methods resides in that the analytical equations may provide a better physical insight and interpretation of the results. Nonlinear quantum kinetic theories more appropriate for the purpose just stated have been derived under some type or other of intuitive techniques and ideas. One such theory based on sound physical foundations, which is compact and practical, is presently

available. It is the kinetic theory derived from a powerful approach consisting of a nonequilibrium ensemble formalism. The latter is the so-called "Nonequilibrium Statistical Operator Method". It is a powerful formalism that seems to offer an elegant and concise way for an analytical treatment in the theory of irreversible processes, adequate to deal with a large class of experimental situations. It provides a kinetic theory of large scope, kind of a far-reaching generalization of the Chapman-Enskog approach or the Mori-Langevin formalism. We resort to this approach to study some transport properties and phenomena in the case of doped polar semiconductors: GaAs, GaN, AlN and InN, and some comparison with experimental data is done. The study of transport properties of semiconductors under high level of excitation, eventually following nonlinear laws, are of great interest not only for its relevance in the functioning of electronic and optoeletronic devices, but also because of providing an excellent testing ground for theoretical ideas in the field of many-body systems in far-from-equilibrium conditions as we do here. Hence, as noticed, nonlinearities are present in both transport properties and relaxation processes, which may give origin to new and interesting phenomena. They may arise, for example, in the case of nonuniform (variation in space) and sufficiently intense (critical point) electric fields, as a result of the influence of an increasing (with the electric field strength) shear stress leading the system to an instability. It is conjectured to be of some chaotic or turbulent type and, of course, relevant to be characterized and fully analyzed because of the accompanying interest on its influence on the performance of electronic and optoelectronic devices. The author CGR acknowledges the financial support received from the FAPEG and CNPq.

SOFT MATTER

[02/11/2015 - P054]
Determination of the fractal dimension of crumpled metallic structures through an electric approach, José Ilberto Fonceca Junior, Pedro Hugo de Figueirêdo, Wictor Carlos Magno, *DF - UFRPE - PE - Brasil*, Tainã Laíse de Melo e Silva, *UFAL - AL - Brasil* ■Transport mechanisms of charge, heat and particles, as well as traffic problems in big cities are closely related to geometric aspects of the physical systems. For example in disordered low-dimensional media, the 'effective' dimension (*fractal dimension*) d of the object yields the diffusion regime. Recent works have established analogies between flexible packed structures and molecules of biological importance. The fractal dimensions of these structures are usually determined by geometrical approaches, typically the mass exponent and box counting. Influenced by these problems, we present a new method to determine the fractal dimension of crumpled wires. The method consists in using the inductance (L) of a packed wire configuration to obtain the fractal dimension from two-dimensional and three-dimensional structures, through a power law $L \sim l^{d-1}$, at which l represents the wire length. This strategy yields the average fractal dimension between configurations of low and high densities. For the three-dimensional packing, we use flexible wires of a fixed radius a varying both their lengths and the rigid hollow plastic spheres' radii in the interval ($14\,mm \leq R \leq 49\,mm$). The maximum packing density $\phi_{max} = l\pi a^2 / \left(4\pi R^3/3\right)$ corresponds to that found in literature. And the dimension obtained was $d = 2.28 \pm 0.07$.

[02/11/2015 - P055]
Micellization in a solution containing ionic surfactants: a Langevin Dynamics study, Karlisson Rodrigo de Almeida Sousa, Alexandre Diehl, *Universidade Federal de Pelotas*, José Rafael Bordin, *Universidade Federal do Pampa* ■Langevin Dynamics (LD) simulation is used to study the micellization process of systems containing ionic surfactants and electrolyte suspensions. In our model system we use a coarse-grained methodology, with no water molecules, where the hydrophobic effect produced by the hydrocarbon surfactant tail monomers is described by a short-range attraction between the neutral tail monomers that are located at different surfactant molecules. This effective short-range attraction is represented through a Lennard-Jones (LJ) potential, with the LJ well depth ε taken as an adjustable parameter. Extensive LD simulations were implemented in the ESPResSo package, a free open-source software for soft matter systems, in order to obtain the critical micelle concentration (CMC) of cationic and anionic surfactants and also for a catanionic mixture, a solution containing both types of ionic surfactants. We use the parameter ε in our simulation model to obtain our CMC estimate, as suggested recently by a Monte Carlo study, in the absence of salt and also when different types of salts are included in the solution. For the catanionic mixtures we are interested to characterize the catanionic micelles that are formed, specially their effective electronic charge and size distribution. We compare our results with the experiments and previous Monte Carlo simulations.

[02/11/2015 - P056]
Scaling analysis of Self-Avoiding Walk with Persistence Lengths, Cristiano Roberto Fabri Granzotti, Alexandre Souto Martinez, *Departamento de Física (DF), Faculdade de Filosofia Ciências e Letras de Ribeirão Preto (FFCLRP), Universidade de São Paulo (USP)*, Marco Antônio Alves da Silva, *Faculdade de Ciências Farmacêuticas de Ribeirão Preto (FCFRP), Universidade de São Paulo (USP)* ■The self-avoiding walk (SAW) in regular lattices is a random walk (RW) model, where the walker steps to nearest-neighbor sites and does not visit a site more than once. Due to non-overlapping paths, the SAW plays a central role on Polymer Physics by capturing the excluded volume effect. A key aspect to study the SAW is the scaling analysis of the conformational quantities. One of these quantities is the average projection of the end-to-end distance, $\vec{R}_N = \vec{u}_1 + \cdots + \vec{u}_N$, along the first step direction, $\vec{u}_1$, or persistence length $\langle \lambda_N \rangle_N = \langle \vec{R}_N \cdot \vec{u}_1 \rangle_N$, where $|\vec{u}_1| = 1$. The known scaling predictions for $\langle \lambda_N \rangle_N$ not even agree one with each others. To address such issue, we write the conformational quantities in terms of the scalar product between the position $\vec{R}_j$ and displacement $\vec{u}_j$, at the j-th step: $\langle \vec{R}_j \cdot \vec{u}_j \rangle_N$, of an N-step SAW. The mean square end-to-end distance, $\langle \vec{R}_N^2 \rangle_N$, is proportional to the summation of the inner

persistence length, $\langle \vec{R}_j \cdot \vec{u}_j \rangle_N$, for $1 < j < N$. For the SAW model, we obtain $\langle \lambda_N \rangle_N = \langle \vec{R}_N \cdot \vec{u}_N \rangle_N$ implying the novel relation $\langle \vec{R}_N^2 \rangle_N = \langle \vec{R}_{N-1}^2 \rangle_N + 2\langle \lambda_N \rangle_N - \vec{u}_N^2$. Based on the accepted $\langle \vec{R}_N^2 \rangle_N \sim N^{2\nu_0}$ scaling behavior and Monte Carlo simulations, we find $\langle \lambda_N \rangle_N$ convergence to a constant value with corrections to scaling, in square and cubic lattices. From Monte Carlo data we find that $\langle \vec{R}_j \cdot \vec{u}_j \rangle_N \approx j^{2\nu_0 - 1}$ for $1 < j < j_{max}$, and reaches a maximum value at the j_{max}-th step. For $j > j_{max}$, the inner persistence length is no longer increasing, but a monotonic decreasing function that contributes largely with the corrections to scaling of $\langle \vec{R}_N^2 \rangle_N$. Such a scaling behavior of inner persistence length is observed in both, square and cubic lattices. We define $\Delta R_j = \langle \vec{R}_j \cdot \vec{u}_j \rangle_{N_2} - \langle \vec{R}_j \cdot \vec{u}_j \rangle_{N_1}$, with $N_2 > N_1$, in order to find the step $j_c(N) < j_{max}$, where the inner persistence length starts to be notably influenced by the walk length. Finally, considering $1 < j < j_c(N)$ we obtain an accurate estimate of ν_0 from $\langle \vec{R}_j \cdot \vec{u}_j \rangle_N$ scaling relation, for walks with few steps, say $N < 100$, in the square and cubic lattice.

[02/11/2015 - P057]
Modeling of Droplet Evaporation on Superhydrophobic Surfaces, Heitor C. M. Fernandes, Mendeli H. Vainstein, Carolina Brito, *Instituto de Física - UFRGS* ■When a drop of water is placed on a rough surface, there are two possible extreme regimes of wetting: the one called Cassie-Baxter (CB) with air pockets trapped underneath the droplet and the one called the Wenzel (W) state characterized by the homogeneous wetting of the surface. A way to investigate the transition between these two states is by means of evaporation experiments, in which the droplet starts in a CB state and, as its volume decreases, penetrates the surfaces grooves, reaching a W state. Here we present a theoretical model based on the global interfacial energies for CB and W states that allows us to predict the thermodynamic wetting state of the droplet for a given volume and surface texture. We first analyze the influence of the surface geometric parameters on the droplets final wetting state with constant volume and show that it depends strongly on the surface texture. We then vary the volume of the droplet, keeping the geometric surface parameters fixed to mimic evaporation and show that the drop experiences a transition from the CB to the W state when its volume reduces, as observed in experiments. To investigate the dependency of the wetting state on the initial state of the droplet, we implement a cellular Potts model in three dimensions. Simulations show very good agreement with theory when the initial state is W, but it disagrees when the droplet is initialized in a CB state, in accordance with previous observations which show that the CB state is metastable in many cases. Both simulations and the theoretical model can be modified to study other types of surfaces.

[02/11/2015 - P058]
Langevin simulations of two dimensional systems with competing interactions, Lucas Nicolao, *UFSC*, Alejandro Mendoza-Coto, Daniel Stariolo, *UFRGS*, Rogelio Diaz-Mendez, *ISIS - France* ■We show some recent advances in simulations of coarse-grained models for systems where pattern formation is an equilibrium phenomena, as a consequence of underlying interactions competing on different ranges. These give rise to modulated (thermodynamic) phases composed of simple domain structures, such as stripes and bubbles in 2D. In the case of thin magnetic films, for example, the competition between the exchange (ferromagnetic) and dipolar (antiferromagnetic) interactions give rise to magnetic stripe domain phases in the absence of applied magnetic field, whereas in its presence bubble or uniform phases appear. While a stripe ground state possess both anisotropic translational and orientational orders, strong fluctuations due to the low dimensionality and continuous symmetry can stabilise a nematic phase, with orientational order alone. Our results give evidence that, depending on the range of the competing interaction, this phase can have quasi-long-range order (of the BKT universality class, in the case of a dipolar interaction) or a true long-range order (in the case of a Coulomb interaction). In the presence of an uniform external field, we show that for sufficiently weak competing interactions, there is a reentrant behaviour of the uniform phase with respect to the modulated phases - for finite applied field, stripe and bubble phases can be found mainly for moderate temperatures.

Oral sessions (11:00-12:30)

FUNDAMENTAL ASPECTS

[02/11/2015 - 11:00 - Room Tubarão]
Nonperturbative renormalization group for the Kardar-Parisi-Zhang equation, Léonie Canet, *Université Joseph Fourier Grenoble I*, Hugues Chaté, *CEA, Service de Physique de lEtat Condensé, Gif-sur-Yvette, France*, Bertrand Delamotte, *LPTMC, Paris 6, Paris, France*, Thomas Kloss, *CEA, Institut de Physique Théorique, Gif-sur-Yvette, France*, Nicolás Wschebor, *Universidad de la República, Montevideo, Uruguay* ■We present a method, rooted in the non-perturbative renormalization group, that allows one to calculate the critical exponents and the correlation and response functions of the Kardar-Parisi-Zhang (KPZ) growth equation in all its different regimes, including the strong-coupling one. We implement an approximation scheme and show that it yields a complete, qualitatively correct phase diagram in all physical dimensions with reasonable values for the critical exponents. We also compute in one dimension the full (momentum and frequency dependent) correlation function, and the associated universal scaling functions. We find an excellent quantitative agreement with the exact results from Praehofer and Spohn (2004). This result is generalized in 2+1 en 3+1 predicting correlation and response functions. Associated universal amplitude ratios were predicted and have after been successfully confirmed by lattice simulations (Halpin-Healy, 2013). Generalizations as the inclusion of anisotropies or long-range correlated noise are discussed. Finally, preliminary results in order to improve the approximation in order to analyze the four and higher dimensional behavior is also discussed. The presented work is based on the references Phys. Rev. Lett. 104 (2010) 150601; Phys. Rev. E84 (2011) 061128; Phys. Rev. E86 (2012) 051124; Phys. Rev. E89 (2014) 2, 022108; Phys. Rev. E90 (2014) 6, 062133,

[02/11/2015 - 11:20 - Room Tubarão]
What is a n-th order temperature?, Sílvio M. Duarte Queirós, *CBPF*, Welles A. M. Morgado, *PUC-Rio* ■Although a huge stake of problems in non-equilibrium statistical mechanics is related to thermal reservoirs that within the context of a Langevin description are described by Gaussian noises, there is an important set of problems - which go from diffusive motion in little dense media to molecular motors powered by exergonic chemical reactions such as the hydrolysis of ATP - for which the stochastic nature of the noise in the dynamical equations ought to be everything but Gaussian. As a matter of fact, most of those systems are very well described by taking into consideration Poissonian shot-noise terms for mimicking the interaction system-reservoir. If, to a good extent, it is possible to map athermal linear systems into standard reservoir cases by means of defining a canonical temperature, the existence of non-linearities puts the singular nature of a shot-noise reservoir in the limelight. In that case, specious violations of the principles of thermodynamics can emerge. Aiming to reconcile such natural principles with the analytical properties of non-standard reservoirs, we introduce the concept of temperature of n-th order to characterise the typical scale of energy that is represented by the n-th order cumulant of the noise. With that concept in hand, we also analyse the form of the large deviation function of the energy fluxes and fluctuation relations in systems of this kind.

[02/11/2015 - 11:35 - Room Tubarão]
Stochastic thermodynamics, Tânia Tomé, Mário J. de Oliveira, *Instituto de Física, Universidade de São Paulo* ■We develop the stochastic approach to thermodynamics based on the stochastic dynamics, which can be discrete or continuous, and on two assumptions concerning entropy. In the discrete case, the system is governed by master equation and in the continuous case, by a Fokker-Planck equation. The first assumption concerns the definition of entropy, which is taken to be the Boltzmann-Gibbs entropy, and thus has the same form as the equilibrium definition. The difference is that the probability distribution may be time-dependent. The second assumption has to do with the definition of entropy production rate, which is taken to be the expression introduced by Schnakenberg. This expression is nonnegative by definition and vanishes in the thermodynamic equilibrium. Based on these assumptions we study interacting systems with many degrees of freedom in equilibrium or out of thermodynamic equilibrium, and how the macroscopic laws are derived from the stochastic dynamics. In particular, we will discuss the quasi-static processes defined as the ones in which the thermodynamic fields are varied slowly. We show that the rates of energy, entropy and number of particle, are linear in the rate of the thermodynamics fields whereas the production of entropy is quadratic in these rates so that it may be negected and the system may be considered to be in thermodynamic equilibrium. We show that along a quasi-static process the representative point in the space energy, entropy and number of particle, remains on a surface and that this surface has the property of convexity.

[02/11/2015 - 11:50 - Room Tubarão]
Exact solution for a 1+1 etching model, Washington S. Alves, Bernardo A. Mello, Ismael V. L. Costa, Fernando A Oliveira, *Universidade de Brasília - UnB* ■We present a method to derive analytically the growths exponents of a surface of $1 + 1$ dimensions whose dynamics is ruled by cellular automata. Starting from the automata, we write down the time evolution for the height's average and height's variance (roughness). We apply the method to the etching model [1,2,3,4] than we obtain the dynamical exponents, which perfectly match the numerical results obtained from simulations. Those exponents are exact and they are the same as those exhibited by the KPZ model [5] for this dimension. Therefore, it shows that the etching model and KPZ model belong to the same universality class [6].

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[02/11/2015 - 12:05 - Room Tubarão]
Entropic Inference and Backward Renormalization Group priors, Nestor Caticha, *IF Universidade de São Paulo* ■Maximum Entropy inference (ME) is a unique inference engine. Starting from prior distributions, codifying previously available information, ME permits the update to new probability distributions, incorporating information as it becomes available. Its ever expanding scope of applications fuels the need to improve the construction of informative priors that lead to improved inferential results. In this paper we are interested in general inverse problems which can benefit from a multiscale approach. We construct a systematic method of transferring information from coarser to finer resolutions based on Renormalization Group transformations. It permits building informative priors in finer scales from posteriors in coarser scales. This can be done since, under some conditions, Renormalization Group transformations in the space of hyperparameters can be inverted. These are a class of Markov embeddings. These priors are then updated using renormalized data into posteriors by ME. ME updating with constraints in the form of data measurements is equivalent to Bayes updating but permits repited use of renormalized data at different scales. The resulting inference method, Backward RG (BRG) priors, is tested by doing simulations of a functional Magnetic Resonance imaging (fMRI) experiment. Its results are compared with a Bayesian approach working in the finest available resolution. Using BRpriors sources can be partially identified even when signal to noise ratio levels are up to ~ -25dB improving vastly on the single step Bayesian approach. For low levels of noise the BRprior is not an improvement over the single scale Bayesian method. Analysis of the histograms of hyperparameters can show how to distinguish if the method is failing, due to very high levels of noise, or whether the identification of the sources is, at least partially possible.
Acknowledgment: Presentation supported by Fapesp

NON EQUILIBRIUM

[02/11/2015 - 11:00 - Room Vitória]
Failure of Steady State Thermodynamics, Ronald Dickman, *Universidade Federal de Minas Gerais* ■Steady state thermodynamics (SST) is an attempt to extend thermodynamics to nonequilibrium steady states arbitrarily far from equilibrium, attributing intensive variables such as temperature and chemical potential to these systems. To be useful, SST must be self-consistent and have predictive value. I examine this issue in the context of driven stochastic lattice gases. Consistency of SST is verified for driven lattice gases under global weak exchange, but only for a particular class transition rates, those defined by Sasa and Tasaki. Under local (pointwise) exchange, consistency only holds in the limit of a vanishing exchange rate. SST fails to predict the coexisting densities under a nonuniform drive, or in the presence of a nonuniform density provoked by a wall or nonuniform transition rates. The steady state chemical potential profile is, moreover, nonuniform at coexistence, contrary to the basic principles of thermodynamics. As a further example, I discuss examples of a pair of systems possessing identical steady states, but which do not coexist when placed in contact. I then turn to the question of phase coexistence in nonequilibrium steady states. Results on the driven lattice gas with attractive interactions show that the bulk densities of coexisting phases are different for phases that (1) separate spontaneously in a single inhomogeneous system, and (2) phases that coexist under particle exchange between two homogeneous systems. These results cast serious doubt on the consistency and predictive value of SST, and on the notion of thermodynamic phases far from equilibrium.

[02/11/2015 - 11:20 - Room Vitória]
Phase transitions in non-equilibrium stationary states driven by multiplicative stochastic processes, Daniel G. Barci, Miguel V. Moreno, *Departamento de Física Teórica, Universidade do Estado do Rio de Janeiro.*, Zochil González Arenas, *Departamento de Matemática Aplicada, Universidade do Estado do Rio de Janeiro* ■Stochastic processes with multiplicative noise often leads to stationary out-of-equilibrium states. They are characterized by the presence of probability currents and, in general, time-reversal is a broken symmetry and usual equilibrium properties, such as detailed balance, are not satisfied. In this type of stationary states, symmetry-breaking phase transitions could take place, induced by noise [1]. That is, for weak noise the stationary state is usually disordered. However, an ordered state sets in when the noise intensity is increased. There are two necessary ingredients to produce this class of phase transitions: multiplicative noise and out-of-equilibrium stationary states.
In this work, we present a study on out-of-equilibrium phase transitions induced by multiplicative noise. Recently, we have presented a functional formalism [2,3]. to compute correlations functions in these systems. Based on that, we built up a "dynamical potential" written in terms of an order parameter capable to describe non-equilibrium phase transitions.
As an example, we applied our formalism to a particularly simple model which captures the physics of non-equilibrium phase transition. The model is defined by a set of stochastic variables arranged in a hyper-cubic lattice satisfying a system of interacting Langevin equations with multiplicative noise, where we consider first neighbors interactions. We computed a "dynamical potential" for the stationary state in the saddle-point plus Gaussian fluctuations approximation. From this, we have built up a phase-diagram in terms of the lattice interaction and the noise. We discovered a phase transition with reentrant behavior for sufficiently strong lattice coupling. We computed the phase diagram for different dimensions and for different values of the stochastic prescription that defines the multiplicative stochastic process. At the level of this approximation we found that the phase transition is continuous and we computed critical exponents. Even thought, the concept of universality is not completely developed in out-of-equilibrium transitions, the computed exponents are in the universality class of the dynamical

Ising model.
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This work was partially supported by CNPq, CAPES and FAPERJ.

[02/11/2015 - 11:35 - Room Vitória]
Restricted permutations and random $(0,1)$-matrices in the symmetric simple exclusion process in discrete time over graphs, J. Ricardo G. Mendonça, *EACH/USP* ■Motivations to study exclusion processes in general and exclusion processes over graphs in particular are manifold. In physics, exclusion processes are simple models that provide nontrivial results on a number of basic issues, such as the relaxation dynamics of a gas or fluid towards the thermodynamic equilibrium. They are also relevant in the modeling of interacting processes such as queueing systems, traffic, signaling in radio and computer networks, and rumour and epidemics spreading in social networks. Moreover, exclusion processes are natural generalizations of the single random walk problem. The mathematics of random walks on graphs and groups has been an active field of investigation for at least four decades by now, having led to many developments in pure and applied probability, statistics, combinatorics, group theory, and harmonic analysis. In this work we describe the dynamics of the symmetric simple exclusion process in discrete time over simple graphs by means of suitably restricted permutations over the labels of the vertices of the graphs. Straightforward Monte Carlo and sequential importance sampling algorithms for sampling restricted permutations inspired by the related problem of computing permanents are implemented and compared. We illustrate the formalism by estimating the relaxation times of the symmetric simple exclusion process in discrete time over Newman-Watts small-world networks.

[02/11/2015 - 11:50 - Room Vitória]
Exact evaluation of high order statistical moments in self-organizing phenomena, Brenno Caetano Troca Cabella, *Departament of Clinical Neurosciences, University of Cambridge*, Cesar Augusto Sangaletti Terçariol, *Centro Universitário Barão de Mauá*, Gilberto Medeiros Nakamura, Alexandre Souto Martinez, *Universidade de São Paulo* ■Self-organizing phenomena (SOP) are ordered collective behavior that arises from small fluctuations and develops positive feedback. These collective effects are macroscopically observable and are governed by higher order statistical moments and correlation functions. An interesting example of the SOP role as the underlying Physics is the atomic superradiant emission of photon in cavities. This effect emerges from the interaction of a single quantum electromagnetic field with N emitters, each modeled as a two-level system, trapped inside an optical cavity. When the typical distance between atoms is smaller than the emitted photon wavelength, the assumption of weak interaction no longer holds. As a result, the iconic spontaneous emission of photons by atoms cannot occur as N independent events, even for $N = 2$, as verified in recent experiments. The quantum interference among the ensemble shapes the emission in cavities. SOP are also relevant in a large variety of classical problems, namely, efficient brochure dissemination in advertising and disease spreading by aerial vectors, such as dengue fever. Here, we present a new technique for self-organizing systems to evaluate high order statis- tics employing a classical toy model. The technique is valid only for SOP where small fluctuations originates a rapid growth rate. The toy model considered is composed by an urn and N distinguishable balls, uniquely identifiable by their labels. Each time, a given ball is randomly selected, its label is then recorded in a list and then the ball is returned back to the urn. However, the samples are formed by counting the number of unique labels found in a given list. This measure process introduces correlations in time for each sample, which in turn triggers a collective behavior, as also reported for pulsed photon emission in the superradiant models. In Probability Theory, this problem is also referred as the classical coupon-collector's problem, whose solution has been unveiled only recently, using the poissonization technique. This technique hides the interesting underlying finite sym- metries, which are relevant for physical properties. Instead, the statistics in the toy model are derived here from the geometrical properties of multidimensional Pascal triangle and are closely related to counting problems. Our findings contemplate both small and large N limit. In addition, the mapping between the classical toy model and superradiance permits the formulation of new simple classical Monte Carlo methods to investigate the cooperative regime in cavity QED models.

[02/11/2015 - 12:05 - Room Vitória]
Fluctuation of heat flow along one dimensional linear conducting chain, Welles Antonio Martinez Morgado, Michael Moraes Cândido, *PUC - Rio*, Silvio Manuel Duarte Queirós, *CBPF* ■Anomalous conductivity is a strong characteristic of linear chains. The main reason for it is the ballistic way phonons propagate in these systems. It would be expected that non-linear systems would fix that problem due to the phonon-phonon coupling present in them. However, due to their crumpled one dimensional topology, non-linearity is not sufficient to effectively diffuse heat under non-equilibrium conditions, namely under distinct temperatures at its extremities. Indeed, it is well known that even non-linear higher dimensional systems do not satisfy Fourier law as well.
The one dimensional model is thus a source of intriguing anomalies that might be of interest due to its applicability to experimental nano-scale systems such as nano-wires, nanotubes (as objects that make the crossover between 1D and 2D), and many more. In fact, thermal properties for these systems are still quite hard to access experimentally.
The use of classical models might give us insight on some of the more important properties for these systems. The heat flux has already been extensively studied for them, in special how to eliminate the anomalous behaviour men-

tioned earlier and make them obey Fourier Law. Several techniques have been developed such as self-consistent thermal reservoirs along the chain, effective interactions with external particles, and mass dispersion among others.
However, higher moments of the heat flux have not been extensively explored despite the fact that they bring important information about the organization of the energy transport throughout the chain.
In this spirit, we have studied them by means of exactly solving the coupled Langevin equations that define the dynamics of the system. We have found interesting properties, such as the non-dependence of chain length for the transmission of higher order fluctuations. We are going to report on these results and show how they are necessary to form a complete and consistent picture of heat conduction for the harmonic chain.

Oral sessions (14:30-16:05)

EPIDEMICS & CELL GROWTH

[02/11/2015 - 14:30 - Room Vitória]
Biological populations and epidemic spreading: stochastic and spatially structured modeling, Tânia Tomé, *Instituto de Física - USP* ■We will address topics covered by the stochastic dynamics, which are inserted in the field of statistical physics of non-equilibrium. The issues we will fix concern the modeling of biologically motivated systems. Topics to be visited consist primarily those related to the dynamics of biological populations as well as those related to spread of epidemics. To this end, we will consider irreversible models described by a Master equation and probabilistic cellular automata. Among the epidemic models to be discussed are: the Susceptible-Infected-Recovered system (SIR) described by a master equation; and a model to describe the stochastic dynamics for dengue epidemic. Among the models for biological populations is a stochastic lattice model to describe the coexistence of predators and prey in a habitat. This coexistence may be accompanied by fluctuations in the populations of each species. We will talk over the nature and characterization of these oscillations. We intend to explore the spatiotemporal patterns related to population dynamics. In addition, we analyze the dynamical and static critical behavior and universality classes associated to non-equilibrium phase transitions, which may occur in these systems. References (1)Tânia Tomé and M. J. de Oliveira, Stochastic Dynamics and Irreversibility, Springer, 2015. (2)D. R. de Souza, Tânia Tomé, S. Pinho and F. Barreto, Phys. Rev. E 87, 012709 (2013). (3)Tânia Tomé and R. M. Ziff, Phys. Rev. E 82 051921 (2010). (4)T. Tomé, A. L. Rodrigues, E. Arashiro and M. J. de Oliveira, Comput. Phys. Comm 180, 536 (2009).

[02/11/2015 - 14:50 - Room Vitória]
Multiple transitions of the susceptible-infected-susceptible epidemic model on complex networks, Angélica Sousa da Mata, *Universidade Federal de Lavras*, Silvio da Costa Ferreira Junior, *Universidade Federal de Viçosa* ■Phase transitions involving equilibrium and nonequilibrium processes on complex networks have begun drawing an increasing interest soon after the boom of network science in the late 1990s. Percolation, epidemic spreading, and spin systems are only a few examples of breakthrough in the investigation of critical phenomena in complex networks. Absorbing state phase transitions have become a paradigmatic issue in the interplay between nonequilibrium systems and complex networks with epidemic spreading being a prominent example where high complexity emerges from very simple dynamical rules on heterogeneous substrates. The existence or absence of finite epidemic thresholds involving an endemic phase of the susceptible-infected-susceptible (SIS) model on scale-free networks with a degree distribution $P(k) \sim k^{-\gamma}$, where γ is the degree exponent, has been target of a intense investigation. Distinct theoretical approaches for the SIS model were devised to determine an epidemic threshold λ_c separating an absorbing, disease-free state from an active phase. The quenched

mean-field (QMF) theory explicitly includes the entire structure of the network through its adjacency matrix while the heterogeneous mean-field (HMF) theory performs a coarse-graining of the network grouping vertices accordingly their degrees. The HMF theory predicts a vanishing threshold for the SIS model for the range $2 < \gamma < 3$, while a finite threshold is expected for $\gamma > 3$. Conversely, the QMF theory states a threshold inversely proportional to the largest eigenvalue of the adjacency matrix, implying that the threshold vanishes for any value of γ. For $\gamma < 3$, there exists a consensus for SIS thresholds. However, for $\gamma > 3$ the different mean-field approaches predict different outcomes. Therefore, in this work, we performed extensive simulations in the quasistationary state of the SIS dynamics on random networks having a power law degree distribution with $\gamma > 3$, for a comparison with these mean-field theories. We observed concomitant multiple transitions in finite networks presenting large gaps in the degree distribution and the obtained multiple epidemic thresholds are well described by different mean-field theories. We observed that the transitions involving thresholds which vanish at the thermodynamic limit involve localized states, in which a vanishing fraction of the network effectively contributes to epidemic activity, whereas an endemic state, with a finite density of infected vertices, can occur at a finite threshold.

Acknowledgements and Financial Support: FAPEMIG, CAPES and CNPq.

[02/11/2015 - 15:05 - Room Vitória]

SIMULATION OF AN EPIDEMIC MODEL WITH VECTOR TRANSMISSION, Adriana Gomes Dickman, *Pontifícia Universidade Católica de Minas Gerais*, Ronald Dickman, *Universidade Federal de Minas Gerais* ■We study a lattice model for vector-mediated transmission of a disease in a population consisting of two species, A and B, which contract the disease from one another. Individuals of species A are sedentary, while those of species B (the vector) diffuse in space. Examples of such diseases are malaria, dengue fever, and Pierce's disease in vineyards. There are several ways of interpreting the model: A contact process (CP) on the A population, mediated by B; a diffusive epidemic process (DEP) on the B population, mediated by A; or a multicomponent epidemic process in which B and A are equally essential. The model exhibits a phase transition between an absorbing (infection free) phase and an active one as parameters such as infection rates and vector density are varied. We study the static and dynamic critical behavior of the model using initial spreading, initial decay, and quasistationary simulations. Although phase transitions to an absorbing state fall generically in the directed percolation (DP) universality class, this appears not to be the case for the present model. Our preliminary results clearly exclude DP scaling for the parameter values studied. Compatibility with DEP scaling remains an open question. Our results raise the possibility of two phase transitions in the epidemic model with vector transmission, as at the apparent critical point for survival in spreading and quasistationary behavior, the number of infected individuals in spreading simulations n(t) grows more slowly than a power law.

[02/11/2015 - 15:20 - Room Vitória]

Assessing the International Spreading Risk Associated with the 2014 West African Ebola Outbreak, Marcelo F C Gomes, *PROCC/FIOCRUZ - RJ - Brasil*, Ana Pastore y Piontti, Alessandro Vespignani, *Northeastern University - EUA*, Luca Rossi, *ISI Foundation - Itália*, Dennis Chao, M. Elizabeth Halloran, *Fred Hutchinson Cancer Research Center - EUA*, Ira Longini Jr., *University of Florida - EUA* ■Background: The 2014 West African Ebola Outbreak is so far the largest and deadliest recorded in history. The mainly affected countries, Sierra Leone, Guinea, Liberia, have struggled to contain and to mitigate the outbreak. After more than one year from the rise in transmission, the latest WHO report finally showed the lowest total number of weekly cases since March 2014. Up to August 2nd, 2015, a total of 27898 confirmed, probable, and suspected EVD cases have been reported worldwide, of which 11296 died. Aside from most affected countries in West Africa, a total of 7 other countries have had imported cases, reaching 3 continents: Africa (Nigeria, Senegal and Mali), Europe (Italy, Spain and the UK) and North America (the USA).
Method: We used the Global Epidemic and Mobility Model to generate stochastic, individual based simulations of epidemic spread worldwide, yielding, among other measures, the incidence and seeding events at a daily resolution for 3,362 subpopulations in 220 countries. The mobility model integrates daily airline passenger traffic worldwide and the disease model includes the community, hospital, and burial transmission dynamic. We use a multimodel inference approach calibrated on data from the month of August 2014. The estimates obtained were used to generate monthly ensemble forecasts that provided quantitative estimates of the local transmission of Ebola virus disease in West Africa and the probability of international spread if the containment measures were not successful at curtailing the outbreak. Results were posted in near real-time to help public health authorities decision making. We also tested the impact of on-site intervention measures in the local spread and importation probability.
Results: We model the short-term growth rate of the disease in the affected West African countries and estimate the basic reproductive number. We simulated the international spreading of the outbreak and provide the estimate for the probability of Ebola virus disease case importation in countries across the world, including intervention scenarios.

[02/11/2015 - 15:35 - Room Vitória]

Cell sorting with variable cluster size: a Smoluchowski equation approach, Carine Priscila Beatrici, Rita Maria Cunha de Almeida, Leonardo Gregory Brunnet, *IF-UFRGS* ■Cell segregation is an widespread phenomena in nature and has interested physicists since the last 50 years. It opens the possibility of studying a system composed of many interacting active identical elements, both theoretically and experimentally. A typical cell sorting experiment measures the evolution of clusters sizes, or also the size of the interface between the two tissues at stake. The dynamics underlying cell migration drives the cell segregation, which is directly related to cluster formation, where the endoderm cells attach

each other forming groups. This development evolves through cluster diffusion and depends on cluster cross section and cell affinity. In the context of active media cluster growth may present unexpected exponents when compared to non-active matter. When clusters are formed by inert particles it is expected that the diffusion scales inversely with the cluster mass, in the case of active matter that does not hold and this is central to define the segregation time scales. Also, finite size effects are important since they impose deviation from power law solutions. To approach this problem from a theoretical point of view we use the Smoluchowski fragmentation-coagulation equation with an adapted coagulation kernel and a fragmentation kernel. It is found that the underlying growth power laws may be hidden depending on initial cluster sizes, sample size and fragmentation constant. The average cluster size solutions found with the Smoluchowski equation are used to fit the data resulting from the simulations and the power law behavior can be clearly separated out of the minimum and maximum cluster size limits.

[02/11/2015 - 15:50 - Room Vitória]
Cell Segregation and Group Diffusion, Carine Beatrici, Rita M. de Almedia, Leonardo G. Brunnet, *Universidade Federal do Rio Grande do Sul* ■The dynamics underlying cell migration drives cell segregation which is essential to tissue formation. Since the mid-twentieth century a series of hypotheses for the microscopic mechanism were put to test to explain the evolution observed in experiments. A typical experiment in cell segregation measures the evolution of clusters sizes, or also the size of the interface between the two tissues at stake. In order to appropriately fit the experiment a series of physical constraints must be taken into account, such as the finite size of each cell, the finite number of cells in the process and the scaling of the cluster diffusion with its mass. Here we explore a mean cluster approach that explicitly includes these constraints. In some appropriate limits this mean cluster approach has exact solutions with simple power laws with finite size effects clearly identified. Simulations of cell segregation based on the differential adhesion hypothesis are implemented using simple active matter models. The mean cluster approach solutions are used to fit the data resulting from the simulations and the power law behavior can be clearly separated out of the minimum and maximum cluster size limits. The relation found between the group diffusion with its mass and the preferential alignment of cell velocities inside clusters impact on the power law exponents with direct consequences to the segregation time scales.

TIMESERIES

[02/11/2015 - 14:50 - Room Tubarão]
Handwrite signature characterization and verification using time causal Information Theory quantifiers, Osvaldo Anibal Rosso, Raydonal Ospina, Alejandro Frery, *Instituto de Física, Universidade Federal de Alagoas, Maceió, Brasil* ■A signature is a handwritten depiction of someone's name or some other mark of identification that person writes on documents or a device as proof of identification. The formation of signature varies from person to person or even from the same person due to the psychophysical state of the signer and the conditions under which the signature apposition process occurs. Handwritten signature characterization and verification is a behavioral biometric modality that relies on a rapid personal gesture. Each hand-drawn signature has a level of complexity which depends on the author. Among all the biometric traits that can be categorized as pure behavioral, the signature is the one that has the widest social acceptance for identity authentication. Online signature verification allows the introduction of the signature's dynamic information, not just the outcome of the signing process. Such dynamical information is captured by a digitizer, and generates "online"signatures, namely a sequence of sampled points during the signing process: $(x, y)(t)$, the coordinate x and y at time t. We compute Information-Theoretic measures (Shannon Entropy, Generalized Statistical Complexity and Fisher information measure), on the Bandt-Pompe nonparametric descriptor, which take into account the time causal of the corresponding time series. These measures are used as the input features of a signature characterization and verification system, whose performance is assessed over the well known MCTY 100 signature data base. Our results are competitive in terms of acceptance and rejection errors, and is shown very attractive in terms of computational requirements.

[02/11/2015 - 15:05 - Room Tubarão]
Nonstationarities and sleep disturbance detection, Sabrina Camargo, *Escola de Matemática Aplicada, Fundação Getúlio Vargas*, Celia Anteneodo, *Departamento de Física PUC-Rio*, Maik Riedl, Jürgen Kurths, Niels Wessel, *Humboldt Universität zu Berlin* ■We present recent results on sleep apnea-hypopnea quantification. Sleep apnea is the most common sleep disturbance and it is an important risk factor for cardiovascular disorders. The diagnostic is obtained trough combined exams, and we aim to offer an alternative procedure. A sleep apnea event is defined as a break in the airflow that lasts at least 10 secs. If the air flow is less than 50% of normal, the resulting airflow limitation is called hypopnea. Individuals who suffer from this kind of disorder usually present daytime sleepiness, loud snoring and restless sleep. Blood pressure, heart rate variability, respiratory variability, and other cardiorespiratory data could be useful to detect sleep disturbances, and it is important to emphasize that cardiorespiratory time series are highly nonstationary, which restricts the use of standard tools of time series analysis. Hence, we apply a nonparametric segmentation procedure to yield patches where stationarity is verified. Within each of these locally stationary data segments, the statistical moments of the signal, such as mean and variance, remain constant. Segmentation also provides the intrinsic time scales, through the duration of segment lengths. We show that the occurrence of sleep apnea events can be quantified by means of blood pressure time series analysis, and by comparing local quantities to an apnea score previously obtained by polysomnographic exams, we propose an apnea quantifier based on blood pressure signal with an accuracy of 82%. Ref: S. Camargo, M. Riedl, C. Anteneodo, J. Kurths, T. Penzel, N. Wessel, Sleep apnea-hypopnea quantification

by cardiovascular data analysis, Plos One **9**, e107581

[02/11/2015 - 15:20 - Room Tubarão]
New Features on Gradient Pattern Analysis of Extended Complex Systems, Reinaldo Roberto Rosa, Rubens Sautter, *LAC-INPE-MCTI* ■Quantitative characterization of spatio-temporal patterns is clearly essential to the understanding of spatio-temporal phenomena. An important question in this problem concerns the long-term evolution of the pattern properties. Usually, the classical measures of complex extended variability do not take into account the directional information contained in a vectorial field: the main source of spatio-temporal variability. Moreover, since spatio-temporal information is even more accessible through high resolution digitized images, the need for sensitive techniques working in the real space is evident In this context, Gradient pattern analysis (GPA)[1] is a geometric computing method for characterizing geometrical bilateral symmetry breaking of an ensemble of symmetric vectors regularly distributed in a square lattice. The measures obtained from GPA are based on the spatio-temporal correlations between large and small amplitude fluctuations of the structure represented as a dynamical gradient pattern. By means of four gradient moments it is possible to quantify the relative fluctuations and scaling coherence at a dynamical numerical lattice and this is a set of proper measures of the pattern complexity and equilibrium. Taking into account massive gradient fields ($N > 104$ vectors) In this talk we describe new features on how to compute the gradient moments based only on the phase portrait of bilateral symmetry breaking computed into the GPU/CUDA paradigm. Examples of this new approuch for big data is performed on Chaotic Coupled Map Lattices and also on gravitational N-body systems for cosmological large structure formation.
[1] Rosa et al. Physica A, 386:366-673, 2007. *doi* : 10.1016/*j.physa*.2007.08.044

[02/11/2015 - 15:35 - Room Tubarão]
Cross-Sample Entropy Analysis for Climate Data, S. T. Silva, *Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso*, S. R. Paulo, *Unversidade Federal de Mato Grosso, Instituto de Física* ■Currently due to intense modification of the natural environment and global climate change, many researches has been motivated to investigate relationships between El Niño phenomena dynamics and climatological variables. Understanding the dynamics that govern the climate can be done through analysis of nonlinear dynamical systems because the phenomenon involved has chaotic behavior. The reconstruction of the system dynamics that originated the possible climate changes patterns, with only one measurement scale, it is possible, through specific techniques of time series analysis. The description of the level of complexity or irregularity of time series can be made through the analysis of their Cross-Sample Entropy.The study was conducted with data from the meteorological station of Cuiabá, provided by INMET (National Institute of Meteorology) through of BDMEP (Meteorological Data Bank for Education and Research) in the 1961-2013 periods. The evidence of a possible connection between air temperature dynamic states and the Oceanic Niño Index - ONI, were verifying by Cross-Sample Entropy analysis of the series. The results point to the existence of a climate system with climate dynamic regulation of low dimensional and presence of deterministic chaos. The temporal evolution of nonlinear parameters obtained present a complex dynamics that may have related and influence of the fluctuations in ONI index.
Keywords: Complex dynamics, Air temperature, Oceanic Niño Index.

[02/11/2015 - 15:50 - Room Tubarão]
Light with tunable non-Markovian phase imprint, Robert Fischer, *CPGEI, Universidade Tecnólogica Federal do Paraná*, Itamar Vidal, *DF - Universidade Federal da Paraíba*, Ana Carolina Ribeiro-Teixeira, *Universidade Federal de Ciências da Saúde de Porto Alegre*, Ricardo R. B. Correia, Sandra D. Prado, Jandir M. Hickman, *Instituto de Física - Universidade Federal do Rio Grande do Sul*, Doron Gilboa, Yaron Silberberg, *Department of Physics of Complex Systems, Weizmann Institute of Science* ■Designing the spatial coherence properties of light is fundamentally important to most applications in optics and photonics. Usually, efforts are made to increase the light's spatial coherence, through spatial filtering, for instance. However, for some applications, like the generation of random numbers or patterns, the opposite is desired. When the light spatial coherence length is smaller than the detection unit (e. g. the pixel size of a CCD camera), then the intensity measured at each pixel is uncorrelated to any other pixels. This is the case of thermal light, usually modeled as delta-correlated. Moreover this is the spatial analogue of a temporal Markovian process. In this work we explore for the first time a spatial phase imprint analogue of a non- Markovian process inspired in the Sudoku puzzle.
Sudoku puzzles are a suitable basis for such conditional randomness in 2D: the fact that only 6.67×10^{21} out of the total $9^{9\times9} \simeq 1.96 \times 10^{77}$ configurations are possible solutions provides a measure of randomness, while the Sudoku rules (in each column, row and 9×9 block the numbers 1 to 9 can only be used once) provide strict constraints to this randomness.
Sudoku light can be experimentally generated by phase imprinting a conditional random pattern on a planar wavefront via a spatial light modulator, for which the phases of different points in the beam profile are generated using a Sudoku solver.
We solve overlapping Sudoku puzzles for a large area (e.g. 1024×1024) and apply the resulting pattern as phase imprint on a Gaussian light beam. Simulations show that such light, when focused, displays a symmetric pattern with a centric cross-shaped minima. Furthermore, we note that the diffraction pattern of the light after a double slit does neither correspond to coherent nor to incoherent thermal light, but rather shows fringes in the outer lobes while having a minimum at the place of the zero's order. These counterintuitive properties of Sudoku light, while violating the spatial equivalent of the Markovian condition, may have some applications in the context of decay and initialization of quantum states.

References:
Robert Fischer, Itamar Vidal, Doron Gilboa, Ricardo R. B. Correia, Ana Carolina Ribeiro-Teixeira, Sandra D. Prado, Jandir M. Hickman, Yaron Silberberg, accepted for publication in Physical Review Letters.

Oral sessions (17:05-18:15)

FUNDAMENTAL ASPECTS

[02/11/2015 - 17:05 - Room Tubarão]
A Modern Approach to Computational Simulation of Phase Transitions., Costa BV, *Departamento de Fisica - UFMG* ■A phase transition is one of the richer and beautiful phenomenon observed in nature. The transformation of ice in water and water in gas, the spontaneous magnetization of a piece of iron or the spontaneous symmetry breaking during the big bang are a few examples of phase transition. Several techniques were developed to treat phase transitions. An experimenter measures the effects in his laboratory and a theorist make the necessary approximations to provide general aspects of that specific model. In this talk we will approach the problem from a different perspective. In fact a perspective more adequate to the XXIst Century. We will use computational techniques or to be more exact "COMPUTATIONAL SIMULATION". Although the technique has appeared for the first time in the middle of the last century, only now it is being recognized as a new branch of the languages used to understand nature. Much of this recognition is due to the fast development of new computers (In the hexaflops nowadays) and to the development of new algorithms. In this lecture I will give an introduction to the Monte Carlo techniques: Metropolis, Single Histograms and Wang-Landau, as well as an analysis of phase transitions using the Fisher Zeros.

[02/11/2015 - 17:25 - Room Tubarão]
Signatures of the Berezinskii-Kosterlitz-Thouless transition in the location of the zeros of the canonical partition function for the 2D XY-model, J.C.S. Rocha, L.A.S. Mól, B.V. Costa, *Universidade Federal de Minas Gerais* ■In this work we show how one can use the zeros of the canonical partition function, the Fisher zeros, to unambiguously characterize a transition as being in the Berezinskii-Kosterlitz-Thouless (BKT) class of universality.
A "fruit fly" model of the BKT transition is the classical two-dimensional XY-model on a square lattice, defined by

$$\mathcal{H} = -J \sum_{\langle i,j \rangle} (S_i^x S_j^x + S_i^y S_j^y). \qquad (1)$$

The sum runs over the nearest neighbors, J stands for the exchange coupling constant and S_i^α stands for the component $\alpha = (x, y, z)$ of the i^{th} spin.
We obtained the Fisher's zeros map via recent Monte Carlo simulations techniques (Replica Exchange Wang-Landau) capable of sampling the entire configuration space efficiently in a single simulation and powerful matrix diagonalization procedures.
We found that in a BKT transition the internal border of the zeros map behave in such a way that for $T \leq T_{BKT}$ it coalesces into the real positive axis in the thermodynamic limit, indicating the existence of a line of critical points in this region, as should be expected, and in contrast to what happens for a continuous or discontinuous phase transition, where a single leading zero touches the

positive real axis. This behavior is therefore the signature of the BKT transition. The inflection point of the zeros map was successfully used to obtain the BKT temperature, $T_{BKT} = 0.704(3)$, in excellent accordance with the literature.
This work was partially supported by Fapemig.

[02/11/2015 - 17:40 - Room Tubarão]
Competing nematic interactions in the XY model in two and three dimensions, Gabriel Canova, Yan Levin, Jeferson J. Arenzon, *UFRGS* ■Although there is no long-range order at finite temperature in two-dimensional systems with continuous symmetry, it is well known that the 2d XY model exhibits an unusual infinite order phase transition, associated with integer-vortex unbinding, which belongs to the Kosterlitz-Thouless (KT) universality class. In Ref. [1], a generalization of the XY model with a mixture of ferromagnetic and nematic-like interactions was studied:

$$\mathrm{H} = -\sum_{\langle ij \rangle} [\Delta \cos(\theta_i - \theta_j) + (1-\Delta)\cos(q\theta_i - q\theta_j)],$$

with $0 \geq \Delta \leq 1$. While the first term favors parallel alignment of the spins, the second one tends to induce a $2k\pi/q$ relative orientation between them ($k \leq q$). The higher order harmonics (in particular, $q = 3$ and 8) lead to further ordered phases and complex phase diagrams. Using a combination of extensive Monte Carlo simulations, finite size scaling and by studying the helicity modulus we extend the results of Refs. [1,2] and study the three dimensional case as well. In particular, for $q = 8$, the usual ferromagnetic phase is divided in two new phases with different kinds of ferromagnetic alignment and topological defects. The transitions between the ordered phases belong to a wide variety of classes, ranging from Ising 2D, Kosterlitz-Thouless and an unusual set of critical exponents. The results seem to be consistent in three dimensions, but the transitions between ordered phases with the paramagnetic one are second order and belong to the 3D XY universality class.
[1] Poderoso, Arenzon and Levin, Phys. Rev. Lett. **106** (2011) 067202
[2] Canova, Levin and Arenzon, Phys. Rev. E, **89** (2014) 012126

[02/11/2015 - 17:55 - Room Tubarão]
Central Limit Theorems for Trigonometric Series Involving Primes, Guilherme França, *IFT/UNESP* ■One of the most fundamental results in probability theory is the central limit theorem, which is also at the heart of statistical mechanics. Roughly speaking it asserts that a sum of independent random variables is normally distributed. We discuss how the central limit theorem applies to some trigonometric series involving the prime numbers. Although the primes are deterministic, each term in the series behave like independent random variables due to the multiplicative independence of the primes. Some of these results can be rigorously proven, while others are still conjectural. We discuss these trigonometric series in relation to the Zeta function, Dirichlet L-functions, and also level one modular forms. In the last case there is a close relation with the Sato-Tate conjecture. The motivation behind this study is its relation to the Riemann Hypothesis, which is one of the most important unsolved problems in mathematics. We do not aim to provide rigorous results, but we do propose a new perspective into this problem, from a physicist point of view. More specifically, the central limit theorem implies the typical $O(\sqrt{N})$ bound for the growth of these trigonometric series. From this we can argue that the Euler product is still valid inside the right-half part of the so-called critical strip, thus eliminating zeros in such a region.

SOFT MATTER

[02/11/2015 - 17:05 - Room Vitória]
Combining Statistical Physics and Quantum Mechanics for Studying Atomic and Molecular Systems along the Phase Diagram., Sylvio Canuto, *IF USP* ■The combination of quantum and statistical mechanics allows inclusion of the thermodynamic condition and hence studying atomic and molecular systems in different locations of the phase diagram. In recent years the studies in the liquid phase have advanced the knowledge of spectral properties of molecules in solution, a situation that is germane in Chemistry and of enormous importance in Biology [1]. More recently, our attention has been devoted to the condition of supercritical fluids analyzing the structure, spectra and properties of molecules in a supercritical environment, [2,3] thus beyond the critical point. Theoretical studies of the critical behavior of fluids have been conducted mostly by universal scaling functions and renormalization theories. We now focus on the electronic properties of homogeneous fluids close to the critical point and have given the first explicitly calculated values of the dielectric constant in the close vicinity of the critical point (T = Tc + 2K). Thus, the behavior of the dielectric constant, only slightly above the critical point, is determined using first-principle quantum mechanical calculations. The multi-scale results [4] obtained by combining statistical and quantum mechanics indicate that the dielectric constant of Ar slightly above Tc and around the critical isochoric (0.531 g/cm^3) becomes density-independent. Further aspects can be explored and our progress will be reported in this presentation.

References

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[3] T. L. Fonseca, H. C. Georg, K. Coutinho and S. Canuto J. Phys. Chem. A 113, 5112 (2009).
[4] M. Hidalgo, K. Coutinho and S. Canuto, Phys. Rev. E. 91, 032115 (2015).

[02/11/2015 - 17:25 - Room Vitória]
Critical Adsorption of Polyelectrolytes onto Charged Janus Nanospheres, Sidney J. de Carvalho, *Institute of Biosciences, Letters and Exact Sciences - UNESP - Brazil*, Ralf Metzler, Andrey G. Cherstvy, *Institute for Physics and Astronomy - University of Potsdam - Germany* ■Based on extensive Me-

tropolis Monte Carlo computer simulations and analytical considerations we study the electrostatically driven adsorption of flexible polyelectrolyte chains onto charged Janus nanospheres. These net-neutral colloids are composed of two equally but oppositely charged hemispheres. The critical binding conditions for polyelectrolyte chains are analysed as function of the radius of the Janus particle and its surface charge density, as well as the salt concentration in the ambient solution. Specifically for the adsorption of finite-length polyelectrolyte chains onto Janus nanoparticles, we demonstrate that the critical adsorption conditions drastically differ when the size of the Janus particle or the screening length of the electrolyte are varied. We compare the scaling laws obtained for the adsorption-desorption threshold to the known results for uniformly charged spherical particles, observing significant disparities. We discovered that there exists no universal parameter κa, where κ is the reciprocal Debye screening length and a is the nanoparticle radius, that couples the surface curvature and the salinity of the solution, in contrast to the case for adsorption onto uniformly charged spherical and cylindrical interfaces. We also contrast the changes to the polyelectrolyte chain conformations close to the surface of the Janus nanoparticles as compared to those for simple spherical particles. Finally, we discuss experimentally relevant physico-chemical systems for which our simulations results may become important. In particular, we observe similar trends with polyelectrolyte complexation with oppositely but heterogeneously charged proteins.

[02/11/2015 - 17:40 - Room Vitória]
Effects of Monomer Size on Polymer Mass Transport at an Interface, Antonio Cadilhe, B. V. Costa, *Universidade Federal de Minas Gerais* ■Polymer mass transport in the bulk has been a topic widely studied in the literature with the main phenomelogical aspects, presently, well understood. These studies are, in general, of great importance to the understanding of the phenomenology of, for example, polymers solutions and polymer melts in the bulk. However, polymer diffusion at an interface, as for example, a crystalline substrate has been a much less researched topic [Desai et al., Phys. Rev. Lett. 98, 218301 (2007)]. Present studies have focused on smooth surfaces defined by a potential field, which are unrealistic for actual substrates as their structure is not taken into account. In fact, we expect monomer diffusion to take place by thermally activated processes over a corrugated energy landscape, instead of moves over a smooth potential. Here, we study the effect of the substrate structure on the diffusion constant of the polymer, by taking into account its crystalline structure, an FCC (100) substrate orientation. Specifically, we vary the monomer radius relatively to that of the substrate particles and study how the diffusion constant varies. We show that the influence of the substrate is important and leads to a non-monotonic diffusion constant with the ratio of the monomer radius relatively to that of substrate particles. This behavior is primarily identified with the total energy, consisting of the polymer energy and the substrate-monomer interaction. The major contribution, leading to the non-monotonic behavior of the diffusion constant, is associated with the substrate-monomer interaction, but there is also, a monotonic dependence, given by the polymer energy. Concomitantly, we also study the Arrhenius behavior of the diffusion process at various temperatures. Finally, we also study the size dependence of the diffusion constant and discuss the implications of a finite lifetime of polymers of different sizes on a substrate.

[02/11/2015 - 17:55 - Room Vitória]
Polydispersed rods on the square lattice, Jürgen F. Stilck, *Instituto de Física, UFF and INCT-SC, Niterói, RJ*, R. Rajesh, *Institute of Mathematical Sciences, C.I.T. Campus, Taramani, Chennai 600113, India* ■We study the grand-canonical solution of a system of hard polydispersed rods placed on the square lattice using transfer matrix and finite size scaling calculations. Only excluded volume interactions are considered. In order to treat both directions on the square lattice in a simmetric way, the transfer matrix is defined along the diagonal direction of the lattice. The polydispersity of the rods is determined by distinct activities for internal and endpoint monomers of a rod, as is done in a lattice model for equilibrium polymerization. We determine the critical line separating an isotropic from a nematic phase, extrapolating data for the correlation length of the model defined on strips of finite width with periodic boundary conditions. In the full packing limit it was possible to handle strips of larger widths, and therefore more precise estimates could be obtained. No second transition to a disordered phase is found at high density, contrary to what is observed in the monodispersed case, therefore the critical line extends up to the full packing limit. The estimates of critical exponents and the central charge, on the whole critical line, and also in the full packing limit, are consistent with the Ising universality class. The extrapolated phase diagram is compared with Bethe lattice results for the same model and with simulational results for monodispersed rods on the square lattice.

Plenary talks (8:30 - 10:00)

PLENARY SESSION

[03/11/2015 - 08:30 - Room Vitória]
Synchronization and antisynchronization of coupled discrete noisy oscillators, Daniel Escaff, Kevin Wood, Katja Lindenberg (University of California San Diego) ■Synchronization phenomena are observed in many noisy systems in nature. In these systems, a large or infinite collection of units, when coupled together, can undergo a transition to synchronized behavior in spite of the presence of noise. The theoretical analysis of these phenomena is notoriously difficult, and the numerical simulations notoriously resource intensive.
Our work deals with arrays of the simplest possible coupled noisy units that exhibit synchronization. Our hope is two-fold: (1) That analytic work is then possible and numerical work much less costly; (2) That the behavior of these "simplest" arrays tells us something about the behavior of more complex realistic systems.
Synchronization occurs when the coupled units "like" to be in the same state. Antisynchronization (a term we coined) is a far more complex behavior when the units "do not like" to be in the same state. We present a number of results in this latter case, one that we have not seen discussed in the literature prior to our work.

[03/11/2015 - 09:00 - Room Vitória]
Thermodynamic constraints on information processing in living systems, Luca Peliti, *Institute for Advanced Study, Princeton NJ* ■Life can be understood as a non-equilibrium process driven by information handling. It is therefore of great importance to understand the constraints that thermodynamics imposes on the efficiency of information processing in a noisy environment. Recent progress in tackling this problem has been made by the use of generalizations of the second law to take into account information, within the general scheme of stochastic thermodynamics. This allows to derive a general lower bound for error correction that generally relates it with dissipation. I shall review these recent developments and illustrate the results by an application to kinetic proofreading, discussing the corresponding speed-dissipation-accuracy trade-offs.

[03/11/2015 - 09:30 - Room Vitória]
Nonadditive entropies and nonextensive statistical mechanics - An updated overview, Constantino Tsallis, *Centro Brasileiro de Pesquisas Físicas / Santa Fe Institute* ■Boltzmann-Gibbs entropy and statistical mechanics is one of the pillars of contemporary physics. It applies extremely successfully to the so called simple systems, whose dynamics is essentially ergodic. When we wish to study complex systems, particularly nonergodic ones, a more powerful theory is needed. For a wide class of such complex systems, nonadditive entropies and the associated statistical mechanics are being currently used and studied. Recent aspects related to its foundations and applications are now available. A brief overview will be presented. Foundations concerns nonlinear dynamics, large deviation theory, probabilistic correlations, calculation of the index q from first principles, among others. Applications concern long-range-interacting many-body classical systems (XY rotators and Fermi-Pasta-Ulam-like models), overdamped motion of repulsively interacting vortices in type-II superconductors, high energy physics (for example distributions of momenta in high energy collisions at CERN/LHC, Brookhaven/RHIC), granular matter (position fluctuations in two-dimensional shear motion), plasma physics (e.g., distribution of velocities), financial laws (e.g., distribution of price returns and of interoccurrence times), geophysics (seismic analysis of geological areas in Greece and elsewhere), biology (chemical distances between classes of nucleotides in DNA sequences of modern and archaic bacteria and Homo Sapiens), cold atoms, image and signal processing, among others. A bibliography is available at http://tsallis.cat.cbpf.br/biblio.htm

Posters (10:00-11:00 / 16:05-17:05)

BIOLOGICAL PHYSICS

[03/11/2015 - P001]
Optimization on the onset of a critical phase transition in the visual cortex, Mauricio Girardi-Schappo, Germano S. Bortolotto, Jheniffer J. Gonsalves, Marcelo H. R. Tragtenberg, *Dept. de Física, UFSC, SC, Brasil*, Leonel T. Pinto, *Dept. Eng. Qmc., UFSC, SC, Brasil* ■Activity in the brain propagates as waves of firing neurons, namely avalanches. These waves size and duration distributions have been experimentally shown to display a stable power law profile and to have long-range correlations and $1/f^{\beta}$ power spectrum *in vivo* and *in vitro*. These are typical features of critical systems. Criticality have the advantages of maximizing the response dynamic range of neural networks, optimizing memory and learning processes, the computational power of the brain and information processing flexibility. We study a feedforward layered network model of the primary visual cortex that process input information via avalanches that emerge spontaneously from a constant input presented to the retina. We show for the first time that there is a minimum value for the time that the network takes to process input information by varying the excitatory postsynaptic potential parameter (EPSP) close to a critical point. Surprisingly, this point lies on the edge of a Griffiths phase where avalanches are power-law distributed and have a $1/f^{\beta}$ power spectrum with $0.3 \leq \beta \leq 1.5$, matching experiments. The order-disorder continuous phase transition point may be analytically approximated by a mean field calculation, and is located close to the expected experimental value of EPSP in the cortex ($\approx$ 1mV). The system presents two second order phase transitions which are described by two independent order parameters similarly to the Blume-Emery-Griffiths model. We discuss how the model could be extended in order to describe recent experimental results of a stable critical point in the visual system of turtles.

[03/11/2015 - P002]
Evolution of an ensemble of mutator strains towards an equilibrium mutation rate, Alexandre de Aquino Soares, *UFMG*, Louis Bernard Klaczko, *UNICAMP*, Ronald Dickman, *National Institute of Science and Technology for Complex Systems, UFMG* ■Mutation rates are fundamental parameters for evolutionary processes in general. If they are excessively low, populations may not adapt fast enough to environmental changes and go extinct. If they are excessively fast, deleterious mutations may reach levels unbearable to life as well. Thus, equilibrium mutation rates commonly found in nature must be compatible with the very existence of the populations they are measured in. Based on a though experiment by Fisher, we investigate the establishment of an equilibrium mutation rate reached after competition within an ensemble of asexual lineages that differ only by a mutator gene which regulate genomic mutation rates in scenarios such as under adaptation or not, and if mutator genes are directly selected or not. Our model consists initially of L wild genes which can become beneficial with a selective advantage s, and by a genic favorable mutation rate r, a constant depletion of the population of a lineage that represents the genomic deleterious mutation rate d, and a single mutator gene that sets the multiplicative factor m to all mutation rates of the strain. We show and discuss here analytical and numerical results for the distribution of the ensemble and for the fitness of the ensemble over time, paralleling them from the distinct scenarios, assessing the effect of the different parameters over the evolution of the ensembles, and comparing the latter with data from a long term evolution experiment. This work is supported by CAPES, CNPq, and FAPEMIG.

[03/11/2015 - P003]
Normal and tumoral melanocytes exhibit q-Gaussian random search patterns, Priscila C. A. da Silva, Tiago V. Rosembach, Márcio S. Rocha, Marcelo L. Martins, *Departamento de Física, Universidade Federal de Viçosa, MG, Brasil*, Anésia A. Santos, *Departamento de Biologia Geral, Universidade Federal de Viçosa, MG, Brasil* ■In multicellular organisms, cell motility is central in all morphogenetic processes, tissue maintenance, wound healing and immune surveillance, and failures in its regulation potentiates numerous diseases, particularly cancer metastasis. Here, cell migration assays on plastic 2D surfaces were performed using normal (Melan A) and tumoral (B16F10) murine melanocytes in random motility conditions, i.e., in the absence of any external gradient of chemotactic signal. The trajectories of the centroids of the cell perimeters were tracked through time-lapse microscopy. The statistics of these trajectories was analyzed by building velocity and turn angle distributions, as well as velocity autocorrelations and the scaling of mean-squared displacements. We find that these cells exhibit a crossover from a normal to a super-diffusive motion with non-Gaussian velocity distributions, q-exponentially velocity autocorrelations, and trajectories without angular persistence at long time scales. Furthermore, our results reveal that B16F10 cells infected by mycoplasmas exhibits essentially the same diffusivity than their healthy counterparts. Also, varying the initial density of plated cells, we find that there is a crossover from anomalous ($q > 1$) to normal ($q = 1$, Gaussian) migration regime as this density increases. Finally, a q-Gaussian random walk model was proposed to account for these cell search patterns. Simulations based on this model correctly describes the crossover to super-diffusivity in the cell migration tracks.
This work was partially supported by FAPEMIG.

[03/11/2015 - P004]
Cell aggregation in monolayer culture: clues to a universal kinetics, Priscila C. A. da Silva, Marcelo L. Martins, *Departamento de Física, Universidade Federal de Viçosa, Viçosa, MG, Brazil*, Anésia A. Santos, *Departamento de Biologia Geral, Universidade Federal de Viçosa, MG, Brazil*, Sidiney G. Alves, *Departamento de Física, Universidade Federal de São João Del Rei, Ouro Branco, MG, Brasil* ■Cell aggregation is a dynamic and complex process ubiquitous in life. It occurs in morphogenesis, from organisms situated at the border between single and multicellular life forms,

for instance *Dyctyostelium discoideum* , to mammals in which tissues are formed by the assembly of migratory and similar cells into cohesive groups. Also, aggregation disorders are present in numerous diseases. The aggregation of animal cells in culture comprises a series of motility, collision and adhesion processes of basic relevance for tissue engineering, bioseparations, oncology research and *in vitro* drug testing. In the present work, we characterize the aggregation kinetics of normal and cancer cells in culture by determining their cluster size distribution functions. Our experiments reveal that the complementary cumulative distributions for eight cell lines from epithelial and mesenchymal origins are described by stretched exponential functions. Also, we find that as time evolves and the cell density increases, a dynamical phase transition occurs from an aggregation regime described by monotonically decreasing cluster size distributions to another one in which these distributions are nonmonotonic, exhibiting local maxima at large cluster sizes. Subtly, the universality of the stretched exponential distributions admits distinct cluster growth processes controlled by motility and adhesion traits of the cells. Finally, both analytical calculations based on a Smoluchowski-like mean-field approach and simulations of an agent based model of the cell aggregation process were developed in order to describe the experimentally obtained cluster size distributions functions.

This work was partially supported by FAPEMIG.

[03/11/2015 - P005]

Molecular interaction of anandamide with gramicidin ion channel of biomimetics membranes modulated by adjustments of the bilayer/protein hydrophobic coupling, D. Medeiros1, L. C. Silva-Gonçalves2, A. M. S. Brito2, M. Arcisio-Miranda2, *1Tecnologia em Sistemas Biomédicos - Faculdade de Ciências Médicas da Santa Casa de São Paulo / Filosofia - Faculdade de São Bento; 2Biofísica - Universidade Federal de São Paulo* ■Endocannabinoids are endogenous molecules lipidic messengers with amphiphilic character that bind to cell membrane receptors CB_1 and CB_2 distributed throughout the nervous system, which are targets of the active principle of cannabis. The first endocannabinoid discovered, and best characterized, is *N*-arachidonoylethanolamine (anandamide). Endocannabinoids also exert direct activities, not mediated by any type of cannabinoid receptor, by modulating the function of ion channels. This can occur by either chemically specific interactions with determinated sites of these membrane proteins, or by non-specific interactions mediated by the bilayer. We hypothesized that the mechanism for the non-specific receptor-independent action of anandamide involve the adjustment of the membrane/protein hydrophobic coupling by varying physical parameters of the lipidic membrane in the region of insertion of the channel. Adjustment process of hydrophobic lengths can affect the conformational state and hence the conductance of the ion channel, involving energy cost, the bilayer Gibbs energy of deformation, which can be analyzed using continuous theories of elastic deformation of bilayers. This approach abstract up the molecular details of the bilayer, considering it behaving like a macrostructure presenting collective mechanical properties well defined as thickness, intrinsic curvature and modulus of elasticity. Planar lipid bilayers are an excellent experimental model to test this hypothesis because mimics essential aspects of biomembranes, and gramicidin, whose β-helices dimerize to form a channel, is a good *in situ* molecular sensor to estimate the variations in Gibbs energy of deformation. The transition between conductance states 'open' and 'closed' corresponds to the transition between the configurations 'dimeric' and 'monomeric' of the protein, respectively, with the equilibrium distribution between the two conformations given by Boltzmann distribution. Its operation can be studied with a single molecule resolution using electrophysiological methods. This work characterized, through electrical measurements of capacitance and conductance, the ion channel activity of gramicidin under the modulatory effect of anandamide partitioned in membranes composed of lipids with fatty acid chain of different lengths. The endocannabinoid does not change the capacitance of the membrane or the amplitude of the current through the single channel, but produces increase in the frequency of occurrence and the average lifetime of the open state of the channels. The analysis indicates that anandamide exerts a local action without specific binding to the protein, by altering the elastic properties of the bilayer surrounding the channel, thus modulating the hydrophobic coupling membrane/protein and determining its effects on the operation of the ion channel.

[03/11/2015 - P006]

Dynamical Monte Carlo for non-equilibrium systems with simultaneous events: application for Tumor Growth, Marco A A da Silva, Flávio H S Costa, *USP* ■The usual Dynamical Monte Carlo (DMC) method has the assumption that just one event may occur, in systems, in the shortest time scale. On the other hand one can find systems in which several events occur simultaneously, i.e., where more than one event takes place in the smallest time scale. In this work we study, as an example, the formulation of Dawson and Hillen for the evolution of a tumor system with active and quiescent cells. In this model, an active element generates simultaneously two individuals in the quiescent state. Mapping this model into one-event approach is possible. However, we develop here, a more comprehensive Markovian DMC theory, which can include, naturally, simultaneous events. Another remarkable feature of the usual one-event approach is the non-uniform time intervals: an increment depends on the rate and the number of elements responsible for each event type. In the regime of low transition rates, the system spends long time in the same configuration, and the waiting times are estimated in a way to overcome this time consumption with a large time step, making the algorithm very efficient. However, when the system reaches a small enough (critical) number of elements, the waiting times becomes poorly evaluated, leading to accumulation of biased errors, and consequently, deviating the system from its actual trajectory. We will address this issue here and solve it by rescaling the system size. Also, we will extend this approach to cases in which the systems are too large to simulate.

[03/11/2015 - P007]

Lévy flights and self-similar exploratory behaviour of termite workers, Leticia Ribeiro Paiva, *Universidade Federal de São João Del-Rei*, Octavio Miramontes, Sirio Orozco, *Universidad Nacional*

Autónoma de México, Og DeSouza, Alessandra Marins, *Universidade Federal de Viçosa* ■It has been established recently that a variety of animals move and explore their surroundings in an optimal way following Lèvy-like patterns in the statistics of the distances traveled. Here we analyze exploratory spatial behaviour in isolated termite workers kept in large containers, free from the constrained movements they experience within tunnels. In this way we were able to assess individual free exploratory behaviour in clueless environments and away from social interactions. We show by analyzing over half a million movement displacements that isolated termite workers actually exhibit a range of very interesting dynamical properties –including Lèvy flights– in their exploratory behaviour. Our study analyses anomalous diffusion and structure functions to estimate values of the scaling exponents describing displacement statistics.
We evince the fractal nature of the movement patterns and show how the scaling exponents describing termite space exploration intriguingly comply with mathematical relations found in the physics of transport phenomena. By doing this, we rescue a rich variety of physical and biological phenomenology that can be potentially important and meaningful for the study of complex animal behavior and, in particular, for the study of how patterns of exploratory behaviour of individual social insects may impact not only their feeding demands but also nestmate encounter patterns and, hence, their dynamics at the social scale.

Reference

Miramontes O, DeSouza O, Paiva LR, Marins A, Orozco S (2014). Lèvy Flights and Self-Similar Exploratory Behaviour of Termite Workers: Beyond Model Fitting. PLoS ONE 9(10): e111183.

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[03/11/2015 - P008]

Analysis of dengue vaccine through an age-structured model using actual epidemics data, Luciana Cardim, Maria da Conceição Costa, Maria da Glória Teixeira, *Instituto de Saúde Coletiva - UFBA*, Rodrigo Carvalho, *Instituto de Matemática - UFBA*, Suani Pinho, *Instituto de Física - UFBA* ■Many efforts have been done in the last years for the development of a tetravalent vaccine against dengue. It is expected that, at the very beginning of vaccination campaigns, there won't be enough vaccines for the whole population. Therefore, mathematical modelling is a very important tool to exhibit different scenarios concerning the most efficient strategy to avoid epidemics, i.e., to reduce the basic reproductive number R0 below unit. In this work, inspired by the literature[1], we propose a model with age structure for human compartments (1-9, 10-19, 20-29, 30-39, 40-49, 50-59, over 60) and homogeneous for vector compartiments, assuming continuous vaccination. The infection rate values are based on the force of infection for different age ranges of actual epidemics occurred in some Brazilian cities: Fortaleza (2008), Goiânia (2010), Manaus (2011), and Rio de Janeiro (2008). The chosen epidemics presents, for each city, the highest peak of dengue cases. We obtain analitically the expressions of global R0 and R0 for each age range [2] and calculate their values for those epidemics. According to these previous scenarios, we conclude that the best strategy to reduce the global R0 of Fortaleza, Goiânia and Manaus is to vaccinate children who are 1 to 9 years old. For Rio de Janeiro it is better to vaccinate people of 2 age ranges: children who are 1 to 9 years old and children and teenagers who are 10 to 19 years old. If the vaccine efficacy is about 60.8%, we obtain that it is enough to innoculate 3%, 4% and 4% per week of children who are 1 to 9 years old in Fortaleza, Goiânia and Manaus respectively. In Rio de Janeiro 1% per week of people who are 1 to 19 years old would have to be vaccinated. Furthermore, we intend to find the minimal proportion of vaccinated people necessary to avoid epidemics, assuming a vaccination campaign instead of continuous vaccination. Finally it would be interesting to extend that analysis to other cities as well as to analyse the effective reproduction number.

[1] Tasman H, Supriatna AK, Nuraini N, Soewono E. A Dengue Vaccination Model for Immigrants in a Two-Age-Class Population. Int. J. Math. Mathl. Sci., 2012: 1-15, 2012.
[2] Van den Driessche P, Watmough J. Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission. Math. Biosci. 180: 29-48, 2002.

[03/11/2015 - P009]

Diffusion of hard spheres a binary quenched-annealed mixtures, T. P. O. Nogueira, *Instituto de Ciências Exatas, Departamento de Física, Universidade Federal do Amazonas - UFAM, Av. Gen. Rodrigo Otávio Jordão Ramos, 3000, Coroado, Campus Universitário, Setor Norte, CEP 69.077-00*, F. Piazza, *Université d'Orléans, UFR Faculté des Sciences, Département de Physique et Sciences de L'Ingenieur Laboratoire: CBM-CNRS UPR 4301 du CNRS, Rue Charles Sadron, 45071 Orléans CEDEX 2 FRANCE.* ■In quenched-annealed (QA) mixtures of hard spheres (HS), a given fraction of the particles is mobile (volume fraction ϕ_m), while the rest are fixed and act as obstacles (volume fraction ϕ_o). Typically, the phase diagram of QA mixtures in the (ϕ_m, ϕ_o) plane features a region where the mobile particles are diffusive, separated from a localized phase by the void percolation line, where the diffusion becomes anomalous.
In this work, we have investigated the self-diffusion coefficient of mobile HSs in binary QA mixtures for different values of the ratio α between the diameter of the mobile HSs and that of the obstacles. We find that the motion is always diffusive, with a diffusion coefficient that decreases linearly with increasing values of α. For large volume fraction of the obstacles we find a more complex decrease, that can be approximated with two successive linear trends with different slopes. In the $\alpha \to 0$ limit we recover the well-known mean-field result. Furthermore, we show that in the limit $\alpha \to 1$ the diffusion coefficient of monodisperse QA mixtures as a function of the obstacle packing fraction behaves as an order parameter for the mobile-to-localized transition, allowing one to recover the void percolation threshold at the same value of ϕ_o as predicted by mode-coupling theory.

COMPLEXITY & INTERDISCIPLINARY TOPICS

[03/11/2015 - P010]
Simulations of Segregation and Ripples on Unpaved Roads, Tiago Moy da Silva, Américo Tristão Bernardes, *Programa de Pós-graduação em Ciência - Física de Materiais, Depto de Física, Universidade Federal de Ouro Preto* ■In this work we present a study on the ripples formation in unpaved roads. This effect, also known as washboard road, annoys thousands of people around the world and it does not exist yet a closed theory about it. This study is made with Molecular Dynamics Simulation applied in soft grains in two dimensions. In this model, the grains are 2d disks with motion of translation and rotation and under action of a constant gravitational field. The simulations are performed in a box with horizontally periodic boundaries. The force of contact has a radial component, also called spring dashpot model, and a tangential component, which charges the friction between the grains. Simulating a rolling wheel, a large grain rolls over the other small disks. In the simulations we observed that the ripples can arise or not together with the segregation of the grains, but recent articles showed that this phenomenon is not determinative to the formation of the corrugations, although they are observed in the real roads. We investigate the evolution of the ripples through of fast Fourier transform (FFT) and we analyzed the segregation by radial distribution function (RDF). We also verified some cases by changing the basic model parameters: physical quantities and geometric elements which play some role in this problem.
Acknowledgment: UFOP, CNPQ, CAPES and FAPEMIG

[03/11/2015 - P011]
Effects of noise and conviction in kinetic models of opinion dynamics with continuous states, A. R. Vieira, N. Crokidakis, *Instituto de Física, Universidade Federal Fluminense, Niterói/RJ, Brazil* ■In this work we study a kinetic exchange opinion model based on [1,2], where the individuals (agents) in an artificial society present continuous opinions in the range [-1.0,1.0]. For a given interaction, we randomly chose 2 agents i and j, which characterizes a mean-field-like approach. The opinion of the agent i at the time $t+1$ is updated following the rule

$$o_i(t+1) = c_i o_i(t) + \mu_{ij} o_j(t),$$

where the interaction between i and j (μ_{ij}) is positive or negative, according to a parameter p. We also consider that each agent has a conviction about his opinion, a real number that can be either positive or negative. On the other hand, we consider the independent behavior of the agents, i.e., with a probability q the agent i changes his opinion independently of the interactions with other individuals.
We studied the model via computer simulations. We investigate numerically the evolution of the opinions in the society, and we verify that the system reaches stationary states. We studied some quantities of interest, for example the "magnetization"of the system, the fourth-order cumulant and an analogous of the magnetic susceptibility. We determine several critical values for p, q and w, which separate an ordered phase (where the majority of the agents presents positive or negative opinion) from a disordered phase (where several opinions coexist in the population). The critical exponents for such transitions suggest that the inclusion of these new parameters does not change the universality of the model, i.e, the model also belongs to the mean-field Ising model universality class. In addition, we compare histograms of the opinions in the society for distinct values of the parameters, for the model with and without conviction. In this case, it is possible to see that inclusion of the convictions strongly decreases the fraction of extremist agents in the population, whereas the fraction of moderate and undecided agents increases, making the model more realistic.
[1] S. Biswas, A. Chatterjee, P. Sen, Physica A 391 (2012) 3257-3265.
[2] Nuno Crokidakis, Phys. Lett. A 378 (2014) 1683-1686.

[03/11/2015 - P012]
A self regulated adaptive model for expenditure propensity and Gini index relationship, Alan de Andrade Santos, Pedro Hugo de Figueirêdo, *DF - UFRPE - PE - Brasil* ■Over the past two decades, physicists have been devoted to the problem of income distribution $P(m)$. A key feature in this study is characterize the inequalities implied by microeconomic models based on the mechanisms of exchange of goods and services. One way to quantify such inequalities is based on the Gini index $0 \leqslant G \leqslant 1$, a parameter that sets the maximum ($G = 1$) and minimum ($G = 0$) concentration of resources. Current studies indicates that income distribution $P(m)$ has two distinct regimes separated by a scale m_c. The first one associated to a low-regime income ($m \leqslant m_c$) described by a gamma distribution $\Gamma(n, \beta)$ and a second one related to a high-income regime ($m > m_c$), mathematically represented by a power law function with a parameter $1 \leqslant \nu \leqslant 2$, usually called Pareto's exponent. More recently it has been pointed out the existence of a bimodality on this distribution. In close connection with microscopic models usually constructed to describe physical systems, two classes of models were introduced as a intent to mimic a closed economic system, compound by a fixed number of economic agents N and resources M. At the first class (homogeneous) which describes the low-regime income, agents have the same consumption expenditure ω ($0 < \omega \leqslant 1$), at the second (heterogeneous) providing a power law there is a single consumption expenditure ω_i, specific to each agent, or in a more realistic case a probabilistic distribution $S(\omega)$. In both cases the expenditure consumption rate are set exogenously to the system. In this communication we introduce an adaptive heterogeneous model in order to describe quantitatively the relationship among the average expenditure rate $\langle\omega\rangle$ of economic agents, and the Gini index associated to the income distribution. In this approach a fraction p_0 of all economic agents N do not modify their expenditure rates, a fraction p_1 are able to modify their consumption rate negatively correlated with their income and lastly a fraction p_2 positively. In this scenario the inertia $\gamma(m)$ associated with adaptation is self-regulated by the agent income level. Besides producing the distribution rates as an emerging feature the model are able to provide a bi-

modality on the income distribution and produce values $(\langle\omega\rangle, G)$ compatible with those available from real data obtained from the World Bank.

[03/11/2015 - P013]
Competition between collective and individual dynamics: Applications to simple economic models, Diego F. de Almeida, André P. Vieira, *Universidade de São Paulo* ■Using Grauwins generalization [1] of Schelling's segregation model [2] we study, in a simplified model, some consequences of the "fiscal war" waged between the states of a federation, and of the "rate tax" generated by the recent Brazilian Central Bank regulation of bank credit portability. The system is divided into blocks and all blocks have the same utility function, which measures the satisfaction of agents living there and depends on the density of agents. We introduce a disorder parameter in one of the blocks to make it more attractive than the others, so as to mimick the essential igredient of competition between states or banks.
In the application to the scenario of a fiscal war between the states of a nation, we interpret blocks as the states of a federation and economic agents as companies that make decisions seeking to increase their own satisfaction. A vacant state, in order to attract agents already established elsewhere, need to give more incentives to attract investment because of its low utility. In this work we try to quantify the costs that states have with this kind of action.
Another analysis of the results can be applied to a bank credit portability model, where we interpret economic agents as customers and blocks as retail credit banks. The interest rate levied on each bank will depend on the size of the portfolio of that bank. Having a bank with a differentiated interest rate makes it more attractive than others, and it begins to "steal" customers from other banks. Studying the selfish scenario (where the government doesnt discourage a client from taking his/her debt to another bank), and assuming that the number of customers in the market is sufficiently small, the dynamics leads to a situation where we have just a few coexisting banks, the others having gone bankrupt.
We study analytically the effects, at the global level, of variations in the density, in the altruism parameter and in the parameter determining the utiliy function at saturation, as well as the effects of introducing disorder in one or more blocks. Finally, computer simulations were performed to check that the dynamic behavior in all scenarios was consistent with the obtained solutions.
[1] S. Grauwin et al., PNAS 106, 20622 (2009).
[2] T. C. Schelling, J. Math. Sociol. 1, 143 (1971).

[03/11/2015 - P014]
Sympatric Multiculturalism in Opinion Models, Felippe Alves, Nestor Caticha, *Instituto de Física - Universidade de São Paulo* ■While social interactions tend to decrease differences in opinions, multiplicity of groups and individual opinion differences persist in human societies. Axelrod identified homophily and social conformity seeking as basic interactions that can lead to multiculturalism in spatial scenarios in models under certain special conditions. We follow another route, where the social interactions between any two agents is given by the descent along the gradient of a cost function deduced from a Bayesian learning formalism. The cost functions depends on a hyperparameter that estimates the trust of one agent on the information provided by the other. If the expected value of the total cost function is relevant information, Maximum Entropy permits characterizing the state of the society. Furthermore we introduce a dynamics on the trust parameters, which increases when agents concur and decreases otherwise. We study the resulting phase diagram in the case of large number of interacting agents on a complete social graph, hence under sympatric conditions. Simulations show that there is evolution of assortative distrust in rich cultural environments measured by the diversity of the set of issues under discussions. High distrust leads to antilearning which leads to multiple groups which hold different opinions on the set of issues. We simulate conditions of political pressure and interaction that describe the House of Congress of Brazil and are able to qualitatively replicate voting patterns through four presidential cycles during the years of 1994 to 2010.

[03/11/2015 - P015]
The evolution of cooperation in structured populations with influence of nature, Elton J. S. Júnior, Jafferson. K. L. da Silva, *Universidade Federal de Minas Gerais*, Lucas Wardil, *University of British Columbia, Canada* ■Cooperation is commonly illustrated as a Prisoner's Dilemma game. Players obtain 1 (reward) for mutual cooperation and b for mutual defection (punishment); in the case in which they choose different strategies, the cooperator obtains 0 (sucker) and the defector obtains $b > 1$ (temptation). Although individual self-interest may not favor cooperation, it can evolve if, for example, players interact multiple times adjusting their behavior accordingly to opponent's previous action. In addition to, if individuals interact to each other as in a structured population (in square lattice, for instance), cooperators can survive by giving origin to clusters; this phenomena is known as spatial reciprocity. However, it happens that sometimes a player, even being a cooperator, is not able to cooperate because of lack of resources (caused by nautral disasters, migration, etc.). In this present work we intend to model the role played by nature setting some nodes of the lattice as empty nodes (inactive nodes). If an individual is in one of this sites, it is not able to do anything once there are no wherewithal there, no matter it is either a cooperator or a defector. We studied the fraction of cooperators on stationary state as a function of both w (fraction of active nodes) and b (tendency of desertion). The authors thank to FAPEMIG, CAPES and CNPq for financial support.

[03/11/2015 - P016]
Leaking Quantum Square Billiards, Emanuel Vicente Chimanski, Brett Vern Carlson, *Instituto Tecnológico de Aeronáutica*, Eduardo Vicentini, *Universidade Estadual do Centro Oeste* ■Open systems are often applied to model natural phenomena in many branches of physics and are commonly related to leaking systems. Problems with leaks also play an important role in the framework of dynamical theories. Quantum billiards are the quantum version of two-dimensional classical systems in which the particle dynamics is restricted by walls. In this work, a closed and an open square quantum billiards are studied. The wave

functions of the problems are obtained by the boundary wall method. Plane waves with different energies are scattered by the infinity potential defined on the billiard table boundary. The influence of the gap size d in a wall of the open system is studied in comparison with results of the closed version of the system. In this investigation the probability density function is computed for both the open and closed billiards. Prelimenary results, show that the presence of a leak shifts the resonant states related to the closed billiard and large values of d can displace hight exited states. The flux of probability current is calculated on the leak and the relation between wave energy and the leaking was studied. In addition the energy level distribution is calculated and compared to Poisson and Wigner distributions.

[03/11/2015 - P017]
Dynamical Properties of the Kleinberg networks, Samuel Morais da Silva, Saulo-Davi Soares e Reis, Ascânio Dias Araujo, José Soares de Andrade Jr., *Universidade Federal do Ceará* ■A great number of systems defined as complex consist of interconnected parts or individual components performing a network or graph. Communication between the parts is essential for their existence so that it is necessary a better understanding of their ability to communicate depending on the amount of information that transits. The dynamics of package transport in these systems and the emergence of congestion are problems of high scientific and economic interest. In this work we investigate the dynamical properties of transport of packages (informations) between sources and previously defined destinations, considering different models of spatially embbeded networks such as lattice and Kleinberg. More precisely, we study a second-order continuous phase transition from a phase of free transport to a congestion phase, when the packages are accumulated in certain regions of the network. By means of a Finite Size Scaling, we describe this phase transition characterizing its critical exponents. For 1D and 2D lattice networks, we observe that the critical parameter p_c scales with exponents approximately -1 and -0.5 with respect to the system size. In the case of Kleinberg newtorks where shortcuts between two nodes i and j are added to the network according to a probability distibution given by $P(r_{ij}) \sim r_{ij}^{-\alpha}$, we show that the best scenario occurs when $\alpha = d$, where d is the dimention of the topology structure. In this regime, package traffic were shown to be more resilient to the increase of number of packages in the network. The confirmation of our result is obtained not only from direct measure of order parameter, that is, the ratio between undelivered and generated packets, but is also supported by our analysis of finite size.

[03/11/2015 - P018]
Non-Markovian models for short-scale financial motion, Victor Galvão, R. Riera, *Department of Physics, PUC-Rio and National Institute of Science and Technology for Complex Systems,Rio de Janeiro, Brazil* ■The random nature of financial price fluctuations is considered as resulting from the imbalance of buy and sell orders at each time step. In this work, we explore minimal models of the behavior of the financial agents to study the emergence of short-scale behavior of prices. At a given time, the state of the market is characterized by the set of unrealized highest buy (lowest sell) orders of the order book, which comprises the potential next trading. In order to explain the non-Gaussian character of market price fluctuations, we consider extensions in the form of Langevin-type equations with an inertia term. The observed financial motion is described as analogous to a damped harmonic particle embedded in an environment which depicts the accumulated orders in the underlying optimal levels of the order book. Memory is a crucial ingredient for the collective properties of markets, especially in the short time regime, and this is account by a non-local exponential kernel in the anticipation of prices by the agents when placing their orders. Using a non-Markovian Langevin description, we consider a random damped harmonic particle in presence of noise. The noises, which represent external and/or internal perturbations, are modeled as an Ornstein-Uhlembeck process and/or as a dichotomous process which show to be more amenable to analytic approaches. Indeed, we can picture two subpopulation of trades, buyers and sellers, exchanging particles at rate $1/\tau$ via some idiosyncratic switching process. We provide the expression for the low order expansion in τ of the effective damping and restoring parameters, in the case where a dichotomous noise process is at play. We also analyze the expected values as well as the dispersion of the log price and the returns analytically and numerically. Using random damped harmonic oscillator models as a reference tool, we conclude by investigating the intra-day Brazilian stock price series.

COMPLEXITY & INTERDISCIPLINARY TOPICS

[03/11/2015 - P019]
Effects of mobility in the epidemic threshold of the SIS dynamics in scale-free networks, Diogo da Silva, Costa Ferreira, *Universidade Federal de Viçosa-MG* ■Many real systems as food webs, friendship networks, transportation and scientific collaboration can be suitably described in he framework of complex networks. The behavior of dynamical processes on the top of them is of great interest, being the epidemic spreading one of the most important issues of the field. The simplest epidemic model is the susceptible-infected-susceptible (SIS), in which every infected vertex of the network transmits the infection to each contact at a constant rate λ and becomes spontaneously susceptible at an unitary rate. In this work, we perform simulations of the SIS including mobility of infected individuals on networks with a power-law degree distribution $P(k) \sim k^{-\gamma}$. The diffusion process consists in exchanging an infected vertex and one of its neighbors at rate D. The theoretical analysis of the SIS dynamics is done through the degree based mean field (DBMF) theory, which assumes that vertices with the same degree have the same behavior, and by the individual based mean field (IBMF) theory, which considers individual properties of each vertex by means of the adjacency matrix. These theories predict different outcomes for the epidemic threshold for exponents $\gamma < 3$ and $\gamma > 3$. Our simulations for $\gamma < 3$ exhibit a good agreement with both theories, which are equivalent. For $\gamma > 3$, we observed a finite epidemic threshold which converges to

the DBMF threshold for large diffusion rate contrasting with IBMF theory. Multiples transitions are observed for small diffusion coefficient but disappear in the large diffusion limit. We explain this the crossover from a IBMF to a DBMF regime in terms of the lifespan of epidemic activity on the hubs of the network.

We acknowledge Fapemig by the financial support.

[03/11/2015 - P020]
Effect of Spatial Distribution of Traffic Lights to the Traffic Flow Behaviour, C. F. M. Magalhães, R. A. Cabral, *UNIFEI* ■We present some preliminary results of a study that extends the work by D-W Huang and W-N Huang [1]. They proposed a model to describe the traffic from suburb to downtown during the rush hours. The model is a cellular automaton which consists of a 1D open lattice with regularly spaced traffic lights and parking lots and vehicles that enter the lattice at one end and left it at a parking lot or at the other end. The vehicles evolve following the single lane Nagel and Schreckenberg local dynamics [2]. We investigate how changes in traffic lights spacing affects the traffic behaviour. The motivation was the fact that the Nagel and Schreckenberg dynamics exhibits a critical state as the density of vehicles approaches a determined value [3]. In that state, the stream of vehicles self-organizes into a fractal structure that reflects a power law distribution of jam sizes. The initial results indicate that a power law distribution of the traffic lights spacing tends to increase the stream flux no matter the value of traffic lights period and the inflow rate. Nevertheless, in contrast to the regularly arranged traffic lights model, a power law distribution spacing caused a high sensitivity of the stream flux to the inflow rate.

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[03/11/2015 - P021]
Shannon entropy applied in networks based on titles of scientific papers, Marcelo do Vale Cunha, Hernane Borges de Barros Pereira, Marcelo Albano Moret Simões Gonçalves, *Programa de Modelagem Computacional, SENAI Cimatec, Av. Orlando Gomes 1845, 41.650-010, Salvador, BA, Brazil* ■Recently, semantic networks based on titles of scientific papers have been explored to study the formal system of scientific communication: the journal. The network theory along with the Shannon entropy of information can give interesting insights on how to differentiate journals. We present an application of Shannon entropy in semantic networks based on titles of scientific papers. These networks are formed considering the words of a title as vertices of a click. The titles come from 15 scientific journals high-impact. For a given network is also built a time-varying graph (TVG). We consider a window bimonthly (week by week) and advancement in time shows the evolution of networks of words from the titles of papers published. The analysis is carried out using indicators timeless. Entropy is calculated based on the uncertainty of edges and vertices of each network. The probabilities are associated with overlapping edges and vertices in the formation of the titles network, taking into account the relative frequency of these indicators before clicks are joined. Thus, it becomes possible to compare different journals, as well as a same journal at different times (through the TVG). The results suggest that these journals can be grouped, based on their entropy values and indices of some networks. This study may contribute to the study of communication and scientific collaboration and dissemination of human knowledge.

[03/11/2015 - P022]
Optimal Path Cracks in Complex Networks, T. C. Nunes, L. R. da Silva., *Departamento de Física Teórica e Experimental - UFRN*, J. S. Andrade, A. A. Moreira., *Universidade Federal do Ceará* ■As we can see in nature, we are surrounded by materials from which their structures have some kind of disorder that may be related to microscopic voids, detachments and even structural composition, which makes them susceptible to fractures that depend on the degree of disorder significantly wherein the material is given. For this reason optimal paths play a fundamental role in physical numerous applications ranging from random polymers to brittle fracture, from the flow through porous media to information propagation. Following the study of optimal path cracks (OPC) on regular square lattices, here we investigate the same problem in Complex Networks. In this problem we associate to each site a determined energy. The optimum path is defined as the one among all possible paths that crosses the system which has the minimum cost, namely the sum of the energies along the path. Once the optimum path is determined, at each step, one blocks its site with highest energy, and then a new optimal path is calculated. This procedure is repeated until there is a set of blocked sites forming a macroscopic fracture which connects the opposite sides of the system. As observed in the work on regular square lattices, the fractured system studied here also presents different behaviors depending on the level of disorder, namely weak, moderated and strong disorder intensities. In the regime of weak and moderated disorder, while the density of removed sites in the system does not depend of the size L in the case of regular lattices, in the regime of high disorder the density becomes substantially dependent on L. We did the same type of study for Complex Networks. In this case, each new site is connected with previous ones. As in the previous work, we observe that the density of removed sites presents a similar behavior. Moreover, a new result is obtained, i.e., we analyze the dependency of the disorder with the attachment parameter m.

[03/11/2015 - P023]
Modelling optimism and the spread of false rumours in sociophysics., André M. Timpanaro, *Instituto de Física da Universidade de São Paulo, Brazil* ■In the recent years, physicists have given a great deal of

attention to the study of social models using tools from statistical physics, dubbed sociophysics. The main purpose of sociophysics is to use results from experiments in psychology as a guide to define microscopic rules to be used in computational models of different sociological and political phenomena. A great variety of such models exist, so a "unified language"is desirable for introducing modifications. In a previous work we introduced the idea of confidence rules [A. M. Timpanaro and C. P. C. do Prado, Phys. Rev. E 80, 021119 (2009)] as a framework to introduce biases and prejudices in these models.
In this work we apply the notion of confidence rules to the Sznajd and voter models in order to study 2 different situations:

- Optimistic and pessimistic voters, using a rule with four opinion states that are symmetric, but interacting in a non-associative way.
- Propagation of false rumours, using a rule with three opinion states, reminiscent of the SIR model.

We are able to explain 50-50 splits with alternance of power in the case of the optimism/pessimism model and we find distinct network signatures in the time series obtained for the rumour spreading model.

[03/11/2015 - P024]
COMPLEX NETWORK ANALYSIS OF BRAZILIAN POWER GRID, Keila Melo, Fabricio L. Forgerini, *Federal University of Amazonas* ■Power Grids and other delivery networks has been attracted some attention by the network literature last decades. Despite the Power Grids dynamics has been controlled by computer systems and human operators, the static features of this type of network can be studied and analyzed. The topology of the Brazilian Power Grid (BPG) was studied in this work. We obtained the spatial structure of the BPG from the ONS (electric system's national operator), consisting of high-voltage transmission lines, generating stations and substations. The local low-voltage substations and local power delivery as well the dynamic features of the network were neglected. We analyze the complex network of the BPG and identify the main topological information, such as the mean degree, the degree distribution, the network size and the clustering coefficient to caracterize the complex network. By the network analysis we also detected the critical locations (nodes and links) on the network and, therefore, the more susceptible points to lead to a cascading failure and even to a blackouts. Due to the characteristic of the topology and physical structure of the network, we show that the BPG is not resilient against random failures, when a fraction ρ of the links are randomly removed, the network may disintegrates into smaller and disconnected parts. We believe that the even a static study of the network topology can help to identify the critical situations and also prevent failures and possible blackouts on the network.

[03/11/2015 - P025]
Caveats on epidemic processes model on complex networks, Ronan S. Ferreira, *Instituto de Ciências Exatas e Aplicadas, Universidade Federal de Ouro Preto, 35931-008, Brazil*, Silvio C. Ferreira, *Departamento de Física, Universidade Federal de Viçosa, 36570-000, Brazil* ■Theoretical and computational approaches to epidemic-like models have met with outstanding success on complex networks. However, some questions remains opened for the dynamics of the *Susceptible-Infected-Susceptible* (SIS) model on networks with a heavy-tailed degree distribution. This archetypal disease spreading model undergoes an absorbing phase transition revealing its epidemic threshold at some value for the effective spreading rate. We numerically test the limits and validity of two competing theoretical approaches proposed to describe the SIS epidemic threshold on uncorrelated networks with degree distribution $P(k) \sim k^{-\gamma}$. On one hand, we have the *Heterogeneous Mean-Field* (HMF) approach that assumes the statistical equivalence for those nodes of the same degree class (same number of contacts). On the other hand, the *Quenched Mean-Field* (QMF) considers the entire connectivity pattern of the network but treating the state (infected or not) of neighboring nodes as being statistically independent. We investigate network properties in which analytical results derived under the theoretical assumptions of HMF and QMF are or not verified. We show that the presence of outliers and formation of densely connected cores on these networks drastically change the outcomes predicted by these theoretical approaches. Moreover, resorting to extensive simulations for a large ensemble of network realizations, we show that network samples (for the regime of $\gamma > 3$) with the presence of outliers can produce a diverging average lifetime for the model, showing that the epidemic lifetime averaged over the ensemble is infinite even for finite sizes independently of the infection rate.

The authors would like to thank FAPEMIG.

[03/11/2015 - P026]
From epidemic hotspots to super-spreading events, Ronan S. Ferreira, *Instituto de Ciências Exatas e Aplicadas, Universidade Federal de Ouro Preto, 35931-008, Brazil*, Rui A. da Costa, *Department of Physics& I3N, University of Aveiro, 3810-193, Portugal*, Sergey N. Dorogovtsev, *Department of Physics& I3N, University of Aveiro, 3810-193, Portugal; A. F. Ioffe Physico-Technical Institute, 194021, Russia*, José F. F. Mendes, *Department of Physics& I3N, University of Aveiro, 3810-193, Portugal* ■We examine the phenomenon of localization and super-spreading by introducing a *superhub* of degree $q \sim N^{\alpha}$ on different network topologies with N nodes. It provides high heterogeneous and controlled environments by tuning the gap exponent α. Recently, localization phenomenon attracted much attention to the issue of epidemic spreading on networks, where this phenomenon means persistence of an island of disease below the epidemic threshold around a strongly connected node or a dense cluster. This phenomenon hinders the observation of the epidemic threshold in complex networks with hubs and heavy-tailed degree distributions. The problem is that the SIS (susceptible-infective-susceptible) epidemic model has an absorbing state in which infection is absent, and so below the epidemic threshold, islands of disease with a finite number of infective nodes cannot survive forever. In other words, a system with a finite number of infected nodes has a non-zero probability to recover immediately. For a large

but finite number of infected nodes, however, this probability is small, so the complete recovery can take a long time. We show that in the heterogeneous SIS model localization should be only metastable, manifesting itself in the form of long-lasting local outbreaks of the disease below the epidemic threshold. Moreover, super-spreading events in which one or a few infective individuals spread a disease providing an unusually large number of second cases, has great importance on current understanding on epidemic spreading. central issue is that heterogeneity in population structures, such as the presence of outliers on networked systems, accelerates infectious disease spread. We present under what circumstances the role reversal from a hotspot to a super-spreading event takes over for the SIS model on heterogeneous networks.

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FUNDAMENTAL ASPECTS OF STATISTICAL MECHANICS

[03/11/2015 - P027]
Real-Space, Mean-Field Algorithm for Calculating Long-Range Dipolar Interactions in Model Systems, Antonio Cadilhe, B. V. Costa, *Universidade Federal de Minas Gerais* ■Long-range interactions are known to be of difficult treatment in statistical mechanics models. There are some approaches that introduce a cutoff in the interactions or make use of reaction field. However, those treatments suffer the illness of being of limited use, in particular close to phase transitions. The use of open boundary conditions allows the sum of the long-range interactions over the entire system to be done, however, this approach demands a sum over all degrees of freedom in the system that makes a numerical treatment prohibitive. Techniques like the Ewald summation or fast multipole expansion account for the exact interactions but are still limited to a few thousands particles. In this talk we introduce a novel mean-field approach to treat long-range interactions. The method is based in the division of the system in cells. In the *inner* cell, that contains the particle in sight, the 'local' interactions are computed exactly, the 'far' contributions are computed as an average for each of the remaining cells. Using this approach, the large and small cells limits are exact. At a fixed cell size, the method also becomes exact in the limit of large lattices. We have applied the procedure to the two-dimensional anisotropic dipolar Heisenberg model. A detailed comparison between our method, the exact calculation and the cutoff radius approximation were done. Our results show that the cutoff-cell approach outperforms any cutoff radius approach as it maintains the long-range memory present in these interactions, contrary to the cutoff radius approximation. Beside that, we calculated the critical temperature and the critical behavior of the specific heat of the anisotropic Heisenberg model using our method. The results are in excellent agreement with extensive Monte Carlo simulations using the exact interactions.

[03/11/2015 - P028]
Universal behaviour for a 1+1 growth model, Waldenor R. Julvito, Washington S. Alves, Ismael V. L. Costa, Fernando A. Oliveira, *Universidade de Brasília - UnB* ■In a recent work [1] a method to derive analytically the roughness evolution was exposed. The method allows to obtain analytically the growths exponents of a surface of $1 + 1$ dimensions whose dynamics is ruled by cellular automata. The method was successfully applied to the etching model [2,3] and the dynamical exponents where obtained. Those exponents are exact and they are the same as those exhibited by the KPZ model [4] for this dimension. We applied the method as well to RSOS model [5,6] and we confirm that the very old conjecture that, the RSOS model and KPZ belong to the same universality class. We show as well a very general procedure to classify the models without hard calculations. This method allows us to verify the universality class of the automata cellular model [7].

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[03/11/2015 - P029]
JARZYNSKY EQUALITY IN THE POLYMER TRANSLOCATION PROBLEM, Nicolau G. Borsato, Taiana F. Cardoso, F. Mondaini, *CEFET-RJ Campus Petrópolis*, L. Moriconi, *UFRJ* ■The process of polymer translocation occurs in many biological and biotechnological phenomena. It has received great attention in both experimental and theoretical studies in recent years due to its important role in many crucial biological processes, such as mRNA translocation across a nuclear pore complex, drug delivery, injection of DNA from a virus head into a host cell and gene therapy. However, due to the complexity of the interactions involved, especially between the pore and the membrane, computer simulations have been widely used as a fundamental research tool. Most of the numerical studies can be classified into the topical issues of (i) translocation driven by chemical potential gradients, (ii) translocation driven by external forces, and (iii) unbiased translocation.
We perform, with the help of cloud computing resources, extensive Langevin simulations, which provide free energy estimates for unbiased three-dimensional polymer translocation. We employ the Jarzynski equality in its rigorous setting, to compute the variation of the free energy in single monomer translocation events. In our three-dimensional Langevin simulations, the excluded-volume and van der Waals interactions between beads (monomers and membrane atoms) are modeled through a repulsive Lennard-Jones (LJ) potential and consecutive monomers are subject to the Finite-Extension Nonlinear Elastic (FENE) potential. Analysing data for polymers with different lengths, the free energy profile is noted to have

interesting finite-size scaling properties.

[03/11/2015 - P030]
Non-Ergodic behaviour of a particle in long range interaction with all the particles of a heat bath, Annibal Figueiredo, Solano Neto, *Instituto de Física, Universidade de Brasilia* ■In this work, we investigate the ergodic properties of a test particle placed in long range interactions with all the particles of a given heat bath. The heat bath is constituted by N punctual Brownian particles that do not interact among themselves and their trajectories may be determined by Langevin equations with gaussian random noise. The non-ergodic behaviour and the issue about the thermalization of the test particle is analysed in the framework of the Weakly Non-Ergodic Statistical Physics (A. Rebenshtok& E. Barkay, J. Stat. 133, 565 (2008) Phys. DOI 10.1007/s10955-008-9610-3).
Many of the methods developed in this present work are the natural development of two works: 1) Ergodicity and central-limit theorem in systems with long-range interactions - EPL, 83 (2008) 30011 and 2) Truncated L'evy flights and weak ergodicity breaking in the Hamiltonian mean-field model - PHYSICAL REVIEW E 89, 022106 (2014). We stress that our focus is to understand the transient regime of convergence toward a non-ergodic equilibrium or the sluggish convergence process toward the ergodic equilibrium.
Finaly we try to set up a model of CTRW (Continuous Time Random Walk), where the ocupation time is described by a truncated levy distribution, in order to explain the ergodic properties associated to the test particle.

[03/11/2015 - P031]
The Van der Waals interaction approach to the liquid-liquid phase-transition, Marcio Pazetti, *Universidade Federal do Vale do São Francisco (UNIVASF/PE)*, Manuel Simões Filho, *Universidade Estadual de Londrina (UEL/PR)*, Francisco Miguel da Costa Júnior, *Instituto Federal do Sertão Pernambucano (IFSPE/PE)* ■Since the pioneering work of Stell and Hemmer [1], proposing the existence of a new critical point inside liquids, we have seen experiments, computational simulations and theory working together to understand the nature of the liquid-liquid transition [2]. However no definitive model of how it happens has been yet established. Some theoretical models, mainly in one-dimension, and some computational works, indicate that an attractive potential combined with an strongly repulsive hard core are essential ingredients for this transition [3]. We will present here a three-dimensional derivation of this transition. Our model is, essentially, a extension of the approach that let to the Van der Waals state equation and the gas-liquid transition. We will analytically show that, with a small improvement, this longstanding approach also predicts the existence of a further critical point, at a high pressure and a high temperature. Namely, we will consider the two particles Mayer cluster expansion [4], and show that when we take into account not only the first, but also its second order terms in the inverse of the temperature, two critical points are obtained; the first corresponding to the usual gas-liquid transition, and the second corresponding to a liquid-liquid transition. [1] P. C. Hemmer and G. Stell, Phys. Rev. Lett. 24, 1284 (1970). [2] M. Aurélio, A. Barbosa, E. Salcedo and M. C. Barbosa. Pry. Rev. E 87, 032303 (2013). [3] G. Stell and P. C. Hemmer, J. Chem. Phys. 56, 4274 (1972); E. A. Jagla, Phys. Rev. E 58, 1478 (1998); P. G. Debenedetti, V. S. Raghavan, and S. S. Borick, J. Chem. Phys. 95, 4540 (1991); W. P. Krekelberg, T. Kumar, J. Mittal, J. R. Errington, and T. M. Truskett, Phys. Rev. E 79, 031203 (2009); J. C. Pàmies, A. Cacciuto, and D. Frenkel, J. Chem. Phys. 131, 044514 (2009). [4] R. K. Pathria, Statistical Mechanics (Pergamon Press, Oxford, 1977).

[03/11/2015 - P032]
Solution of fractional diffusion equations with absorbing boundaries, Hugo Andrade, Ernesto Raposo, *Laboratório de Física Teórica e Computacional-Departamento de Física-Universidade Federal de Pernambuco* ■In this work we focus on the construction and solution of a fractional diffusion equation (FDE) in one-dimensional space with absorbing boundaries. FDEs involve fractional derivatives in the form d^α/dx^α, with $\alpha \in \mathbb{R}$, enabling the emergence of anomalous (superdiffusive) behavior which cannot be taken into account in the conventional (Brownian) diffusion equation. The superdiffusive regime, in which we focus our work, arises from the solution of the FDE and also makes contact with the distribution of the flight lengths of a Lévy flight random walker. By solving analytically the FDE we obtain the probability $W(x,t)$ of finding the walker in a position x at a given time t in terms of Fox H-functions. We can also calculate the survival rate $S(t)$, which measures the probability that the walker is still active (i.e. nonabsorbed) at a given time. We discuss the failure of the image method to solve the FDEs in a finite domain in the context of the violation of the Sparre-Andersen theorem. We also propose an alternative approach to circumvent the problems related to the images technique. In particular, the long-term behavior of the survival probability presents a time-dependence with a shift from the (Spare-Andersen-like) power-law to the exponential decay. Our approach is based on both analytical as well as numerical techniques.

[03/11/2015 - P033]
Superstatistics and the quest of ensemble equivalence in a system with long-range interactions, Nelson A Alves, *Universidade de São Paulo*, Rafael B Frigori, *Universidade Tecnológica Federal do Paraná* ■Superstatistics inception by Beck and Cohen was intended to provide an extension of the standard statistical mechanics formalism into a more general one, focusing on describing out-of-equilibrium systems, which are most likely characterized by spatio-temporal fluctuations of an intensive parameter. Its usual formulation employs, as a working hypothesis, the argument that fluctuations evolve on a long-time scale, while the studied system can still be locally decomposed in many small cells (subsystems) obeying the (equilibrium) statistical mechanics characterized, for instance, by an effective local (inverse) temperature β. For such systems, not only the temperature environment is considered to be a fluctuating quantity, with probability density $f(\beta)$, but also it may carry a spatial modulation as a classical scalar field. Here, the thermodynamic properties yielded by the nonextensive Statistical Mechanics of Tsallis are derived, as

a particular limit from the Superstatistics approach, for the Blume-Capel (BC) model with infinite-range interactions. This model exhibits nonconcavity of the entropy as a function of the energy. Thus, it is well-known to present ensemble inequivalence, which implies on different predictions for the first-order phase transition line when taking its microcanonical or canonical description. Starting from the Superstatistics approach, we numerically investigate how the microcanonical limit can be recovered as a function of the nonextensive parameter q and system-size (N). Moreover, we highlight how this solution can be compared to our previous work where BC model was solved in an interpolating generalized ensemble, known as Extented Gaussian Ensemble (EGE), which is able to continuously recover the stable microcanonical states as its "nonextensive" parameter γ is gradually increased. In this vein, we found out that it is not necessary to take the theoretically expected limit $q \to 1$ to recover the microcanonical states in the region between the canonical and microcanonical tricritical points of the BC phase diagram.

[03/11/2015 - P034]
Ergodic Hypothesis and the Thermalization Time for Chaotic Hamiltonian Systems with Few Degrees of Freedom, Marcio Woitek, Gastão Krein, *IFT-UNESP* ■One of the fundamental assumptions of Classical Statistical Mechanics is the ergodic hypothesis. Using this hypothesis amounts to assuming that, in thermal equilibrium, the time average of a phase function will be equal to the corresponding microcanonical average. Even though this assumption plays an important role in the formulation of the microcanonical ensemble, the introduction of the ergodic hypothesis was always criticized. We argue that this criticism is the result of an incorrect understanding about the hypothesis under consideration. In this article, we shall discuss some results that were established by means of computer simulations in order to provide a modern justification for using the ergodic hypothesis. Moreover, we are going to explain how the validity of this assumption can be checked for a given physical system whose numerical study can actually be carried out with the aid of a computer. For such a system, we shall discuss how the ergodic hypothesis allows us to obtain an estimate for the time it takes to reach thermal equilibrium. Our approach is based on the dynamical calculation of temperatures. To illustrate the ideas we consider in this work, we are going to present the statistical-mechanical description of two chaotic Hamiltonian systems with few degrees of freedom. These systems can be obtained as particular cases of certain classical field theories.

[03/11/2015 - P035]
Comparative study of the precision provided by the Wang-Landau Sampling and the Broad Histogram Method, Paulo M.C. de Oliveira[1], Alexandre Lima[12], [1]*Instituto de Física, Universidade Federal Fluminense;* [2]*Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, CEFET-RJ UnED Itaguaí* ■The work presented here investigates the precision provided by two computational techniques in the evaluation of the density of states and canonical averages of the two-dimensional ferromagnetic Ising model. We obtained the microcanonical and canonical averages carrying out a Wang-Landau sampling and performing a statistical study of the convergence of the microcanonical averages and of the temperature related to the peak of the specific heat. In order to use the Broad Histogram Method, besides the computation of the usual microcanonical averages of the powers of the magnetization, we also compute, during the Wang-Landau sampling, the microcanonical averages of the number of possible changes in the system's state with energy E which would increase ($N_{up}^{\Delta E}(E)$) and decrease ($N_{dn}^{\Delta E}(E)$) the energy by an amount ΔE. We performed simulations for several lattice sizes and from each size we took a large number of samples to build a representative sample of the density of states and the canonical averages. We show our findings for the density of states, as well as for the finite-size scaling exponents, and compare it with exact values. Our findings suggest that the Broad Histogram Method provides a slightly better precision on the computation of the density of states, along with the canonical averages, than the one obtained within the Wang-Landau sampling.

NON-EQUILIBRIUM

[03/11/2015 - P036]
Classical limit of Jarzynski Equality, Josiane Oliveira Rezende de Paula, Adélcio Carlos de Oliveira, *UFSJ - MG - Brasil* ■The study of mesoscopic systems out of balance is actually one of the most active areas of physics. Several approaches to the treatment of these systems have been developed in the last decade, highlighting the results of Jarzynski as well its experimental verification in many systems. The discovery dates the nineties of last century, where an exact relationship between non equilibrium work and variation of the Helmholtz free energy of the system prepared interest in two states of thermal equilibrium at temperature T. It is conjectured that, in the coming years, that quantum devices can be built using this rule, which will work in your state nonequilibrium. Theoretically, it has been shown that quantum systems 'ratchet' are candidates for a new type of mesoscopic device working well in contact with a thermal reservoir and subjected to external driving. In this work, we investigated the classical and quantum equilibrium relationships for the harmonic oscillator and analyze the classical limit equal Jarzynski for the system. The model for the study consists of a harmonic oscillator with a linear disturbance. We used Statistical Mechanics methods based on the canonical ensemble and perturbation theory to obtain the quantum analog, also we use quantum open system technics. We calculated the partition function, the Helmholtz free energy, stochastic work and showed classical Jarzynski equality for the harmonic oscillator with external drive. The same calculation were obtained for its quantum analogue, considering the expected value of work in two areas: the work as the variation of energy and work as an operator in the Heisenberg representation. The two definitions for quantum work and its corresponding averages correctly describe classical result for $\beta \ll 1$, otherwise we are in the quantum regime and Jarzynski equality is not satisfied.

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[03/11/2015 - P037]
Relaxation time as a tool to characterize phase transitions in dynamic processes on complex networks, Guilherme H. S. Costa, Silvio C. Ferreira, *Departamento de Física, Universidade Federal de Viçosa* ■The criticality of non-equilibrium processes in regular lattices can be investigated using the generalization of susceptibility of equilibrium systems which is intrinsically associated to the spatial and temporal correlations. However, many complex networks are highly heterogeneous and requires alternative definitions of susceptibility to capture different properties of system, generating an ambiguity in the susceptibility definition. Moreover, spatial correlations in complex networks becomes meaningless due to small-world property but temporal correlations are well defined and emerges as an alternative or complementary tool to characterize phase transitions in complex networks. We analyzed the integrated correlation time for two basic reaction-diffusion processes related to the epidemic spreading and observed that this characteristic time provides the correct critical point and exponents for the contact process (CP), a model that exhibits an absorbing state phase transition, on regular lattices in 1, 2 and 3 dimensions. The method was also able to identify the epidemic threshold of CP model on synthetic scale-free networks with a power-law degree distribution $P(k) \sim k^{-\gamma}$. Also, we applied the method in a double random regular network where epidemic processes undergoes two phase transitions and both were identified. Currently we are investigating the susceptible-infected-susceptible (SIS) model where multiple transitions are also observed in finite-size networks.

We acknowledge the financial support of FAPEMIG.

[03/11/2015 - P038]
Stochastic model for coexistence of ant colonies, Flávia Mayumi Ruziska Hirata, Tânia Tomé, *IFUSP* ■We will present a stochastic model defined on a lattice to describe the coexistence and the oscillations of two types of ant colonies that use different resources of the environment. This model has four states per site, which denote occupation by elements of niche 1 (state 1); occupation by individuals of colony 1 (state 2); occupation by elements of niche 2 (state 3); occupation by individuals of colony 2 (state 4). If a site is in state 1 (or in state 3) it means that it has resources for colony 1 (or colony 2). The transition probability of state 1(3) to state 2(4) is given by the probability a(c) times the fraction of first neighbors in states 2(4). Therefore, the processes of birth of individuals of the colonies are given by autocatalytic reactions. And colony 1(2) develops in niche 2(1) by means of a spontaneous process whose probability is b(d). From the perspective of biology, this is interesting because in Amazon, it is observed the coexistence of several genres of ant colonies that use different resources, and there are studies with experimental data about that. From the viewpoint of the study of stochastic processes out of equilibrium, the exploration the model itself is interesting. We will show results obtained with mean field approximation (simple and pair approximations) and Monte Carlo simulations. Thanks to the financial support from FAPESP.

[03/11/2015 - P039]
Autocorrelation Function and Dynamical Transition on the Periodic Lorentz Gas: Stochastic and Deterministic Approaches, Rafael Mateus Feliczaki, Eduardo Vicentini, Pedro Pablo González Borrero, *Universidade Estadual do Centro-Oeste* ■The Periodic Lorentz Gas is a system where a point mass moves freely between a periodical arrangement of scatterer disks, often modeled by Sinai billiards. The main interest in its study is the diffusion coefficient, which shows the connection between the billiard geometry and its statistical and dynamical properties. It is known that the geometric property that mostly influences the dynamics is the horizon, which defines whether a trajectory along corridors without collisions is possible (infinite horizon or H∞) or not (without horizon or H0). The dynamics is hyperbolic and normal diffusion is observed on H0 billiards, and it is non-hyperbolic and anomalously superdiffusive on H∞. The stochastic approach to diffusion in billiards has recently gained a lot of interest. It is based on random walks of particles between traps formed by adjacent scatterers, so the diffusion coefficient is determined in function of escape time and lattice spacing between traps. Another method to calculate the diffusion coefficient is the integration of the velocity autocorrelation function $C(t)$. This technique is interesting since the $C(t)$ decay provides information on the billiards's dynamics as it is known for decaying exponentially on H0 and algebraically on H∞ billiards. Our interest is on the transition of geometries between H∞ and H0, exploring the variety of configurations of a double square lattice by finely tuning the disks radii. In our case, we propose an escape-rate formalism, where the particles perform a continuous-time step between traps but maintain correlations if they travel along corridors on H∞. We have introduced and demonstrated that the survival probability $\phi(t)$ provides information on the dynamics as well as the diffusion coefficient. By numerical simulation, $\phi(t)$, $C(t)$ and the diffusion coefficient were determined. We observed similar behavior in the decay of $\phi(t)$ and $C(t)$, which suggests that both quantities are originated from the same dynamics within the billiard. Nevertheless, the asymptotic behavior of $\phi(t)$ shows a smooth curve which is advantageous over $C(t)$ since the latter oscillates strongly at long times. The divergence and convergence of the diffusion coefficient on H∞ and H0 configurations, respectively, are also observed. On H∞ geometries with narrow corridors, the normal diffusion regime is still dominant when the phase space of the corridors are very small. However, $\phi(t)$ is sensible enough to the dynamics to show the algebraic tail and transition time between exponential and algebraic decay even on this limit.

[03/11/2015 - P040]
A Langevin equation for a two-dimensional rotating fluid, João Paulo Galdino Pessoa, Pedro Hugo de Figueirêdo, Luiz Carlos da Silva, *DF - UFRPE - PE - Brasil* ■The Langevin equation essentially describes the dynamic behavior of variables under the action of stochastic terms, due to its easy implementation and phenomenological interpretation it has been applied to a wide range of problems. In this sense it occupies a

paradigmatic position in statistical mechanics covering a wide range of applications to interdisciplinary areas such as chemistry, biology, economics and quantitative linguistics. In this communication we consider the problem of floating particles on a two-dimensional fluid of viscosity α and temperature T, which rotates at a constant angular velocity ω around a fixed axis. In addition to the common viscous term $-\alpha\vec{v}$ proportional to particle velocity, the non-inertial system introduces terms associated to centrifugal and Coriolis forces. As long as the Coriolis term introduces a coupling between the Cartesian components the centrifugal term expelled the particles from the origin. We investigates computationally and analytically the root-mean-square displacement (RMSD) $\langle\Delta r\rangle$ behavior of particles as a function of model parameters. As a result of the competitive relationship between angular velocity and fluid viscosity the system exhibits three regimes defined by different time scales. At the first two regimes ($t \leqslant 2\pi/\omega$) , characterized by low angular velocities, we have a superdifusive behavior $\langle\Delta r\rangle \sim t^{\alpha}$ ($\alpha \geqslant 1/2$) with a viscosity exponent dependence. On the other hand at the third regime we get an exponential dependence $\langle\Delta r\rangle \sim e^{\omega t}$.

[03/11/2015 - P041]
Role of temperature on the global response in the interface growth dynamics, Thiago A. de Assis, *Instituto de Fisica, Universidade Federal da Bahia - Salvador - BA - Brazil*, Fábio D. A. A. Reis, *Instituto de Física, Universidade Federal Fluminense - Niterói - RJ - Brazil* ■An interesting problem in thin film science is a sudden change in the dynamics during the interface growth. For instance, this is the case of a change from sputtering to annealing in a cycle of surface cleaning. Since erosion or dissolution are frequently present in those processes, KPZ scaling was also observed in films after high-temperature annealing, with initial deposition by sputtering. Thus, the apparently simple situation of a sudden change in the growth dynamics may have a variety of applications that involve KPZ scaling.
The global response of the sudden changes in the interface growth dynamics is discussed using models of the Kardar-Parisi-Zhang (KPZ) and Villain-Lai-Das Sarma (VLDS) classes during their growth regimes in 2 + 1 dimensions. We introduce scaling arguments and present simulation results to predict the relaxation of the difference in the squared global roughness of the perturbed and the unperturbed interfaces. Following the same lines of previous works [1-3] discussed in previous talk, we propose an asymptotic scaling which includes the temperature effects in the scaling of the correlation length. Interestingly, our results indicate a crossover from a dynamic where the plateau formation prevails to a dynamic with the scaling of the correlation length of the corresponding VLDS model [4]. Finally, we discuss our results making a parallel with experiments for KPZ-VLDS case that may be viewed as a potential application [5].
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[2] Y.-L. Chou and M. Pleimling, J. Stat. Mech. P08007 (2010)
[3] T. A. de Assis and F. D. A. Aarão Reis, Phys. Rev. E **89**, 062405 (2014)
[4] F. D. A. Aarão Reis, Phys. Rev. E **81** 041605 (2010)

[03/11/2015 - P042]
Langevin dynamics for vector variables driven by multiplicative white noise: A functional formalism, Miguel Vera Moreno, Zochil González Arenas, Daniel G. Barci, *Universidade do Estado do Rio de Janeiro (UERJ)* ■We present a study on multidimensional stochastic processes described by a Langevin equation with multiplicative white noise. In particular, we address the problem of how time reversal diffusion processes are affected by the variety of conventions available to deal with stochastic integrals. For this reason we used a tool called formulation of functional integral, where we build a functional generator of correlation functions without reference to any discretization in the Langevin equations. This type of formalism is characterized by a functional integration over two sets of commuting variables, called Grassmann variables. In this sense, the stochastic process is represented in a manner similar to a quantum theory of fields with contents "bosonic"and "fermionic"..The usual prescriptions to define the stochastic integral arise in the formalism by the definitions of Green functions in the sector of Grassmann variables in the field theory. The stochastic calculus is codified in our formalism in the structure of the Grassmann algebra. In particular we are interested in the study of systems that exhibit a noisy behavior multiplicative way, which means that the intensity of stochastic fluctuations depends on the system state. We study some examples such as higher order derivative Langevin equations and the functional representation of the micromagnetic stochastic Landau-Lifshitz-Gilbert equation.

[03/11/2015 - P043]
Critical behaviour of the monomer-monomer reaction model with desorption, Edio Cunha da Costa, Flávio Roberto Rusch, *Universidade do Estado de Santa Catarina - UDESC* ■The study of phase transitions in systems far from equilibrium has aroused the interest of the scientific com- munity and has been growing progressively in recent years, due to its application in various complex systems, including the heterogeneous catalysis. A heterogeneous catalysis model well known and used to study phase transitions is the monomer-monomer reaction model, described by the reaction $A + B \rightarrow AB$. This catalysis reaction model displays a first order phase transition at the point $y_B = 1/2$, where y_B represents the probability of a monomer B to arrive the surface. For $y_B > 1/2$ the system evolves into a saturated lattice by monomers of the type B, and if $y_B < 1/2$ the system evolves to an A poisoned lattice. Only for $y_B = 1/2$ the system displays an active stationary state in which the reaction $A + B \rightarrow AB$ occurs indefinitely. We studied, in the present work, the critical behaviour of this reaction model on a one-dimensional catalytic surface, and attach to the monomer B a desorption rate α. We used the mean-field approach, at the level of sites and independent pairs, as well as Monte Carlo simulations, and found a change in the type of transition, from a first order phase transition to a continuous phase transition. This phase transition occurs between an absorbing state, in which the lattice is saturated by monomers of the type A, and an active steady state, in which the reaction takes place between the two monomers indefinitely. We found that the critical point (y_{B_c}) depends

on the value of α, and a phase diagram that separates the saturated phase and the active steady state was drawn. The static critical exponents β and $\nu_\perp$ was obtained through finite size scaling, confirming the conjecture due to Grassberger. We also obtained the dynamical critical exponents z, by introducing a suitable time variable that is defined as being the mean time required for the system to become completely poisoned, and $\nu_{||}$, through the time evolution of the order parameter (fraction of empty sites) at the critical point.

[03/11/2015 - P044]
Growth exponents in a surface model with probabilistic diffusion, Edio Cunha da Costa, Josias Carvalho, *Universidade do Estado de Santa Catarina - UDESC* ■Surface growth models are nonequilibrium systems because they present flux of particles toward the surface of some substrate. These particles are deposited and form a thin film. The mean height and the roughening are physical quantities of interest because they give information about the growth of the film and its mildness. These physical quantities obeys power laws and the more interesting is the roughening power low. In the thermodynamic limit the roughening evolves as $\omega \sim t^\beta$ and, for long times, the roughening depends on the system size as $\omega \sim L^\alpha$. The Family - Vicsek scaling relation allows one to obtain these asymptotic forms. There are different deposition models, as the ballistic deposition model, the Eden model and solid on solid models as well as different relaxation mechanisms. In the present work, we consider the random sequential adsorption and we allow the deposited particle to diffuse to the nearest neighbour site that has the lowest height. However, the diffusion occurs with some probability λ and we are interested in the effect of this probability on the exponents β and α. By employing Monte Carlo simulations and finite size scaling, we show that the exponent β depends on the values of the probability λ.

[03/11/2015 - P045]
Heat transport in a chain of α-XY rotators, Carlos Olivares, Celia Anteneodo, *Depto. de Fisica, PUC-Rio* ■The conduction of heat is one of the simplest but at the same time most intriguing problems in non-equilibrium physics. Its study has put into evidence transport anomalies for low dimensional systems. In other words, in the thermodynamic limit, the Fourier's law is not satisfied for low-dimensional systems. The conductivity shows a dependence on the size N of the system according to the form $\kappa \sim N^a$, where the value of a is dependent on the interaction potential. But there are controversies concerning its origin. It has been argued that the momentum conservation is the responsible for a non-Fourier behavior, however rotator systems have displayed normal heat transport. On the other hand, it is known that the range of the interactions brings new phenomena to a system [1,2]. So, in this work, we investigate by means of molecular dynamics simulations the role that the interaction range plays on the heat conductivity. For this purpose we consider a chain of rotators with interactions that depend algebraically on the distance between rotators, with a parameter that controls the range of the interactions [1]. We determine the critical range at which the systems passes from a flat temperature profile (mean field) to a normal profile (first neighbors).

[1] Anteneodo & Tsallis, PRL 80, 5313 (1998); Tamarit & Anteneodo, PRL 82, 208 (2000)
[2] Moyano & Anteneodo, PRE 74, 021118 (2006)

[03/11/2015 - P046]
Solvable Small Thermal Engines, L. A. e Defaveri, W. A. M. Morgado, *PUC-Rio* ■With the advent of modern microscopic and nanoscopic techniques it became possible to understand the workings and constraints of very small systems, such as biological ones.
It has become clearer in the last few years that the physics of those systems is quite different from the macroscopic ones that obey the laws of thermodynamics and equilibrium statistical mechanics.
Microscopic systems are driven by fluctuations, and are mostly in non-equilibrium states. Eventual violations of the 2nd Law of Thermodynamics become possible for a single realization of a thermodynamic process, but the 2nd Law is still valid for averages of many realizations.
In order to study these interesting problems, here we propose a minimal model consisting of a massive damped Brownian particle subjected to an harmonic and quadratic ($k_3x^4/4$) potentials. The particle is enclosed in a box of size $L(t)$ and in contact with a heat bath of temperature $T(t)$. Having full control of the expressions for $T(t)$ and $L(t)$ allows us to write a wide range of cycles, from equilibrium to non-equilibrium.
Our goal is to obtain the exact analytical expansions in orders of k_3 for the averages of functionals such as work and absorbed heat. From there we can calculate the efficiency of our engines for different cycles.

[03/11/2015 - P047]
Absorbing phase transitions on random Voronoi triangulations, Sidiney G Alves, Marcelo M de Oliveira, Silvio C Ferreira, *Universidade Federal de São João Del Rei* ■Nonequilbrium phase transitions from an active (fluctuating) to an inactive (absorbing) phase in spatially extended systems is a topic of current great interest. The so-called absorbing state phase transitions (APT) arise in a wide variety of problems, for example, heterogeneous catalysis, interface growth, population dynamics and epidemiology. Recent experimental realizations in turbulent liquid crystals, driven suspensions and superconducting vortices increased the interest in this kind of transitions. Of particular interest is how spatially quenched disorder affects the critical behavior of APT. In real systems, quenched disorder appears in the form of impurities and defects. On a regular lattice, quenched disorder can be added in the forms of random deletion of sites or bonds or of random spatial variation of the control parameter. In all the cases above, one finds a change in the critical behavior of the model, with strong Griffiths singularities.
An important question is what happens when the disorder is configurational, *i.e.*, when the underlying graph is not periodic, as observed in a deterministic aperiodic structure, or in a graph with a random connectivity such as the Voronoi triangulation. The Voronoi lattice represents a natural way of introducing quenched coordination disorder in a lattice model, and also plays an important role in the description of idealized statistical geometries such as planar cellular structures, soap throats, etc.

In this work, we study first-order and second-order absorbing-state phase transitions on the Voronoi-Delaunay lattice. Our extensive simulations confirm recent findings of Barghatti and Vojta [1] on the effects of random topological (connectivity) disorder. We observe that such kind of disorder is irrelevant for the critical behavior for models belonging to the directed percolation and manna universality class. Using the ZGB model as example, we show that the coordination disorder is not capable of changing the nature of the transition, as occurs when uncorrelated random defects are present in the substrate.

[1] H. Barghathi and T. Vojta, Phys. Rev. Lett. **113**, 120602 (2014)

porting Agencies: FAPEMIG and CNPq.

[03/11/2015 - P048]

Residual entropy and waterlike anomalies in the repulsive one dimensional lattice gas, Fernando Barbosa V. Silva, Marco Aurelio A. Barbosa, Fernando Albuquerque de Oliveira, *Universidade de Brasilia, Instituto Federal de Brasilia*

■Water is special fluid for its biological relevance and technological applications but most intriguing is that it presents thermodynamic and dynamic properties with anomalous (or unusual) behavior. The origin of its anomalous properties is actively discussed in the literature, with different thermodynamic scenarios competing to describe its behavior on regular and metastable regimes. Among alternative views on water thermodynamics, it should be relevant to mention the second critical point hypothesis and the singularity free scenario, which will be relevant in the context of the current work.

In this work, we proceed on this direction by investigating the repulsive 1D lattice gas, which is even simpler than our previous models and presents waterlike anomalies in density, thermodynamic response functions, and self-diffusion constant. The model was studied through transfer matrix technique and Monte Carlo simulations. With the results obtained from these techniques, a connection between temperature of maximum density and GSTP was found as in a previous work with more complex models. In addition, it was also found that GSPT does present a residual entropy, due to phase mixing, and it is shown that this property is fundamental in determining waterlike anomalies for the model considered here. Finally, a comparison between regions with density and diffusion anomaly indicated that this model presents so called hierarchy of anomalies.

OTHER TOPICS

[03/11/2015 - P049]

Detection Response Evaluation of a Solid State Nuclear Track Detector Durolon®, Reginaldo Ribeiro de Aquino, *Instituto de Pesquisas Energéticas e Nucleares IPEN/CNEN-SP*

■In a radioactive decay process of the ^{222}Rn, in accordance with the Poisson distribution, the emitted α particle probability reaching a particular point in the active area of the solid state nuclear track detector (SSNTD) is equal to any other particle emitted reaching any point of any area of this detector. Considering the fact that the probability is equal to any part of the area and that there are no external influences, it is reasonable to say that the quantity of incident particles expected per area is equal and corresponding. This characteristic allows these films may be applied as SSNTD detectors. It is assumed so as essential characteristic for SSNTD detectors that regularity in the observed counting frequency of the incident particles should match the expected frequency for counting. The aim of this work is an evaluation of response of count for the SSNTD detector in relation of the total count per area of incident α particles by applying the χ^2 test at a 5% level of statistical significance hoping that the expected and observed frequencies are equivalent (null hypothesis). To demonstrate this proposition, samples of 1cm^3 of Durolon® (Bisphenol-A, used as SSNTD) packed in a dosimeter type NRPB/SSI-H were irradiated in a calibrated source PYLON RN-1023 with a activity of 21kBq/m^3 and revealed using a standard chemical attack protocol PEW-40 with subsequent track counting using a conventional microscope with magnification of 40x. In the process data acquisition it was discarded lateral area of the SSNTD and randomly selected 10 areas (770x1028μm) along the central part of the detector. For each region was made the total count of the tracks. Based on the tracks counts, the average and the standard deviation was determined and a relative error. Considering the average value as an expected value, was applied the χ^2 test considering the partial counting as a observed values. The average of counts is 63±4 tracks/area, with a relative error of 7%, the determined χ^2 value was 2.38 and the tabulated value considering 5% of statistical significance was 3.33. As $\chi^2_{9,0.05} > \chi^2_{calculated}$, the null hypothesis is accepted. In conclusion, the results show that the null hypothesis is accepted and the tracks counting in partial areas they are corresponding to a level of statistical significance of 5%. The detection response for this SSNTD can be considered as valid.

[03/11/2015 - P050]

AN APPLICATION DYNAMICS OF NONLINEAR COMMUNITIES FOR PERFORMANCE EVALUATION OF VIRTUAL LEARNING, Wesley Mendes Lopes da Silva, Francisca Lívia Lima Demontiêzo, Francisco Felipe Moura Fontele, Danielle Luize Santos de Oliveira, Vanessa Lígia Serafim, *IFCE Sobral*

■Permanent learning is a basic requirement for organizations to remain competitive in a market constantly changing. Along this line, companies are intensifying their action in the field of corporate education. The use of distance education is each time bigger, providing the employees the opportunity to study in adjusted place and moment. A practice much used in distance education is the asynchronous meeting, especially discussion forums. The intention of this work was to evaluate the effectiveness of this practice for the construction of knowledge and the conversational abilities necessary to promote the amount and the quality of the interactions in the forums. Agreeing with some authors that question the efficiency of the current methods of evaluation, based in the subjectivity and/or linear metrics, we present a methodology of evaluation for discussion lists, based on nonlinear dynamical systems theory. The Meta Learning

model, used in face-to-face teams, establishing the relationship between positivity and negativity with the performance of teams, was tested in discussion forums of distance classes, to verify if the same parameters can be used in the virtual environment. The Ontology of Language was the theoretical referential for evaluation of conversational competence. The results obtained showed that a positive correlation exists between positivity/negativity and the construction of knowledge, as well as highlight the importance of conversational competence for the effectiveness of the forums as an educational practice. With this research we verify that the Meta Learning model can be used for evaluation of the performance of virtual communities of learning and that possessing conversational competence also favors relationships in the virtual environment.

[03/11/2015 - P051]
Kinetic Study of Small Particles Transport in Rarefied Gas Media., Lucas G. L. F. Pollito, Carlos A. B. Silva, *Instituto Tecnológico de Aeronáutica SP Brasil* ■This work presents a kinetic study of small (micrometer or nanometer scale) particles transport in gas media in a free molecular regime. It is based on a Boltzmann like kinetic theory adapted to treat inelastic collisions through the concept of scattering kernels [1]. The work focus on a generalized treatment of the drag force on a spherical particle due to its motion in a low density gas, with Knudsen number Kn¿¿1. The approach Is shown to be equally applicable to particle diffusion and electric mobility. It is explicitly considered the influence of soft interaction potential, between the particles and the gas molecules, on the transport, compared to the transport based on rigid sphere potential. An interaction potential relevant for molecule/particle interaction, recently developed by Rudyak and Krasnolutski [2] is used. Interaction between gas molecules and particles is a rather complex process which changes with particle size and depends on the reflection mode on particle surface which is described by a reflection kernel (transition probability). This requires simplified models for molecule /particle interaction. The best known is the Maxwell model which introduces an accommodation parameter that measures the fraction of molecules diffusively reflected and consider the remaining fraction specularly scattered [3], [4]. The real scattering behavior is still not known and may depend on the particle surface roughness. In this work the transport is analyzed adding to Maxwell model a scattering kernel to describe the perfectly rough particle surface which will scatter the molecules into arbitrary directions while preserving their absolute velocity. The study made here is then compared to that made by Li and Wang[5] which used Maxwell model for the transport of almost spherical silver and copper oxide nanoparticles, both, in a nitrogen gas.
[1] G. M. Kremer, An Introduction to the Boltzmann Equation and Transport Processes in Gases. Springer, 2010. [2] V. Ya. Rudyak and Krasnolutski, Dokl. Phys. 47, 758(2002). [3] J. C. Maxwell, Philos. Trans. R. Soc. London 170, 231-256(1879). [4] Lucas G. L. F. Pollito, Dissertação de Mestrado, Instituto Tecnológico de Aeronáutica, 2013. [5] Z. Li and H. Wang, Phys. Rev. E 68, 61207(2003).

[03/11/2015 - P052]
Self-consistent statistical theory of crystal structures, J. N. Teixeira Rabelo, *UFG - GO - Brasil* ■In this presentation I give a short review of the state of the art in the development of the statistical theory of crystal structures. It is a generalization of the unsymmetrized self-consistent field approximation proposed and applied earlier to crystals with Bravais lattices. This method is an alternative to the known self-consistent phonon theory of strongly anharmonic solids. It is free of any perturbative schemes and can be applied with in principle any type of empirical or semi-empirical interatomic potential functions. The basic equations are derived and solved for a few graphene-type systems. The solutions of these equations are used as a background for the investigation of some structural properties of these materials. We calculate the equilibrium nearest neighbor distances and the lattice parameters, the coefficient of thermal expansion, the effective amplitudes and other higher moments of the configurational atomic phase probability densities. We also investigate the thermodynamics of these systems, and calculate the Gruneisen parameter, the thermal coefficient of pressure, the thermal capacities at constant volume and pressure, the isothermal and adiabatic compressibilities. We show here also results for the energy of formation of defects like vacancies, and also for the surface free energy. For imperfect crystals we calculate the distortion of the lattice and the softening of the atomic vibrations at the vicinity of the surfaces. We also give comparisions to other available theoretical, experimental, and simulational results.

[03/11/2015 - P053]
Anomaly in the phase diagram of the spin quantum 1/2 anisotropic Heisenberg antiferromagnet model with Dzyaloshinskii-Moriya interaction: A low temperature analysis, Walter E. F. Parente, J. T. M. Pacobahyba, Ijanílio G. Araújo, *Universidade Federal de Roraima*, Minos A. Neto, J. Ricardo de Sousa, *Universidade Federal do Amazonas* ■In recent years, multiferroics are materials in which ferroic properties, e.g., magnetism and polar order, coexist. Magnetic and ferroelectric ordering couple microscopically or macroscopically to form the magnetic ferroelectrics. These have potential applications in information storage, actuators, sensors, and functional devices. Perovskite $BiFeO_3$ exhibits both "weak" ferromagnetism and ferroelectric characteristics and has been studied extensively in the last decade. The G-type antiferromagnetic (AF) order of the Fe magnetic moments exhibits a canting caused by the antisymmetric DMI under rhombohedral R3c space group. Experimentally, the Dzyaloshinskii-Moriya interaction (DMI) has gained renewed interest because of the evidence to interpret an anomalous magnetic behavior in $BaCu_2M_2O_7$ ($M = Si$, Ge), Yb_4As_3, $YVO_3 - SrVO_3$ and La_2CuO_4. The DMI has gained renewed interest because of the evidence of its existence the coupling between antiferrodistortive (AFD) distortions and weak ferromagnetism where anomalies in AF vectors and band gap varying with on site Coulomb interaction. We will study phase diagram the quantum spin-1/2 anisotropic Heisenberg antiferromagnet model in the presence of a DMI (D) and a uniform longitudinal (H) magnetic field, where we have observed an ano-

maly at low temperatures. Using the effective-field theory with a finite cluster $N = 2$ spin (EFT-2) we calculate the phase diagram in the $H - D$ plane on a simple cubic lattice ($z = 6$). We analyzed the cases: anisotropic Heisenberg - case I: ($\Delta = 1$), anisotropic Heisenberg - case II: ($\Delta = 0.5$) and anisotropic Heisenberg - case III: ($\Delta = 0$), where are observed only second order phase transitions.

[03/11/2015 - P054]
Quantum Random Walks in Honeycomb Lattice, Bruno Felipe Venancio, Marcos Gomes Eleutério da Luz, *UFPR - Brasil* ■The term quantum random walks (QRW) appeared in the early 1990 as the quantum analogous of classical random walks (CRW) (Physical Review A 48, 1687, 1993). Thus, while the CRW is defined by probability of a stochastic event occurs, the QRW is defined by probability amplitudes associated with unitary transformations. One feature that differs a QRW of a CRW is the mean square displacement $[\Delta r]^2$. For QRW $[\Delta r]^2 \sim t^2$ and to CRW $[\Delta r]^2 \sim t$, where t is time. For an introduction to QRW we suggest the following reference (Contemporary Physics, v. 44, n. 4, p. 307-327, 2003). The QRW can be divided into two groups, one with an discrete time evolution, and other with a continuous time evolution. However, the system is always implemented on discrete space (lattices or graphs). The discrete time QRW version can be formulated in terms of two entirely equivalent models, the coin model and the scattering model, we will adopt the scattering model, which we consider more physically intuitive. This model consists of a particle moving through the edges lattice and the sites act as scattering centers. Thus, in a time step, the particle to focus on a site is scattering towards the edges connected to site. These processes of scattering are weighted by probability amplitudes given by scattering matrix (Physical Review A 68, 3, 032314 (2003). Since they were proposed the QRW are well studied in the linear lattice. However, there are few studies that dedicated to analyze them in the honeycomb lattice. Furthermore, since the QRW have been employed in the study of electronic transport properties of some quantum systems (Physical Review Letters 94, 100602, 2005), we will study the in the honeycomb lattice in order to a possible application in the theoretical study of the properties electronic and the transport system involving graphene and other materials that exhibit the honeycomb pattern, for example carbon nanotubes and fullerenes. In this work we present a formulation for the QRW in honeycomb lattice, compare the classical and quantum random walks and found the expected behavior for mean square displacement in those two systems.

[03/11/2015 - P055]
Beyond the modulational approximation in the wave triplet interaction, Paulo Iorra, Samuel Marini, Eduardo Alcides Peter, Renato Pakter, Felipe Barbedo Rizzato, *Universidade Federal do Rio Grande do Sul* ■One of the most well accepted and well established models for nonlinear wave interaction is based on the wave triplet concept . The wave triplet arises as an entity of physical significance, as one selects the three most prominent modes of an oscillatory system and investigates the coupled dynamics of these selected modes as an isolated subsystem. In general, one mode starts off with a sizeable energetic content, which is then periodically exchanged with the other two modes in a resonant fashion. Resonant conditions, thus a key ingredient for an active interaction of the modes, are defined as the matching conditions for the high-frequencies of the slowly modulated carriers involved in the interaction. The decay of mode *"1"* into the other two (*"2"* and *"3"*), for instance, is favored when the resonant condition $\omega_1 = \omega_2 + \omega_3$ among the three high-frequencies is observed. One promptly sees that, in its canonical form, resonant conditions are heavily based on a clear separation of the time scales referring to the high-frequency and the slow modulational dynamics. The present work investigates the breakdown of the traditional modulational approximation in the three wave nonlinear interaction, the wave triplet interaction. A common way to describe the interaction of three high-frequency carriers is to assume that amplitudes and phases are slowly modulated. This is the basis of the modulational approach, which is accurate when the three wave coupling is weak. We examine the types of dynamics arising when the coupling rises from very small to large values. At large values we detect an abrupt transition where the limited amplitude excursions of the modulational regime reach much larger regions of the appropriate configuration space. Extensions to similar cases are also investigated.

[03/11/2015 - P056]
Spatial and temporal localization of light in two dimensions, C. E. Máximo, Ph. W. Courteille, R. Bachelard, *Instituto de Física de São Carlos, Universidade de São Paulo, 13560-970 São Carlos, SP, Brazil*, N. Piovella, *Dipartimento di Fisica, Università Degli Studi di Milano, Via Celoria 16, Milano I-20133, Italy*, R. Kaiser, *Université de Nice Sophia Antipolis, CNRS, Institut Non-Linéaire de Nice, UMR 7335, F-06560 Valbonne, France* ■Multiple scattering of waves has been the subject of intense debates and proliferic studies in the context of disorder-induced Anderson localization [1]. However, despite several decades of research, the mere existence of Anderson localization of light [2] and its relation to another long predicted phenomenon, namely Dicke super- and subradiance [3], are still not clearly understood. As most experiments are typically performed in a three dimensional setting, models have also been focused on such 3D configurations. However, both numerical and fundamental aspects of localization strongly depend on the dimension of the explored system. For this reason, we have focused our efforts on a 2D system. Two-dimensional set-up can be obtained, e.g., with a disordered arrangement of scatterers in microwave cavities, in photonic crystals, near surface plasmons or with laser-cooled atoms located in an off-resonance optical cavity. The main advantage of that the reduced dimensionality also allows for a direct comparison between two regimes of scattering, one corresponding to a scalar model of light, the other one corresponding to a vectorial model of light, where the polarization of the wave needs to be taken into account. Then we are able to switch between the scalar or vectorial regime, between the presence or the absence of polarization degrees of freedom, and the presence or the absence of near field terms, making it an ideal tool to investigate the role of polarization in localization and subradiance. Performing scaling analysis we observe in both cases long lived atomic modes of the scattering, yet

only the scalar case exhibits Anderson localized modes. Investigating the reasons for the absence of localization in cold atoms ensambles, it appears that both the coupling of polarization and the presence of near field terms are able to prevent long lifetimes and Anderson localization. We finally show that, albeit extremely long mode lifetimes are present only in localization regime, this lifetimes and their localization length are uncorrelated [4].

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[03/11/2015 - P057]
Stall in a numerical wind tunnel, Paulo Victor Santos Souza, *Instituto Federal do Rio de Janeiro - RJ - Brasil*, P M C de Oliveira, *Universidade Federal da Integração Latino-Americana* ■In this work, we introduce a new method for determining the behavior of the drag force. We have used this method in order to compare the drag and lift coefficients for a simple model of wing within numerical wind tunnels. The inspiration comes from an experimental result: a small, light ball falls on air; its speed increases, reaches a maximum, decreases and finally stabilizes. This surprising behavior is due to the gradual formation of the so- called von Kármán street of vortices: while it is not completely formed, the transient drag force is smaller than the known steady state value and the ball can reach speeds higher than its final value. In building the numerical wind tunnel we solved the Navier-Stokes equation by the finite difference method and successive relaxations. The initial condition is the flow around the obstacle immersed in an incompressible fluid with vanishing velocity (obeying the same equation for vanishing Reynolds number). At this moment, the wind tunnel is turned on with a constant, finite free stream speed (corresponding to a Reynolds number of the order of 1,000). After a transient time, we observe the formation of a street of vortices in the fluid portion behind the wing, the so-called von Kármán street. In particular, we investigated the relationship between the behavior of the coefficients and the attack angle. Our results suggest the manifestation in the wind tunnel of a well-known phenomenon in aviation, the stall crisis.

Oral sessions (11:00-12:30)

LONG RANGE INTERACTIONS

[03/11/2015 - 11:00 - Room Vitória]
Statistical Mechanics of Systems with Long-Range Interactions, Y. Levin, R. Pakter, F. Rizzato, T. N. Teles, F. P. C. Benetti, A. C. Ribeiro-Teixeira, *Instituto de Física, UFRGS* ■Systems with long-range forces behave very differently from those in which particles interact through short-range potentials. For systems with short-range interactions, for arbitrary initial conditions, the final stationary state corresponds to the thermodynamic equilibrium and can be described equivalently by either a microcanonical, canonical, or a grand-canonical ensemble. On the other hand, for systems with unscreened long-range forces, equivalence between ensembles breaks down. Isolated long-range interacting systems — in thermodynamic limit — do not evolve to the usual Maxwell-Boltzmann equilibrium, but become trapped in a non-ergodic stationary state which explicitly depends on the initial particle distribution. In this talk, a theoretical framework will be presented which allows us to predict the final stationary state to which a long-range interactioning system will evolve. The theory is able to quantitatively account for both density and velocity distributions in the stationary state, without any adjustable parameters [1,2,3].

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[03/11/2015 - 11:20 - Room Vitória]
Ergodic properties of systems with long-range interactions., Cínthia Helena Silvestre, *IF/Universidade de Brasília*, Tarcísio Marciano da Rocha Filho, *cifmc-IF/Universidade de Brasília* ■We study the ergodic properties of a two-dimensional self-gravitating system using molecular dynamics simulations by applying three different tests for ergodicity: a direct method comparing the time average of a particle momentum to ensemble averages, sojourn times statistics for cells in momentum space and the dynamical functional method. These methods are also applied to a short-range interacting system (a hard-sphers gas in two dimensions), and the Hamiltonian mean-field model, for comparison purposes. Our results show that a two-dimensional self-gravitating system takes a very long time to establish ergodicity. This time is independent of particle number, at variance with what is observed in the Hamiltonian mean-field model.

[03/11/2015 - 11:35 - Room Vitória]
Dynamical threshold in the relaxation of long-range systems, Romain Bachelard, *IFSC-USP, Brazil*, Michael Kastner, *NITheP, Stellenbosch, South Adrica* ■The dynamics of systems with mean-field interaction, when all the particles interact with equal strength, is characterized by very long equilibration times: Indeed, the system gets trapped in quasi-stationary states, where macroscopic quantities (temperature, magnetization, etc) evolve very slowly toward their equilibrium value. The lifetime of these states generally increases with the system size and, as a consequence, the time for the system to reach equilibrium diverges in the thermodynamic limit.
We here investigate the equilibration of lattice systems with long-range pair interactions, decaying like $1/r^\alpha$ with the distance r. The long-range regime corresponds to $\alpha < d$, with d the dimension of the system. We characterize the relaxation times and show that long-range lattice systems also exhibit quasi-stationarity, as well as relaxation times that diverge with the size of the system. However, upon varying the interaction range α, we find evidence for the existence of a threshold at $\alpha = d/2$, at which the relaxation behaviour changes qualitatively and the corresponding scaling exponents switch to a different regime. Since our observation is based on the behaviour of both a quantum and a classical system, investigated analytically and numerically, for ferro- and antiferromagnetic interactions, we conjecture this threshold and some of its characteristic properties to be universal.

[03/11/2015 - 11:50 - Room Vitória]
Temperature inversion in long-range interacting systems, Tarcisio N. Teles, *Instituto de Fisica, Universidade Federal do Rio Grande do Sul.*
Departamento de Ciências Exatas e Sociais Aplicadas, Universidade Federal de Ciências da Saúde de Porto Alegre., Shamik Gupta, Pierfrancesco Di Cintio, Lapo Casetti, *Dipartimento di Fisica e Astronomia and CSDC, Università di Firenze, and INFN, sezione di Firenze, via G. Sansone 1, I-50019 Sesto Fiorentino, Italy* ■Temperature inversions occur in nature, e.g., in the solar corona and in interstellar molecular clouds: Somewhat counterintuitively, denser parts of the system are colder than dilute ones. We propose a simple and appealing way to spontaneously generate temperature inversions in systems with long-range interactions, by preparing them in inhomogeneous thermal equilibrium states and then applying an impulsive perturbation. This work is motivated by an attempt how such a counterintuitive effect may spontaneously arise in nonequilibrium states, unveiling its minimal ingredients and the underlying physical mechanism. We start with asking a simple yet physically relevant question: What happens if an isolated macroscopic system in thermal equilibrium is momentarily disturbed, e.g., by an impulsive force or a "kick"? If the interactions among the system constituents are short-ranged, collisions redistribute the kick-injected energy among the particles, yielding a fast relaxation to a new equilibrium, with a Maxwellian velocity distribution and a uniform temperature across the system. Is the scenario the same if instead the interactions are long-ranged? For long-range systems, collisional effects act over a characteristic time that, unlike short-range systems, scales with the system size N, diverging when N goes to infinity. By contrast, in long-range systems, the interplay between wave-particle interaction and spatial inhomogeneity drives the system to nonequilibrium stationary states that generically exhibit temperature inversion. We demonstrate this mechanism in a simple mean-field model and in a two-dimensional self-gravitating system. Our work underlines the crucial role the range of interparticle interaction plays in determining the nature of steady states out of thermal equilibrium. We have shown that nonequilibrium stationary states with temperature inversions are the typical outcome of a perturbation acting for a short time on a clustered equilibrium state of a long-range interacting system. This rather surprising result can be explained in terms of Landau damping and velocity filtration, suggesting that temperature inversions may occur whenever the dynamics is collisionless up to the relevant timescales. This mechanism may be actually relevant to understand temperature inversions observed in nature. This work was partially supported by CNPq and published in its complete version at Physical Review E (Rapid Communications) 92, 020101(R) (2015).

[03/11/2015 - 12:05 - Room Vitória]
Zeno dynamics and Cooperative Shielding from long range interaction, Giuseppe Luca Celardo, *Universita' Cattolica del Sacro Cuore* ■We analyze both single particle transport models with long range hopping and many-body systems with long range interaction. First we discuss a paradigmatic one dimensional disordered model with both nearest-neighbor and $1/r^\alpha$ hopping amplitudes. Such a model is relevant for different physical systems and it can be directly implemented in ion traps, where α can be tuned from zero to a value larger than one. In case of long range hopping, in the large system size limit, we show the existence of a subspace where the dynamics occurs as if long range hopping was absent or reduced to short range. We named such effect *Cooperative Shielding*. Cooperative shielding strongly affects transport properties: while long range hopping is usually thought to destroy localization, strong signatures of localization can be found in the shielded subspace. Next, many-body quantum spin-1/2 systems with long-range interaction, are discussed. Contrary to the common expectation that long-range interaction should always induce an instantaneous spread of information in the thermodynamic limit, the shielding effect may lead to a finite velocity of the propagation of information or even the entire freezing of the dynamics, even in absence of disorder. This shielding phenomenon can be related to the quantum Zeno effect, which refers to the freezing of the dynamics into invariant subspaces in a system under continuous measurement. Thus long-range interaction plays a role similar to a measuring apparatus.

QUANTUM SYSTEMS & CONDENSED MATTER

[03/11/2015 - 11:00 - Room Tubarão]
Dual landscapes in Anderson localization on discrete lattices, M. L. Lyra, *Universidade Federal de Alagoas - Brazil*, S. Mayboroda, *University of Minnesota - USA*, M. Filoche, *Ecole Polytechnique, France* ■In Anderson localization, electronic states are expo-

nentially localized despite the absence of classical confinement, this localization being explained as originating from the destructive interference of waves reflected in the random atomic potential. Despite numerous theoretical advances, such as the prediction by the scaling theory of the lower critical dimension of the Anderson transition, there was until recently no general formalism capable to accurately pinpoint the spatial location of these localized modes for any given potential, nor to predict the exact energy at which delocalized modes would begin to form. Recently, a new theory has been proposed, unveiling in continuous media a direct relationship between any specific realization of the random potential and the corresponding location of localized states. It has been demonstrated that the boundaries of the localization regions, which cannot be deduced by directly looking at the bare random potential, can be accurately retrieved as the valleys lines of a "hidden landscape" $u(x)$ which is the solution of a Dirichlet problem with uniform right-hand side for the same Hamiltonian.
In this talk, we show that not only the exact same theory can be extended to the case of a tight-binding Hamiltonian defined on a discrete lattice, but also that, contrary to the continuous case, two different types of localization occur here. First, localization of low energy states can be predicted using a discrete analog of the landscape $u(x)$ defined in the continuous situation. Secondly, the discreteness of the system also triggers a strong localization of states of typical wavelength of the order of the lattice spacing (corresponding to the top of the band for a periodic potential). We show that this localization can also be studied in the framework of the landscape theory, with a different operator than the original Hamiltonian and, respectively, a different landscape.

[03/11/2015 - 11:20 - Room Tubarão]
Improving the extraction of characteristic field enhancement factors from non-linear Fowler-Nordheim plots: role of the irregular morphology of large area conducting field emitters, Thiago A. de Assis, *Instituto de Física - Universidade Federal da Bahia - Salvador - Ba - Brazil* ■We show that the dependence between the effective emission area and the macroscopic electric field, F_M, allow for the introduction of a new correction, ω, in the elementary slope characterization parameter (SCP) for extracting the characteristic field enhancement factor, γ_C, from (precise) orthodox cold-field electron emission measurements [1,2]. First, we discuss the effects of the Hurst exponent (H) on the local electric field distribution and the slope of the Fowler-Nordheim (FN) plot when considering the cold field electron emission properties of rough Large-Area Conducting Field Emitter Surfaces (LACFESs) [3]. We discuss also the case where the local macroscopic enhancement factors, γ, are Gaussian-distributed [4], as has been experimentally determined for the potential candidates of cold-field electron emission applications [5]. In this case, using the recent developments in cold-field electron emission theory, we found that for the typical experimental range of 1 V/μm $\leq F_M \leq$ 10 V/μm, the nonlinearities that are often observed in cold-field electron emission experiments may appear in J_M-F_M-type Fowler-Nordheim (FN) plots. Finally, our results show that depending on the distribution of γ over the LACFES, the error in estimating the γ_C using the elementary SCP (a common practice for experimentalists) may be relevant.
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[03/11/2015 - 11:35 - Room Tubarão]
Hydrodynamic Decay of Decorated Quantum Vortex Rings, L. Moriconi, *Instituto de Física - Universidade Federal do Rio de Janeiro* ■The decay of quantum vortex rings in HeII, visualized with the help of solid hydrogen particles trapped in their cores (which are regions of the flow with local pressure drop) [1,2], has been a problematic issue within the standard approach based on the two-fluid model of superfluidity [3]: the large drag exerted on the vortex rings by the flow of normal fluid past the hydrogen particles would ultimately lead to decay times that mismatch the ones measured in the laboratory, besides non-observed dynamical phenomena (as vortex ring rotation and contour deformation). Taking into account the so-called "triple structure" of quantum vortex rings, as predicted by Kivotides et al. [4], we discuss a phenomenological solution of vortex ring decay puzzle, which is based on the fact that the vortex ring energy loss is accounted for not only by mutual friction, but also by the viscous dissipation and sweeping of the flow structures produced from the vortex ring backreaction on the normal component of the surrounding superfluid.

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[03/11/2015 - 11:50 - Room Tubarão]
Electron-soliton dynamics in chains with cubic nonlinearity, Messias Oliveira Sales, Francisco Anacleto Barros Fidelis de Moura, *Instituto de Física - UFAL* ■The lattice vibrations and its coupling with the electronic dynamics (the electron-phonon interaction) plays relevant roles on the effective electronic transport. In our work, we consider the problem of electron transport mediated by the coupling with a solitonic wave. Our model consists of a one-electron moving in an unharmonic lattice and we will focus on the existence of an electro-soliton pair. In our model, we will consider a one-dimensional unharmonic lattice with a cubic interaction between nearest neighboring sites. The electron-lattice interaction was introduced by considering the energy hopping following the (SSH) approximation, i.e. a linear function of the distance between neighboring atoms. We will solve numerically the dynamics equations for the electron and lattice and compute the dynamics of an initially localized electronic wave-packet. Our results suggest that the solitonic waves that exist within this nonlinear

lattice can control the electron dynamics along the entire lattice. We will study in details the formation of a electron-soliton state that can move along the chain. This mobile electron-soliton pair can be a key ingredient to the charge transport in a nonlinear chain. Moreover, we will investigate in details which intensity of the electron-lattice interaction necessary to promote the appearance of this electron-soliton pair. Our calculations suggest that, even for strong electron-lattice coupling, we can find an electronic dynamics non mediated by solitonic waves.

[03/11/2015 - 12:05 - Room Tubarão]
Thermodynamics of a Relativistic Generalization of Ginzburg-Landau Theory, Carlos Bonin, *Federal University of Technology - Paraná (UTFPR-PG)* ■Superconductivity is a key milestone for technology advance. Superconduting magnets are used in Magnetic Resonance Imaging Machines and for steering of the beams in particle accelerators such as the Large Hadron Collider. Although there is no unified description for "high-temperature superconductors, low-temperature superconductors are reasonably well-understood. The understanding of low-temperature superconductors started with phenomenological theories, such as those of the London brothers and the famous Ginzburg-Landau theory. Finally, a deeper understanding of the underlying mechanism for superconductivity was achieved in the celebrated Bardeen, Cooper and Schrieffer Theory of Superconductivity (BCS Theory). Later on, using techniques of Statistical Mechanics, Gor'kov was able to recover the Ginzburg-Landau action (or Free Energy) starting from BCS Theory. In this talk we follow a similar path. We start from a relativistic generalization of BCS Theory proposed by Bertrand and, through Gor'kov's and Bertrand's statistical approach, we review as a Relativistic Generalization of Ginzburg-Landau Theory can be achieved. Then, from the effective action of the relativistic theory, we use methods of Finite Temperature Field Theory (also known as Statistical Quantum Fields) to compute, to some degree of approximation, relevant thermodynamic quantities, such as the partition function and the free energy density. Furthermore, quantum statistical effects, such as the dependence of the "vaccum" polarization and self-energy with the temperature, may be presented.

Oral sessions (14:30-16:05)

CRITICAL PHENOMENA

[03/11/2015 - 14:30 - Room Tubarão]
Nematic phase in the J_1-J_2 square lattice Ising model in an external field, Alejandra Guerrero, Daniel Stariolo, *Departamento de Física, Universidade Federal do Rio Grande do Sul*, Noé G. Almarza, *Instituto de Química Física Rocasolano, CSIC, Madrid, Spain* ■The J_1-J_2 Ising model in the square lattice is a minimal model with competing nearest-neighbor and next-nearest-neighbor interactions. Its phase diagram in the temperature versus $\kappa = J_2/|J_1|$ plane has three phases: ferromagnetic and a striped phase at low T and a disordered phase at high T. The nature of this phase diagram has been debated in the last 20 years. Instead, the effects of an external field on the phase diagram have been much less studied. We have studied it by two approaches: the Cluster Variation Method (CVM) and Monte Carlo simulations. The use of the CVM in the square approximation leads to the presence of a new equilibrium phase, not previously reported for this model: an Ising-nematic phase, which shows orientational order but not positional order, between the known stripes and disordered phases. Monte Carlo simulations are in qualitative agreement with the CVM results, giving support to the presence of the new Ising-nematic phase. Phase diagrams in the temperature-external field plane are obtained for selected values of the parameter κ which measures the relative strength of the competing interactions. From the CVM in the square approximation we obtain a line of second order transitions between the disordered and nematic phases, while the nematic-stripes phase transitions are found to be of first order. The Monte Carlo results suggest a line of second order nematic-disordered phase transitions in agreement with the CVM results. Regarding the stripes-nematic transitions, the present Monte Carlo results are not precise enough to reach definite conclusions about the nature of the transitions.

[03/11/2015 - 14:50 - Room Tubarão]
Annealed Ising model with site dilution on self similar structures, Vanessa S. T. Silva, Roberto F. S. Andrade, *Instituto de Física, Universidade Federal da Bahia*, Silvio R. Salinas, *Instituto de Física, Universidade de São Paulo* ■We consider an Ising model on the triangular Apollonian network (AN), with a thermalized distribution of vacant sites. The statistical problem is formulated in a grand canonical ensemble, in terms of the temperature T and a chemical potential μ associated with the concentration of active magnetic sites. We also investigate the analogous model on the diamond hierarchical lattice (DHL). We use a well-known transfer matrix method, with a number of adaptations, to derive a set of (non linear, discrete) maps for the free energy and other auxiliary variables along successive generations of the hierarchical structure. The major changes as compared to the quenched or ordered situations amounts to formulating the statistical problem in terms of an effective Hamiltonian in a grand-canonical ensemble, depending on temperature T and a chemical potential μ, which is associated with the concentration of occupied sites. This is justified by the fact that, in a

thermalized system, the orientational variables are treated on the same basis as the positional disorder degrees of freedom. From the numerical iteration of the recursion relations, we obtain various thermodynamic quantities. In the $\mu \to \infty$ limit, we reproduce the results for the uniform models: in the AN, the system is magnetically ordered at all temperatures, while in the DHL there is a ferromagnetic-paramagnetic transition at a finite value of T. Magnetic ordering, however, is shown to disappear for sufficiently large negative values of the chemical potential.

[03/11/2015 - 15:05 - Room Tubarão]
Information entropy of classical versus explosive percolation, Tiago M. Vieira, Gandhi M. Viswanathan, Luciano R. da Silva, *UFRN - RN - Brasil* ■Percolation is used to model diverse phenomena, ranging from porous media to social interactions. There is a well-known phase transition associated with percolation, characterized by the emergence of a giant cluster at the critical point, comparable in size to the entire network. Besides the classical percolation, in which the giant cluster emerges from a completely random process of adding edges to a network, in recent years a novel type of percolation, called explosive, has been studied. In explosive percolation, the addition of edges includes a choice process aimed to retard the emergence of the giant cluster. Looking for a method of studying phase transitions of percolating systems without the explicit use of order parameter (relative size of the network's largest cluster), we analyze the Shannon entropy associated with the cluster size probability distribution. It's known that at the critical point the cluster size distribution is a power-law, i.e. there are clusters of all sizes, so one expects the information entropy to attain a maximum. As expected, our results show that the entropy attains a maximum at this point for classical percolation. Surprisingly, for explosive percolation the maximum entropy does not match the critical point. Moreover, we show that it is possible determine the critical point without using the conventional order parameter, just analysing the entropy's derivatives.

[03/11/2015 - 15:20 - Room Tubarão]
Marginal stability, heterogeneous force distribution and vibrational properties in hard sphere glasses, Carolina Brito, *Universidade Federal do Rio Grande do Sul (UFRGS)*, Eric de Giugli, *University of New York (NYU)*, Edan Lerner, *University of Amsterdam*, Mattieu Wyart, *University of New York (NYU)* ■When the temperature of a liquid is decreased in such a way that crystallization is avoided, the resulting material is a glass or an amorphous solid. There are two sets of open questions concerning this subject. The first is a central problem in soft and condensed matter physics that aims understanding how a liquid becomes rigid at the glass transition. Although there are many scenarios to describe this transition, even in the simplest glasses - hard spheres -, what confers mechanical stability at large density is a matter of debate. The second set of questions is related to the properties of the amorphous material which is generated in this transition: when in the glass phase the material present different properties in respect to its crystal phase, as for example transport and vibrational properties.
In this work these two set of questions will be addressed. First, it will be shown that the glass of hard spheres can be mapped in a network of points connected with nonlinear springs [1]. Using this idea, it is shown that to understand quantitatively stability of a glass at a microscopic level, the presence of weakly interacting pairs of particles must be included. This approach allows us to predict various non-trivial scaling behaviour of the elasticity and vibrational properties of glasses. Some of these exponents are tested numerically and experimentally in colloidal glasses. It also gives a spatial interpretation to recent calculations in high-dimensions [2].
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[03/11/2015 - 15:35 - Room Tubarão]
Short-time Monte Carlo simulation of a frustrated Ising model in two dimensions, Adauto José Ferreira de Souza, *Universidade Federal Rural de Pernambuco* ■The frustrated Ising antiferromagnet with first- and second-nearest-neighbor interactions is studied within the framework of short-time non-equilibrium behavior on square lattices. The Hamiltonian reads

$$\mathcal{H} = -J_1 \sum_{\langle i,j \rangle} s_i s_j - J_2 \sum_{\langle i,k \rangle} s_i s_k, \qquad (1)$$

where $s_i = \pm 1$, $J_1 < 0$, $J_2 < 0$, and the first summation is carried out only over nearest-neighbor pairs of spins whereas the second one is over next-nearest-neighbor pairs of spins. Notice that the Hamiltonian given by Eq. (1) is frustrated on square lattices.
Recently, the phase diagram of this model system was obtained through an effective-field theory with correlations [Phys. Rev. E **91**, 032145 (2015)] and approximations based on different cluster sizes in the $R = J_1/|J_2|$ *versus* temperature plane. It was found that the phase transitions between the antiferromagnetic and paramagnetic phases ($R > -0.5$) close to $R = -0.5$ are of first order and turn into second order for $R > R_{\rm tcp}$, with $(T_{\rm tcp}, R_{\rm tcp})$ the coordinates of the tricritical point. Obviously, the effective-field theory does not give any information on the true critical exponents.
In this work, the critical properties of the frustrated Ising antiferromagnet, Eq. (1), is investigated through short-time Monte Carlo relaxation on square lattices. The main goal is to locate the line separating the paramagnetic phase from the antiferromagnetic phase ($-0.5 \leq R \leq 0$) and obtain estimates to the critical exponents along this line. The values of the critical exponents to R in the range $[-0.4, 0]$ are compatible with the Ising universality class in two dimensions. Therefore, no signal of a tricritical point was found in the range of R investigated.

[03/11/2015 - 15:50 - Room Tubarão]
Discontinuous absorbing phase transitions: Minimal mechanisms and generic finite size scaling, Carlos E. Fiore, Marcelo M. de Oliveira, M. G. E. da Luz, *IFUSP* ■Motivated by recent findings, we first discuss the existence of a direct and robust mechanism providing discontinuous absorbing transitions in short range systems with single species, with no extra symmetries or conservation laws. We consider variants

of the contact process, in which at least two adjacent particles (instead of one, as commonly assumed) are required to create a new species. Many interaction rules are analyzed, including distinct cluster annihilations, particle diffusion, and a modified version of the original pair contact process (PCP). Through detailed time dependent numerical simulations we find that for our modified models, the phase transitions are of first-order, hence contrasting with their corresponding usual formulations in the literature, which are of second-order. By calculating the order-parameter distributions, the obtained bimodal shapes as well as the finite scale analysis reinforce coexisting phases, so a discontinuous transition. These findings strongly suggest that above particle creation requirements constitute a minimum and fundamental mechanism determining the phase coexistence in short-range contact processes. Also, a phenomenological but general finite size scaling theory is proposed for discontinuous nonequilibrium phase transitions into absorbing states. Analogously to the equilibrium case, we show that quantities such as, response functions, cummulants, and equal area probability distributions, all scale with the volume, thus allowing proper estimates for the thermodynamic limit. To illustrate these results, distinct lattice models displaying nonequilibrium transitions – including above examples– are investigated. Our findings (allied to previous numerical studies in the literature) strongly point to an unifying discontinuous phase transition scaling behavior for equilibrium and this important class of nonequilibrium systems.

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POPULATION DYNAMIC

[03/11/2015 - 14:30 - Room Vitória]

Integrating genetics and geography in population dynamics, Marcus Aloizio Martinez de Aguiar, Ayana de Brito Martinas, *UNICAMP - Instituto de Física Gleb Wataghin*, Yaneer Bar-Yam, *New England Complex Systems Institute, Cambridge, MA, USA*, Micael Nagai, *UNICAMP - Instituto de Biologia* ■The evolution of a population depends on the way its individuals interact with one another and with the environment. In spatially distributed populations interactions are local and specific features of the geography can affect its genetic evolution. In this talk I will first discuss an individual based model of speciation that is driven by local mating and does not require the existence of geographic barriers separating the population in isolated groups. Each individual will be characterized by its position in space and by a genome composed of several biallelic genes. In the model mating is possible only if the individuals are sufficiently close to each other in space (local mating) and also similar genetically (assortative mating). Depending on the parameters of the model the population can evolve into separate species even in the absence of natural selection. Using the same theoretical framework I will show simulations for ring species, where an initially localized population expands in two directions around a physical barrier in such a way that the two expanding fronts meet at the other side of the barrier after many generations. Finally I will discuss coevolution in a spatially distributed population of predators and prey that engage into an arms race. In all cases the results of simulations will be compared with empirical data.

[03/11/2015 - 14:50 - Room Vitória]

Metapopulation dynamics in a complex habitat: the role of resource aggregation and dispersal strategy, Eduardo H. Colombo, Celia Anteneodo, *PUC-Rio* ■Habitat heterogeneity exists due to the spatial distribution of resources, water, shelter, etc. This variability fragments the habitat in regions, known as patches, which are favorable or not for population growth. This leads to the emergence of a metapopulation structure made of sub-populations that remain connected due to individuals' movements [1]. We present a general model [2] to study the role of habitat spatial structure and dispersal strategy in metapopulation dynamics. The local dynamics is driven by fundamental mechanisms, consisting of a logistic expression plus multiplicative noises that take into account demographic and environmental fluctuations [3]. Nonlocality is introduced in a general way, considering that individuals dispersal can be diffusive (random) or selective (habitat dependent). Furthermore, the ecological landscape of favorable patches is generated like a *Lévy dust*, which allows to build a range of patterns, from dispersed to clustered ones. As regards the habitat spatial structure, the results show a critical degree of clusterization to preserve the population. The generalization of animal dispersal enables us to show the importance of a mixed strategy, i.e. the combination of random movement and direct routes between favorable regions. In a general way, our results highlight the interplay between noise and spatial coupling schemes in the asymptotic behavior of the total population size.

[1] Hanski I., and Ovaskainen O., *Nature* **404**:755–758 (2000)

[2] Colombo E.H., Anteneodo C., *ArXiv*-1503.08168 (2015)

[3] Ovaskainen O., Meerson B., *Trends in Ecology & Evolution* , **25**(11):643-652 (2010)

[03/11/2015 - 15:05 - Room Vitória]

A non-phenomenological model of competition and cooperation to explain population growth behaviors, Fabiano L. Ribeiro, *UFLA* ■This work proposes a non-phenomenological model of population growth that is based on the interactions among the individuals of a population. When there is competition between the individuals, the model proposed reaches the Malthus, Verhulst, Gompertz, Richards, Bertalanffy and power-law growth models. And when there is cooperation, the model reaches the von Foerster growth model and also presents a regime of divergence of the population at a finite time. This approach explains the Allee effect as an emergent behavior of the cooperative and competitive interactions among the individuals. The Allee effect is the characteristic of some populations of increasing the population growth rate in a small-sized population. Whereas the models presented in the literature explain the Allee effect with phenomenological ideas, the model presented here explains this effect by the interactions between the individuals. The model is tested with empirical data to

justify its formulation. Another interesting macroscopic emergent behavior from the model proposed is the observation of a regime of population divergence at a finite time. It is interesting that this characteristic is observed in humanity's global population growth.
The presentation is based on two recent published papers: 1. RIBEIRO, F. L. ; RIBEIRO, K. N. . A one dimensional model of population growth. Physica. A (Print), v. 434, p. 201-210, 2015. 2. RIBEIRO, F. L. . A Non-phenomenological Model of Competition and Cooperation to Explain Population Growth Behaviors. Bulletin of Mathematical Biology (Print), v. 77, p. 409-433, 2015.
I would like to acknowledge the financial support from FAPEMIG.

[03/11/2015 - 15:20 - Room Vitória]
Evolving cellular automata for diversity generation and pattern recognition: deterministic versus random strategy, Marcio Argollo de Menezes, *UFF - Niteroi - Brazil*, Edgardo Brigatti, *UFRJ - RJ - Brazil*, Veit Schwaemmle, *University of Southern Denmark - Odense - Denmark* ■Microbiological systems evolve to fulfil their tasks with maximal efficiency. Modelling efforts depend crucially on this assumption and adaptation is the key element for evolution to take place. The immune repertoire is a remarkable example of an adaptable, evolving system whose main role is the defense of living organisms against pathogens (antigens), where the distinction between self and non-self is made by means of molecular interactions between proteins and antigens, triggering affinity-dependent systemic actions. Specificity of this binding and the infinitude of potential antigenic patterns call for novel mechanisms to generate antibody diversity. Inspired by this problem, we develop a genetic algorithm where agents with antibody information encoded as bit strings evolve their repertoire in the presence of random antigens (encoded as random strings) and reproduce with affinity-dependent rates. We develop a population dynamics with stationary populations constrained by size-dependent, Verhulst-like death rates. We ask what is the best strategy to generate diversity if agents can rearrange their strings a finite number of times. We find that endowing each agent with an inheritable cellular automaton rule for performing rearrangements makes the system more efficient in pattern-matching than if transformations are totally random. In the former implementation, the population evolves to a stationary state where agents with different automata rules coexist.

[03/11/2015 - 15:35 - Room Vitória]
Interplay between wildfires and forest age structure in steady state., Rebeca Cabral de Novaes, Gustavo Camelo Neto, Sérgio Coutinho, *Universidade Federal de Pernambuco* ■Stationary forests can be characterized by a spatiotemporal distribution of species of trees in respect of its location and age. Several external factors like wildfires, recurrent plagues and forest managements for harvesting of timber, should perturb the dynamics of the evolution of the populations of tree species, superimposed to the inherent topographical and hydrological factors as well as the climate seasonal variations. We investigate the interplay between the distribution of long-term and large-scale forest fires and the forest tree age distribution, using a cellular automata model. For this, we associate the age of a tree with its robustness and hence to its degree of flammability, so that much younger or older trees, shall be more susceptible to burning than those at the ripe age. Particularly, we investigate the effects of wildfires in the most simplest case of single-species forests focusing on the dynamic regime where the probability of interaction between fires is null. In such scenario, the density of trees can evolves in large time scales to one of two possibles steady state attractors, *dense forest* or *savana forest*, regardless of the initial configuration of trees. The time dependent profile of the density of trees and its steady-state age-frequency histograms and fire-size distributions were estimated through various simulations and the records analyzed according to the model parameters.
The *dense forest* state is characterized by a high density of trees with an uniform age histogram for almost all classes, except for the one of the very young trees and those of the senescence period, the later exhibiting an exponential decay. Moreover a typical exponential decay for the fire-size distribution function appears indicating that the presence of a massive number of mature trees prevents the spread of large fires. On the other hand, the *savana forest* state is characterized by a low density of very young trees exhibiting an power-law like behavior for the fire-size distribution function. In short, the inclusion of correlation between the age of trees and its flammability even in a mono-species forest environment, leads to a possible dynamic phase transition between dense forest to a savanna forest state. An outline of the phase diagram according the model parameters is discussed.

[03/11/2015 - 15:50 - Room Vitória]
Percolation and cooperation with mobile agents: Geometric and strategy clusters, Mendeli H. Vainstein, Carolina Brito, Jeferson J. Arenzon, *UFRGS - RS - Brasil* ■We study the conditions for persistent cooperation in an off-lattice model of mobile agents playing the Prisoner's Dilemma (PD) game with pure, unconditional strategies (C: cooperate, D: defect) [1]. Each agent has an exclusion radius r_P that accounts for the population viscosity, and an interaction radius r_{int} that defines the instantaneous contact network for the game dynamics. The agents undergo random diffusion and the strategy evolution follows the finite-population analog of the replicator dynamics. We show that, differently from the $r_P = 0$ case (pointlike agents), the model with finite sized agents presents a coexistence phase with both cooperators and defectors. Moreover, there are also two absorbing phases in which either cooperators or defectors dominate. We provide, in addition, a geometric interpretation of the transitions between phases and present a phase diagram of the PD dynamics as a function of both parameters, r_P and r_{int}. To determine the phases, we performed a finite-size analysis and studied the probability of percolation of D clusters as a function of time. In analogy with lattice models, the geometric percolation of the contact network (i.e., irrespective of the strategy) enhances cooperation. More importantly, we show that the percolation of defectors is an essential condition for their survival. Differently from compact clusters of cooperators, isolated groups of defectors will eventually become extinct if not percolating, independently of their

size. Our results are robust for a great range of mobilities and of the temptation parameter in the PD game.

[1] M. H. Vainstein, C. Brito and J. J. Arenzon, *Phys. Rev. E.*, **9**0, 022132 (2014).

Oral sessions (17:05-18:15)

BRAINS AND NEURONS

[03/11/2015 - 17:05 - Room Vitória]
If the brain is critical, what is the phase transition?, Mauro Copelli, *UFPE - PE - Brazil* ■Neuronal avalanches were experimentally observed in vitro a decade ago, lending support to a long-held conjecture that the brain as a dynamical system might be operating near a second-order phase transition. Nontrivial statistics, such as power law distributions and other scale-invariant properties, have been the essential connection between the theory of critical phenomena and neurophysiological data. Many models which have been used to simulate neuronal collective behavior share common features, displaying a phase transition from an absorbing (quiescent) to an active (but otherwise unstructured) phase. Most of these belong to the directed percolation universality class, which has served as a theoretical workhorse in the field.
I will discuss the strength and limitations of this theoretical framework in light of experimental results, which have since been extended to in vivo experimental setups, including both anesthetized and non-anesthetized animals. More generally, I will highlight the need of theoretical developments in Neuroscience, which offers theoretical physicists a fertile ground for interdisciplinary research. For instance, how can we model the long-range time correlations and universal scaling functions observed in the brain activity of freely-behaving animals? Or, given that current recording techniques severely undersample neuronal activity, is it possible to come up with a model that yields scale-invariant statistics even under similar sampling conditions? Can we reconcile these ideas with the plethora of oscillatory activity which is observed in the brain?

[03/11/2015 - 17:25 - Room Vitória]
Resilience and Synchronization of Brain Networks, Mauro Copelli, *UFPE - PE - Brazil* ■

[03/11/2015 - 17:45 - Room Vitória]
Thermo-Comparative Analysis of Texts: Translations and Target Readerships, Hênio Henrique Aragão Rêgo, *Departamento de Física/Instituto Federal de Educação, Ciência e Tecnologia do Maranhão - IFMA, São Luís/MA/Brazil*, Lidia A. Braunstein, *Departamento de Física, Facultad de Ciencias Exactas y Naturales, Instituto de Investigaciones Físicas de Mar del Plata (IFIMAR), Universidad Nacional de Mar del Plata-CONICET, Mar del Pla*, H. Eugene Stanley, *Center for Polymer Studies/Boston University/Boston/MA/USA*, Sasuke Miyazima, *Department of Natural Sciences/Chubu University/Kasugai/Aichi/Japan* ■Scaling laws have been an important topic in the physics community across a wide range of Fields. The dynamics of several complex systems in biology, economics, and natural phenomena, have been described with relative success using scaling laws. Scaling phenomena also emerge in the analysis of data associated with human behavior, especially those containing a statistically distributed component, such as the number of links in the World Wide Web or the size of

cities. In current research, the analysis of scaling in data continues to produce new and interesting Findings in a variety of scientific fields. In another multidisciplinary approach, the usual concept of energy can be related to the frequency of word occurrence in a text, therefore, its probability distribution can also be related with the temperature concept. We propose a comparative ẗhermo-analysisẗechnique that allow us to determine the academic level of a text and its corresponding target readership in any given language. We apply this technique to a large number of books by several authors and examine how the vocabulary of a text changes when it is translated from one language to another. Unlike the uniform results produced using the Zipf law, using our ẅord energyd̈istribution technique we find variations in the power-law behavior. We also examine some common features that span across languages and identify some intriguing questions concerning how to determine when a text is suitable for its intended readership.

[03/11/2015 - 18:00 - Room Vitória]
Properties of semantic networks derived from automatic generated word embeddings, Marco Idiart, *Instituto de Física, UFRGS*, Aline Villavicencio, Rodrigo Wilkens, *Instituto de Informática, UFRGS* ■Recently Mikolov et al.[1] proposed a very successful neural network algorithm to automatically extract a vector representation of the words of a language (word embeddings) from a training set composed of large collections of representative texts. From the word embeddings with simple vector algebra it is possible to derive a series of language properties such as word similarity, plural and gender operations, compositionality of multiword expressions, etc. For instance, the similarity of two words in the schema is simply the cosine between their vector representations. Therefore the similarity matrix of the whole lexicon can be viewed as a semantic network, where words correspond to nodes and the distances between them are the weighted edges. In this work we characterized statistically the semantic network derived from Mikolov's vector embeddings for different spatial dimensions and compare it with studies performed in semantic networks from manually constructed thesaurus. In addition we show that the eigenvalues distribution of the word embeddings covariance matrix follows a power law. This indicates that the dimension of the word embeddings space cannot be well defined via representation reduction methods such as principal component analysis. We examine separately the networks of nouns and verbs, given their different characteristics, and to what extent these are reflected in the resulting network properties.
[1] Tomas Mikolov, Kai Chen, Greg Corrado, and Jeffrey Dean. Efficient Estimation of Word Representations in Vector Space. In Proceedings of Workshop at ICLR, 2013.

FUNDAMENTAL ASPECTS

[03/11/2015 - 17:05 - Room Tubarão]
Universal behavior of Shannon and Rényi mutual information of 1d system and some special 2d quantum eigenfunctions., Francisco C. Alcaraz, *Instituto de Física de São Carlos, Universidade de São Paulo, Caixa Postal 369, 13560-970, São Carlos, SP, Brazil* ■Associated to the equilibrium Gibbs state of a given critical classical system in d dimensions we can associate a special quantum mechanical eigenfunction defined in a Hilbert space with the dimension given by the number of configurations of the classical system and components given by the Boltzmann weights of the equilibrium probabilities of the critical system. This class of eigenfunctions are generalizations of the Rokhsar-Kivelson wavefunctions, initially proposed for the dimer problem in 2 dimensions. In particular in two dimensions, where most of the critical systems are also conformal invariant, such functions exhibit quite interesting universal features. The entanglement entropy of a line of contiguous variables (classical spins), is given by the classical mutual information of $d = 1$ quantum chains, and the entanglement spectrum of the two dimensional system are given by the amplitudes of the ground-state eigenfunction of the quantum chain. We present a conjecture showing that the mutual information of the quantum chains in some appropriate basis (we called conformal basis) show a universal behavior with the size of the line of the entangled spins (subsystem size). This dependence allow us to identify the conformal charge of the associated classical critical system (used to define the $d = 2$ quantum eigenfunction) or the quantum critical chain. We will also make a connection with a possible classification of the 2d Rokhsar-Kivelson wavefunctions following the Renormalization-Group ideas of scaling invariant systems.

[03/11/2015 - 17:25 - Room Tubarão]
Temperature and entropy oscillations of a gas in circular geodesic motion in the Schwarzschild field, Gilberto M. Kremer, Winfried Zimdahl, *Universidade Federal do Paraná, Universidade Federal do Espírito Santo* ■The present work is devoted to a global equilibrium configuration on the background of the static Schwarzschild metric. We consider a Boltzmann gas with its center of mass moving on a circular geodesic of this metric, and we study the equilibrium thermodynamics of this system as seen by a comoving observer on the geodesic. The lowest-order gravitational effects that a freely falling observer can detect locally are conveniently described with the help of Fermi normal coordinates. These coordinates are Minkowskian on the geodesic, while gravitation at lowest order manifests itself in quadratic corrections in the space-like geodesic distance, orthogonal to the observers time-like trajectory. We apply a description of this type to the gas motion, admitting additionally a pure spatial rotation. This corresponds to using a "proper reference"frame up to second order. Fixing this frame determines, via Tolmans law, the temperature profile of the gas as measured by a central, geodesic observer. It turns out that the comoving observer measures oscillations of the temperature and other thermodynamic quantities, like entropy, with frequencies that are double the frequencies known from test-particle motion in the Schwarzschild field. We apply this scheme to the gas dynamics in the gravitational fields of the planets of the Solar System as well as to strong-field configurations of neutron stars and black holes.

[03/11/2015 - 17:40 - Room Tubarão]

Landau theory for uniaxial nematic, biaxial nematic, uniaxial smectic-A, and biaxial smectic-A phases, Dora Izzo, Mário José de Oliveira, *Instituto de Física da UFRJ, Instituto de Física da USP* ■We consider a lyotropic liquid crystal and search for a model able to predict smectic, nematic and isotropic phases: an extension of the model proposed by de Gennes and Prost (1), where no smectic phases are found. In that order, we use a Ginzburg Landau mean field approach to obtain these phases. This method also takes into account optical anisotropy for it predicts the existence of uniaxial and biaxial domains that have been observed experimentally (2), (3). Solutions of the mean field equations rely on analytical and numerical calculations. We choose a particular set of parameters of the free energy and obtain a sequence of two-dimensional phase diagrams, which show the appearence of the different domains. The transition between the biaxial nematic and biaxial smectic is continuous as well as the transition between the nematic phases and the transition between the smectic phases. The transition from uniaxial nematic and uniaxial smectic is continuous with a tricritical point. The tricritical point may be absent and the entire transition becomes continuous. The four phases meet at a tetracritical point. Although, the Landau free energy was set up to describe the smectic-A phase, it can also be applied to the lamellar phase due to the correspondence concerning symmetry between lamellar and smectic phases.

(1) de Gennes,P. G., Prost, J., The Physics of Liquid Crystals (Clarendon Press, Oxford), 1974.
(2) Boden,N. and Holmes, M.C. ,*Chem.Phys.Lett* **109**,76 (1984).
(3) Oliveira,E.A., Liébert,L and Figueiredo Neto, A.M. ,*Liq.Crys.***5**,1669 (1989).

Plenary talks (8:30 - 10:00)

PLENARY SESSION

[04/11/2015 - 08:30 - Room Vitória]
Active matter: An introduction and some recent advances, Hugues Chaté, *CEA - Saclay, France,& Beijing Computational Science Research Center, China* ■In this talk, I will introduce the new, fast-growing, interdisciplinary field of active matter and present some recent important advances.
Active matter is the term now used by physicists to designate out-of-equilibrium systems in which energy is spent in the bulk, locally, to produce persistent motion/displacement. Examples abound, not just within living systems (bird flocks, fish schools, collective motion of cells, etc.) but also, increasingly, in man-made, well-controlled, non-living systems such as micro- and nano-swimmers, active colloids, in vitro mixtures of biofilaments and motor proteins, etc.
I will show some striking experimental/observational examples and then proceed to give an account of our current understanding of some of the simplest active matter models, which consist of self-propelled particles locally aligning their velocities. In this context, the fluid in which the particles move is neglected, and one speaks of "dry ctive matter". I will argue that these models do have experimental relevance, in addition to being important per se, much as the Ising model is important in statistical mechanics. I will show that a wealth of new physics arises, which calls for further theoretical studies.

[04/11/2015 - 09:00 - Room Vitória]
Complex human contact networks: Empirical data, modeling and dynamics, Romualdo Pastor-Satorras, *Universitat Politecnica de Catalunya* ■In recent years, the possibility to access large digital databases, as well as the development and deployment of large scale monitoring frameworks, has allowed to peer for the first time into the statistical properties of human behavior. Surprisingly, the patterns of human activity have been shown to be extremely *bursty*, characterized by long tailed distributions, in opposition to the Poissonian behavior expected from traditional mathematical approaches. Apart from the insights that these discoveries have in the description and hypothetical predictability of human behavior, they are most relevant due to the direct connection between the patterns of human activity and the topological description of the representative social networks. Here we will discuss recent modeling efforts designed to understand and reproduce the empirical properties of social networks, as well as their effects on simple dynamical processes.

[04/11/2015 - 09:30 - Room Vitória]
Recovering the equivalence of statistical ensembles, Vera B. Henriques, Silvio Salinas, *Instituto de Física, Universidade de São Paulo* ■The equivalence of thermodynamic results in the canonical and the microcanonical ensembles has been questioned in a number of calculations for lattice spin models with equivalent-neighbor (mean-field) interactions. We show that these claims of inequivalence are related to an inadequate definition of the independent (density) variables in the microcanonical ensemble. We illustrate this point by revisiting the paradigmatic examples given by Ruffo, Mukamel, and coworkers: (i) A fully-connected spin-1 Blume-Capel model, which is known to display a phase diagram with a tricritical point; (ii) An Ising chain with competing short and long-range interactions, which displays second and first-order phase transitions for suitable choices of parameters (see A. Campa, T. Dauxois, and S. Ruffo, Phys. Repts. 480, 57-159, 2009). Although long-range interactions pose notoriously difficult problems, we show that in these elegant and paradigmatic cases there is no disagreement between calculations in the usual canonical and microcanonical ensembles. The crucial point is the recognition that the microcanonical ensemble describes an isolated system, in terms of suitable thermodynamic density variables, while the usual canonical ensemble is characterized by the thermodynamically conjugate field variables. Details of our arguments are described in V. B. Henriques and S. R. Salinas, Recovering the equivalence of ensembles, arxiv: 1501.04029v1 (and in part II, to be posted soon).

Posters (10:00-11:00 / 16:05-17:05)

BIOLOGICAL PHYSICS

[04/11/2015 - P001]
Effects of habitat fragmentation on biodiversity patterns, José Alvino de Lima Filho, Viviane Moraes de Oliveira, *Universidade Federal Rural de Pernambuco*, Fernando Fagundes Ferreira, *Universidade de São Paulo* ■The understanding of how species diversity is related to habitat conditions is a major issue in ecology. In this sense, spatial heterogeneity can have great influence on the number of species. The diversity of species in natural communities is also related to the rate at which energy flows through the ecosystem. There is an increasing interest in understanding the effects of habitat fragmentation on biodiversity patterns. In this work we investigate the effects of habitat destruction on species diversity patterns by using a spatial computer simulation model in which species compete for limiting resources on habitats with spatial heterogeneity. In our model each site of the lattice holds n resources and the amount of each available resource is obtained from a uniform distribution. Each species k is characterized by a set of n half-saturation constants K_{kj}, where j denotes the resource label. The efficiencies of each species in the management of resources are taken into account by using the fitness function of species k on site i, which is given by $f_{ki} = \min(R_{i1}/(K_{k1} + R_{i1}), R_{i2}/(K_{k2} + R_{i2}), \ldots, R_{in}/(K_{kn} + R_{in}))$. In order to study the effects of habitat fragmentation on biodiversity patterns we assume that a proportion p of the sites can not be colonized. The distribution of unsuitable sites is controlled by a fractional Brownian motion, which produces spatially correlated landscapes. We investigate the behavior of the species-area relationship and the distribution of species abundance for some values of p and also by varying the degree of spatial autocorrelation of the landscape. Our results indicate that both the level of spatial correlation and the degree of fragmentation have a strong influence on the shape of the species-area relationship and also on the distribution of species abundance.

[04/11/2015 - P002]
Temporal Correlation Between Stimulus And Response In Spiking Neural Networks, Eduarda Demori Susin, Beatriz Eymi Pimentel Mizusaki, Rubem Erichsen Júnior, Leonardo Gregory Brunnet, *UFRGS* ■ It is well known that temporal processing on time scales of tens and hundreds of milliseconds plays an important role in simple and complex sensory problems in the brain, such as, motion discrimination, and speech recognition. Recent studies showed that cultured cortical networks can be shaped by the history of an external stimulus by reflecting the temporal patterns of these stimuli in the network dynamics, suggesting that cortical networks are capable of learning the stimulus time scales. Although one might know that synaptic plasticity may be a key process in this phenomenon, the detailed process underlying it still demands for an explanation.

In this work we are concerned in exploring, mathematically and computationally, by means of a bottow-up model , the possible mechanisms that take place in these time events. For that we make use of a conductance-based integrate-and-fire model with a spike-timing-dependent-plasticity (STDP) rule. We train the network with a special-temporal pattern, similar to previous experimental works, and search for the network topology and plasticity effects. We use networks with three different topological connections: random, regular square lattices and small world, with different connectivity and connection probabilities, and change gradually the parameters of the STDP model in order to control the plasticity action.

We have verified that the minimum frequencies that allow a self-sustained activity is closely dependent of network size. Namely small networks demand higher frequencies than bigger ones, and usually asynchronous irregular (AI) states are only found in large networks. Assuming that this kind of state is important for modeling, since it is observed in an awake cortex, we also added poissonian processes in a fraction of neurons randomly chosen, mimicking a network of bigger size. This produced the expected AI behavior and turned possible the use of realistic synaptic weights and the acquisition of firing rates of $\sim$ 10 Hz. This work is still in progress, and the step we are implementing now is the fine tuning of the stimulus-response system. This will allow us to evaluate the time scales for which the network is able to respond to the stimulus.

[04/11/2015 - P003]
How to perform Monte Carlo simulations for protein chains far from equilibrium concerning to the solvent, João Paulo Dal Molin, Antonio Caliri, *DFQ - FCFRP - USP* ■When we perform Monte Carlo (MC) simulations in order to emulate the protein folding process we handle with a chain-solvent system. The first component is a finite (nanometric) sub-system, while the second one, the solvent (the thermal reservoir), is a large and homogeneous system well characterized by the thermodynamic equilibrium. However, at nanoscale domain, thermal fluctuations emerge as a fundamental feature, because thermal noise plays an important role over chain' configurations. In order to incorporate this aspect in our MC sampling we adopt the Tsallis weight instead of the usual Boltzmann factor [1]. Once we choose the Tsallis' weight, the entropic index q is regarded as a dynamical variable; q values are associated with instantaneous degrees of freedom n of an evolving chain. As the chain packing goes on, the number of inter-residue contacts changes, so n becomes a function of the globule surface, which is roughly estimated by the square of the gyration radius RG. In our point of view, q reflects the effect of local thermal fluctuations on the chain, which are more critical over compact configurations ($q>1$) than over those extended ones ($q\to1$). The effect of $q>1$ on the transition probability, faced to the standard Boltzmann factor, is quite equivalent to the conventional exponential factor in which its argument has been effectively decreased (increased temperature of the thermal reservoir). Therefore, for more compact configurations, larger q values are needed. Which is equivalent to the situation in which the chain is submitted to a little higher temperature than the pre-established thermal reservoir temperature [1]. The net effect on the chain evolution is that wrongly com-

pacted configurations can escape more easily from energetic/steric traps. In order to stress our point of view we will show an extended set of MC simulations for the folding process performed with both statistical weights.
[1] Dal Molin JP, da Silva MAA, Caliri A, Effect of local thermal fluctuations on folding kinetics: A study from the perspective of nonextensive statistical mechanics, Phys. Rev. E 2011,84:041903.

[04/11/2015 - P004]
Convergence of the transfer-integral technique in the framework of Peyrard-Bishop model, Mateus Rodrigues Leal, Gerald Weber, *Departamento de Física, UFMG* ■The Peyrard-Bishop model is a simplified physical statistics method proposed in 1989 for calculating key properties of DNA and RNA molecules. Currently, it is widely used with several theoretical techniques such as molecular dynamics and path integrals, but its main application still lies with its original method the transfer-integral technique. It also used to predict hydrogen bonds and stacking interaction in oligonucleotides from melting temperature experiments, complementing experimental techniques such as NRM and X-ray diffraction. In 1997 Zhang et al [Phys. Rev. E 56, 7100] showed that due to the form of the DNA stacking interaction potential the integral equation, which is central to the method, suffers from a numerical convergence problem which leads to a divergence in the partition function. The workaround to this divergence problem is either to add a fixed upper limit to the integral equation or to add specific terms to the model Hamiltonian. These additional terms could be an angle dependence or a stress term as suggested by some authors. These workarounds have allowed the development of the Peyrard-Bishop model into a highly successful method, still a clean solution to the divergence problem would be highly desirable. Recently Estrada et al [J. Comp. Appl. Math. 236, 3561, 2012] developed an analytical technique where the 1D Hamiltonian is mapped into 3D which they claim would be able to resolve the divergence problem. But a numerical implementation of this technique was not attempted and it is still unclear if the problem has really been solved. Here we analyse in detail the influence of the various approaches to the divergence problem on the eigenvalue spectrum. We implement a numerical algorithm for the method proposed by Estrada et al and compare them with the proposed workarounds to evaluate the effects on the eigenvalue spectrum.
Funding: CPNq, Capes and Fapemig

[04/11/2015 - P005]
How can macromolecular crowding affect protein stability ?, Rafael B Frigori, *Universidade Tecnológica Federal do Paraná* ■The interior of cells is a crowded environment, this can make molecules in cells behave in radically different ways than in test-tube assays. Therefore, the study of biochemical processes under realistically crowded conditions is very important, since these conditions are a ubiquitous property of all cells and crowding may be essential for the efficient operation of metabolism. Notably, the size of such effect is non-linear, so macromolecules are much more strongly affected than are small molecules as amino acids. Most likely, it is due to the fact that high concentrations of macromolecules reduce the volume of solvent available for other molecules in the solution, which has the result of increasing their effective concentrations. In particular, the importance of crowding in protein folding is of great interest in biophysics, once the crowding effect can accelerate the folding process, given that a compact folded protein will occupy less volume than an unfolded protein chain. However, crowding can reduce the yield of correctly folded protein by increasing protein aggregation.
Then, we try to answer the question above by showing that all those aforementioned complex interactions can be well-described by a straightforward generalization of a simple Ising-like model, previously proposed by Bakk and Høye to account for protein folding under the influence of a polar solvent. There proteins are described in a close analogy with a one-dimensional homopolymer, where relevant degrees of freedom are ascribed by contact maps built from protein residues. Thus, closed contacts are assigned a binding energy while open contacts present several configurations of equal (zero) energy. Additionally, we have introduced a new long-range cooperative/competitive interaction term that properly models inter-protein interactions (crowding). As an outcome the model exhibits both cold and warm unfolding, which are properly affected by the crowded environment as already verified experimentally for several small globular proteins.

[04/11/2015 - P006]
Stability of neural network activity regimes achieved by the balance between excitatory and inhibitory synaptic scaling, Beatriz Eymi Pimentel Mizusaki, Eduarda Demori Susin, Rubem Erichsen Jr., Leonardo Gregory Brunnet, *UFRGS* ■Neural circuits, such as the cerebral cortex, display a resting basal activity that never ceases. In order to better understand the functioning of these systems, and how they may process information, it takes to understand what is needed for the maintenance of an uncorrelated basal activity. This is the so-called background state, in which an input representation may be embedded while avoiding pathological regimes such as network-wide synchronization. One of the processes that is considered to be critical for this is the experimentally observed plasticity mechanism of homeostatic synaptic scaling. This phenomenon consists on the reaction by the network upon a sudden activity disturbance, in which its synaptic weights are adjusted so that a set spiking frequency can be regained. In neurons of the visual cortex, it is seen that the amplitude of excitatory signals is enhanced if the activity is damped, and decreased if the activity is augmented. The inhibitory connections follow the opposite direction of change. While the effects of the plasticity on excitatory connections have been recently studied, the concurrent inhibitory plasticity and their results over the network balance, as well as the following interferences with other long-term plasticity mechanisms, are not clear. Our work is based on the analysis of a mean-field model adapted to account for the synaptic scaling and the comparison of its results with those of detailed numerical simulations of integrate-and-fire neural networks to assert the stability of the basal activity state. We find necessary relationships between macroscopic parameters, such as the ratio between the recurrent and feedforward

connections according to the frequency to which the network is expected to converge in order to keep the activity from diverging.

[04/11/2015 - P007]
GU mismatch stability investigation by a mesoscopic model, Tauanne D. Amarante, Gerald Weber, *Departamento de Física, Universidade Federal de Minas Gerais, Belo Horizonte-MG- Brazil* ■The guanine-uracil (GU) mismatch, as well as being the most common base pair after the canonical base pairs CG and AU, plays an important role in RNA by acting as a recognition site for biomolecules. According to Crick, a GU mismatch would be formed by two hydrogen bonds. However, later experimental measurements showed that the stability of this base pair depends on its sequence context. For instance, NMR data indicates that the number of hydrogen bonds varies depending on the GU mismatch flanking base pairs, and when arranged in tandem with another GU also exhibits a dependence on the strand direction. The mesoscopic model proposed by Peyrard and Bishop [1] seems ideal to investigate the stability of GU mismatch due to its ability to distinguish the contribution of stacking interaction and hydrogen bonds. We adapted this model to deal with context-dependent hydrogen bonds of GU mismatches by allowing the parameters to take into account the dependence on the neighbours pairs and strand direction. The optimization of the model parameters was obtained through a set of experimental melting temperatures data [2] by using the technique developed by our group [3,4]. As expected, in most contexts the Morse potential obtained for GU mismatches indicate hydrogen bond strengths comparable to AU base pairs. While, in particular, our prediction of a single hydrogen bond for GUpUG tandem configurations agrees with NMR measurements. Our results also suggest that the stability of GU terminal pairs could be attributed to hydrogen bonds as we found that Morse potentials were generally larger than for AU base pairs.
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[04/11/2015 - P008]
Fractal analisys of tandem repeats protein, Fernando S. Silva, Marcelo A. Moret, Marcelo C. Santana, *Universidade Estadual do Sudoeste da Bahia UESB - Brasil; Programa de Modelagem Computacional, SENAI Cimatec Salvador -Brasil; Universidade Salvador, UNIFACS Salvador - Brasil* ■Proteins are biopolymers essential to life, constituted by a long amino acid sequence. They may be formed from up to 20 different kinds of amino acids. A significant portion of these proteins, about 14% *et all* [1,2], they have repeated segments of amino acids. These repetitions occur when in tandem trigger regular tertiary structures, exactly by a plurality of different sizes and functions resulting in different classifications repeat protein family. Repeat proteins have the advantage of the folding pathways that are likely to be schematized. In this article were selected in 1213 proteins deposited in the Brookhaven Protein Data Bank suggested by Andrade and collaborators [3], divided into six tandem repeat class with different lengths from 20 to 50 residues, wherein we investigate characteristics of fractal geometry. Using the Mean Field Theory of Flory, the mass-size scale exponent analysis shows that the exponent is $\delta = 2.15$. The average packing density tends to $\rho = 0.86 a.u./A^3$ with q-Gaussian distribution to the masses of proteins with entropic index $q = 1.90$. The findings indicate self-organized criticality as to the explanation protein folding and no hydrophobicity scale can be relevant to these proteins. Therefore, the fractal geometry behaves between a two-dimensional wire crumpled and packed spheres randomly in the percolation threshold.
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[04/11/2015 - P009]
Integration properties of the Burak & Fiete continuous attractor network model, Samoel Renan Mello da Silva, Roger P. M. da Silva, Marco Aurelio Pires Idiart, *Instituto de Física, Universidade Federal do Rio Grande do Sul* ■Observed in 2005 by Hafting et al, grid cells are neurons in the medial entorhinal cortex of rats that have the property of firing when the animal is at specific periodic positions in a 2D space such that the map of their activity forms a hexagonal grid pattern. In one of the classes of models that are used to theoretically describe this observation, called continuous attractor networks, a hexagonal pattern present in a neural network is moved accordingly in response to the animal displacement. One of this models, proposed by Burak & Fiete (2009), uses neurons sensitive to the animal velocity and direction to move this pattern. The network proposed, however, is very well structured in the sense that only four angles (north, south, west and east) are present and that their locations in the network are very specific. In the present study, we compare the model performance when this preferred directions are located at not so organized positions and also when their preferred angle are subjected to noise. Moreover, we also analyze the hexagonal pattern against defective and single bump patterns aiming to show that the first one is less suitable to integrate space displacement in the presence of noise. The hexagonal pattern is the one that maximizes activity in the network and can therefore be more robust to local perturbations.

[04/11/2015 - P010]
Boundary effects in the Burak & Fiete continuous attractor network model, Roger Prochnow Moreira da Silva, Samoel Renan Mello da Silva, Marco Aurélio Pires Idiart, *Instituto de Física*
Universidade Federal do Rio Grande do Sul ■In the

search of understanding how the brain processes the position and navigation of an animal, researchers found cells in the hippocampal region that were tuned to positions in space. The first type of cell to be characterized in the 70s were the place cells, pyramidal cells that are active when the animal is in a particular position in the environment. In 2005 researchers found a yet more intriguing type of cells in an adjacent area called entorhinal cortex, the grid cells. When a rat moves in 2D space, the grid cells fire action potentials according to a hexagonal pattern, covering the environment with a grid of activity. Our study focus on the understanding of a continuous attractor model of grid cells proposed by Burak & Fiete (2009). In the model the activity in the network is linked to the rat's translation, so that change of position of the rat creates a corresponding displacement of a group of centers of activity in the network. In our study we focus on the boundary properties of the network. Periodic networks integrate better the position compared to aperiodic networks. However periodic networks may present stable pattern of activities with grid defects and in discrete orientations, while aperiodic networks are more flexible in orientation and do not present defects. We also study how the propensity for grid defects of periodic networks depends on the model parameters.

COMPLEXITY & INTERDISCIPLINARY TOPICS

[04/11/2015 - P011]
Diffusion, correlations and mobility in a two-dimensional conserved stochastic sandpile, Sharon Dantas da Cunha, *UFRN/UFMG*, Ronald Dickman, *UFMG* ■The conserved stochastic sandpile (CSS) belong to a universality class called *conserved directed percolation* (CDP) [1,2,3,4], distinct from directed percolation (DP). The existence of the CDP class was nevertheless questioned by Basu *et al.* [5], who claim that the one-dimensional CSS belongs to the DP class, but these results were reexamined in one and two dimensions by Lee [6,7], who presented numerical evidence to prove the existence of CDP. In this work we perform large-scale simulations of a two-dimensional restricted-height conserved stochastic sandpile, focusing on particle diffusion, spatial correlations and mobility. Initially we use Quasistationary simulations (QS) to determine the critical particle density [$p_c = 0.7112687(2)$], and show that the diffusion constant scales in the same manner as the activity density, as found previously in the one-dimensional case [3]. We analyze the particles mean-square displacement (msd) and verify the subdiffusive behavior in the initial ("short-time") scaling regime, and linear, in the stationary regime. At criticality, the activity correlation function behaves as $C(r) \sim r^{-\beta/\nu_\perp}$. Our results for critical exponents are consistent with predictions derived from the Langevin equation for stochastic sandpile in two dimensions [8]. The effect of weak force or bias f were studied in CSS, where we implement the bias by altering the transition probabilities and the results were consistent with theoretical relationships.
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[04/11/2015 - P012]
Vorticity Curvature Criterion for Two-Dimensional Vortex Identification, José Hugo Capella Gaspar Elsas, Luca Roberto Augusto Moriconi, *Insituto de Física - Universidade Federal do Rio de Janeiro* ■Vortical structures are an emblematic feature of turbulent flow, and, recently, due to better experimental techniques and computer simulations there is a growing interest in vortical, and, more generally, coherent structures in turblent fluid flow[1]. Systematic procedures for the identification of vortices/coherent structures have been proposed as a way to address their kinematical and dynamical roles in structural formulations of turbulence[2]. As a general rule, all of the known vortex detection algorithms are plagued with shortcomings[3]. In this work, we focus on one of the most popular methods - the swirling strength criterion - and investigate how it performs in controled Monte-Carlo tests. We, then, emphasize its main problematic issues: (i) vortex deformation and suppression due to the near presence of intense vortical structures; (ii) vortex merging; (iii) spuriuos vortices created in many-vortex configurations and (iv) in the presence of background shear. The inner layer of turbulent boundary layer flows is, in particular, the region where the swirling strength criterion looses accuracy in a dramatic way. We propose an alternative vortex detection criterion, based on the curvature properties of the vorticity profile, which clearly improves over the results obtained with the swirling strength criterion in a number of relevant case studies.
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[04/11/2015 - P013]
Degree distribution orients the flux of information in network of networks, Mariana Sacrini Ayres Ferraz, Alexandre Hiroaki Kihara, *Laboratório de Neurogenética, UFABC* ■Neuronal networks oscillate across a broad range of frequencies, leading to synchronization to be a very intriguing subject in both neuroscience and dynamical systems. A large number of physiological functions depend on the coordination of neurons, which act in concert, generating specific rhythm in certain regions of the brain. These several synchronous rhythms are resulted from properties of individual neurons, plasticity of synaptic coupling, as well as the network topology. It is expected that neuronal networks on the brain operate on criticality, showing advantages in information processing and pattern formation, which maximize the

numbers of metastable states. Also, the topology is said to be like scale-free, predicting the existence of hubs that correspond to highly connected neurons. Circuitries from different regions are interconnected, thus the brain can be considered as a network of networks. In this context, very little is known about how different networks synchronize themselves. In this work, we used random and scale-free networks, according to Watts-Strogatz and Barabási-Albert models. Both networks were connected by highly connected nodes and hubs, respectively. We used leaky integrated-and-fire (IF) neuron model to simulate plausible neuronal network activity. Surprisingly, our results indicated that random networks have more influence in the synchronization of scale-free networks than the other way around. However, this tendency can be neutralized and even reverted with the monotonic increase of the networks oscillatory frequency. Therefore, we were able to provide formal demonstration that a system of networks can self-govern the flux of information over its parts. In summary, we demonstrated for the first time that information directionality can be "embedded"into the networks, providing new possibilities for system designing, as possibly observed in interconnected cerebral areas with distinct degree distribution.

[04/11/2015 - P014]
Fractal aspects in O2 enriched combustion, Jefferson W. G. de Souza, Alex Alisson B. Santos, Lilian Lefol N. Guarieiro, Marcelo A. Moret, *SENAI - Cimatec* ■The study of the technology of flame enrichment with oxygen, together with the study of soot formation coupled with thermal radiation, has attracted interest in industries that involve combustion processes where a large amount of energy is released as heat and, consequently, light. The main objective of combustion is maximize the heat while minimizing the production of polluting gases. The more harmonic the union of these elements, the more efficient the combustion will be. The stoichiometry of the fuel composition provides a basis to calculate the required amount to be burnt in the reaction. Although there are existing studies on the mechanisms of soot formation and control, a more detailed understanding of these processes is important for technological advances in environmental impact (emission of polluting gases). In this study, we investigate the self-affinity of time series of thermal radiation from two fuels, natural gas (NG) and acetylene (AC), enriched with oxygen at 21%, 23% and 25% concentrations during the combustion process. We used the detrended fluctuation analysis method to evaluate the burning process of these fuels. We found a well-defined self-affine aspect for these gases in this dynamic process. Using the proposed method, we were able to characterize the time series of NG as a sub-diffusive process and the time series of AC as a process with persistent self-affinity.

[04/11/2015 - P015]
Oil Companies Share Prices Self-Affinity, Jefferson Willes G. de Souza, Aloísio S. Nascimento Filho, Marcelo A. Moret, *SENAI - Cimatec* ■The study of the variation of share prices on the stock market, as well as their behavior in the long range are not an easy task. Indeed the attempt to understand the underlying behavior on financial normally it requires a great effort because we are facing a complex system. In this work, we assess the scale properties of changes in share prices of seven oil companies listed in the NYSE stock market between the years 2008-2015 by using fractals properties. In order to do that we use the method Detrended Fluctuation Analysis (DFA), that through a power-law relation between its detrended function and α coefficient of correlation shows self-affinity properties in non-stationary time series. In additional we quantify the cross correlation among all seven companies by using the Detrended Cross correlation Analysis (DCCA) method, that is based on DFA. The results showed anti-persistent DFA α coefficient for all seven companies and the DCCA λ coefficients were correlated among all time series. Furthermore, we use these two methods combined in order to present statistical evidence that prices oil companies variation are consistent with the Efficient Market Hypothesis (EMH). Supplementary, the α coefficient and λ coefficient show that individual oil company motion cannot be predicted on long range, unless that a trader analyze the behavior motion of all companies, that avoid that individual disturb or some speculation action affect the its scale properties. The main contribution of this paper is present these scale methods (DFA and DCCA) working together in favor to help purchases and sales assets.

[04/11/2015 - P016]
Impact of the network structure on plurality rule opinion dynamics, Vivian Dornelas, Celia Anteneodo, *Depto. de Fisica, PUC-Rio* ■People often face the challenge of choosing amongst different options with similar attractiveness, such as when choosing a parlamentary candidate, a movie or buying a product in the supermarket. In order to study the distribution of preferences in such situations, it is adequate to consider a plurality rule opinion dynamics on small-world networks, where different options are available as well as the undecided state. Depending on the structural properties of the network and on the initial conditions, the final distribution can range from a wide distribution of preferences to consensus, or also give rise to situations where indecision dominates. Decision making governed by the plurality rule may yield ties, contributing to overchoice stagnation. This is more pronounced in random networks than in scale-free ones. Also, in the latter networks consensus is facilitated. However, it is not still clear which are the contributions of randomness and preferential attachment for those effects. In order to investigate that issue, we develop the plurality rule dynamics in generalized Watts-Strogatz networks. We start from regular networks and rewire their connections to obtain different degrees of randomicity p. Moreover, the rewired nodes can be selected by means of a parameter w which allows to tune from random selection to preferential attachment. Through a phase diagram in (p, w) space, we characterize the conditions that lead to the different final configurations.

[04/11/2015 - P017]
Self-affinity and dengue fever, Stela M. Azevedo, *Universidade Estadual de Feira de Santana*, Hugo Saba, *Universidade do Estado da Bahia*, José Garcia Vivas Miranda, *Universidade Federal da Bahia*, Aloisio Nascimento Filho,

Marcelo A. Moret, *Faculdade de Tecnologia SENAI CIMATEC* ■Dengue is a complex public health problem common in tropical and subtropical regions. This disease has risen substantially in the last three decades and the physical means depicts the self-affine behavior of the occurrences of reported cases of dengue in the state of Bahia-Brazil. This study uses Detrended Fluctuation Analysis (DFA) to verify the scale behavior in time series of cases of dengue and to evaluate the long-range correlations characterized by the power-law α exponent for different cities of the state of Bahia-Brazil. The scaling exponent (α) presents different long-range correlations, i.e., uncorrelated, anti-persistent, persistent and diffusive behaviors. The long-range correlations highlighted a complex behavior of the time series of this disease. The findings show that there are two distinct kinds of scale behavior. The first one, the time series presents a persistent α exponent for a period of one month. Nevertheless, for large periods, the time series signal approaches of the subdiffusive behavior. The hypothesis of the long-range correlations in the time series of the occurrences of reported cases of dengue was validated. The observed self-affinity can be useful as forecasting tool in future periods through an extrapolation of the α exponent behavior. This complex system has a higher predictability in relatively short time (about one month) and it suggests a new tool in epidemiological control strategy. However, predictions for large periods using DFA are hidden by the subdiffusive behavior.

[04/11/2015 - P018]
Diagnostic of spatial organization in the Vicsek Model, Tiago Kroetz, Gabriel Sousa, *UTFPR* ■Collective motion is the name given to the complex behavior exhibited by a set of moving elements interacting with each other. The moving elements are usually called "self-propelled particles" and normally represent living organisms with some kind of simple interaction rules with their neighbors. Schooling, swarming, herding and flocking are examples of a wide variety of collective behaviors exhibited by groups of animals, insects or bacteria. The interest on models of self-propelled particle is to understand how and why individuals become unified groups. We propose a method to measure the cohesion of collective motion exhibited by self-propelled particles and compare to the already existent methods. We perform this study using the well-known Vicsek model. In this model, all the elements move with a constant absolute velocity and at each time step they assume the average direction of their neighbors into a chosen radial distance. A random angle is added to the average direction of each element, which are considered to be a natural perturbation caused by the many stochastic and deterministic factors affecting the motion of the living organisms. The most common diagnostic for measure the self-organization of the system is the average normalized vectorial velocity. This order parameter is capable to quantify the directional organization took by the particles but omits the spatial distribution of the set. We introduce an order parameter based on Informational Entropy defined by Claude Shannon applied separately on the positions and directions distributions. This method gives a normalized quantification of spatial and directional organization of the system. The results obtained by this order parameter reveal an unexpected behavior not detected by the well-established order parameters. In some cases, the maximum cohesion does not occurs for trivial values of noise and interaction radius.

[04/11/2015 - P019]
A Monte Carlo Study of Entropy from Sound Spectra, Debora Coimbra Martins, João Lucas de Paula Batista, *Universidade Federal de Uberlândia* ■Percussion instruments are impulsively excited instruments which would work even if their behavior were strictly linear. They are classified as "incidentally nonlinear"because, at small excitation amplitudes, their sound output is based entirely upon their natural mode frequencies, despite the fact that nonlinearity sometimes contributes a great deal to their sound. In this work, we studied Shannon entropy of suitably preprocessed Fourier spectra obtained from cuica 8 inches (a brazilian percussion instrument) by Monte Carlo method. First the sound is recorded using a professional microphone and decoded in WAV format through Audacity software. We implemented Fast Fourier transform aplaying MatLab®package to obtain indexed frequencies spectra. We found fundamental frequencies 661 Hz (E5) to sharp and 347 Hz (F) to bass sound. To each coarse-grain clustered in a subset of harmonics, the power spectrum was binned defining an array, corresponding to a suitable frequency. In this representation, adjacent bins differ by a frequency ratio of one cent. We mapped the correspondends intensities and computed Shanon entropy. We change randomly one of pitches and compute the entropy again. If entropy obtained is lower the change is accept, otherwise restore the previous value. The procedure is iterated until no further improvement restore previous value. This procedure furnish local minimum of the entropy and is inherently sensitive to all frequencies intervals. The authors thank FAPEMIG by financial support.

COMPLEXITY & INTERDISCIPLINARY TOPICS

[04/11/2015 - P020]
Modelling the Air-Water Interface, Frank Longford, *University of Southampton, Institute of Complex Systems Simulation*, Jonathan Essex, Chris-Kriton Skylaris, Jeremy Frey, *University of Southampton, School of Chemistry* ■Water is an incredibly important molecule for chemical and biochemical modelling of complex systems. Despite this, many of its emergent properties are not fully understood. Recent ellipsometry experiments into probing the surface of water-air interface have shown the presence of a water-like surface film with a much higher refractive index of light than the bulk solvent [1]. This runs counter to molecular dynamics calculations, which propose a tapering off of molecular density in this region over sub-nm thickness, and of refractive index as well. It has been suggested that there is some emergent behaviour of water molecules at the air-water interface that give rise to the high electric field at the surface, causing the observed higher refractive index. Ellipsometry experiments can be simulated by studying the arrangement of molecules at an interface during a

molecular dynamics (MD) simulation in terms of order parameters to calculate surface polarisation. Usually hyperpolarisabilities are then taken from quantum simulations to describe the molecular response to an applied electric field, however these are normally parametrised to a single molecule and so may neglect complex surface interactions. In addition, performing quantum MD simulations on large scale systems to simulate physical experiments is highly time consuming, so a full ensemble of states may not be generated within the computational resources available. Therefore, it is advantageous to perform as much of the simulation as possible using classical polarisable force field methods. Using the commercially available AMBER 12 molecular mechanics software we have so far implemented ways to deal with long range Lennard-Jones force corrections based on the methodology of Janeček [2]. These corrections to particle forces and energies can be accurately dealt with during post-processing in systems containing homogeneous densities, but it becomes necessary to include them "on-the-fly" during each simulation time-step in the presence of interfaces. We present an overview of how these force corrections are important for replicating surface behaviour in Lennard-Jones fluids, and also the development of a novel way to thermodynamically estimate surface energetic and entropic terms to assess their accuracy.

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[04/11/2015 - P021]
Non-additive complex systems: Applications in Astrophysics, Chemistry and Engineering, Antonio C. do P. Rosa Jr., *UFOB - BA - Brasil*, Pablo Vaveliuk, *CICBA-CONICET - La Plata - Argentina*, Marcelo A. Moret, *SENAI-CIMATEC - BA - Brasil* ■In this work, a physical modeling for the stochastic dynamics based on nonlinear continuity equations is proposed. In this sense, self-similarity, long range correlations, self-organized criticality, among others, occurs in complex systems. Besides, non-Markovian stochastic processes might be noticed. The probability densities are solutions of the nonlinear Fokker-Planck equations that maximize the non-additive Tsallis entropy. Based on a nonlinear Fokker-Planck equation, a diffusion coefficient that it is proportional to the supercooled-liquid concentration is observed. The proposed model allows explaining the anomalous behavior of the diffusivity. We demonstrate that this new approach is consistent with experimental patterns. Besides, it could be applied to non-Arrhenius chemical kinetics. Then, a reaction-diffusion model to non-Arrhenius chemical kinetics is proposed. On the other hand, this non-Markovian model properly depicts the time evolution of a distribution of depth values of pits that were experimentally obtained. The solution of this equation in a steady-state regime is a q-Gaussian distribution, i.e. a long-tail probability distribution. In additional, the X-ray intensities of 142 light curves of cataclysmic variables, galaxies, pulsars, supernova remnants and other X-ray sources are studied. The X-ray light curves coming from astrophysical systems obey q-Gaussian distribution as probability density. This fact strongly suggests that these astrophysical systems behave in a nonextensive manner. Furthermore, the q entropic indices for these systems were obtained and they provide an indication of the nonextensivity degree of each of these astrophysical systems. The q-value increases for systems if the Tsallis entropy decreases.

[04/11/2015 - P022]
Wavelet-based entropy: a new approach for characterizing time series, Marcos Vinícius Cândido Henriques, *Marcos Vinícius Cândido Henriques*, Francisco Edcarlos Alves Leite, *Universidade Federal Rural do Semi-Árido*, Liacir dos Santos Lucena, *Universidade Federal do Rio Grande do Norte* ■Quantitatively characterizing the degree of order-disorder in finite resolution multi-frequency time series is a major challenge due to limitations imposed by mensuration scales. The Wavelet transform is a multiresolution mathematical tool that allows one to decompose a signal into multiple components, each one representing some scale of observation. We apply the Tavares-Lucena Wavelet Entropy (TLWS), which is based on the discrete wavelet transform, to analyze an ensemble of Gaussian stochastic processes following Fractional Brownian Motion (FBM), generated from different methods and with distinct Hurst exponents. In order to test the reliability of this new method, we compare the results for entropies with those obtained by using the traditional Shannon entropy. In an attempt to measure the balance of order-disorder of multi-frequency stochastic signals that can be modeled as Gaussian process, we apply TLWS formalism to analyze the statistical properties of time series of financial data (BOVESPA) in different periods. We show that the wavelet-based entropy measure can be a good characterization method for stochastic processes as those used for modelling financial data. It allows to distinguish periods related to different degrees of volatility, besides dealing well with the presence of noise, which can be easily eliminated with a suitable choice of scales.

[04/11/2015 - P023]
Using the Theory of Social and Complex Networks for Applying Business Logistics Solutions, Carlos César Ribeiro, Marcelo A. Moret, Hernane B. B. Pereira, *SENAI CIMATEC* ■Modern society increasingly demand speed and quality of the logistics industry in its operations, forcing them to seek innovative alternatives that make them competitive. To Fawcett& Clinton (1996) modern companies are at a time of developing new production philosophies, growing global competition, supply chain development and a great emphasis on the use of information technology. In this sense, the use of Social and complex networks theory has become one of the main methods used by logistics managers in the search for solutions that result efficiency and competitiveness in its processes. Importantly, the analysis of social networks and Complex is defined as the mapping and investigation of the relationship between a particular group of actors (Scott, 2000). Relations, specifically in logistics, can be constructed and applied in the most important modal, as a transport of goods from one city to another (road transport), from port to port (water modal) and between one airport to another

(modal air transportation). Such relationships, network theory, are built from the identification of vertices (focal points such as ports) and edges (transport of goods) that when applied in specific softwares such as Pajek or UCINET result in a series of strategic indicators that provide the logistics manager taken more assertive and competitive decisions. Using the theory of Social Networks and Complex in logistics organizations allow administrators to better manage their supplier relationships, determine assertive decisions on physical distribution and also get cost savings throughout the supply chain (Supply Chain). In conclusion, Social Networks and Complex focus in relations between actors as the main unit of analysis, and such relationships may result in management information capable of providing organizations, efficiency and effectiveness in their logistics processes.

[04/11/2015 - P024]
WORLD CUP 2014 - AN ANALYSIS OF THE PERFORMANCE OF PLAYERS, Antônio J. A. Cordeiro, *SENAI CIMATEC e ESTÁCIO*, Hernane B.B. Pereira, Marcelo A. Moret, *SENAI CIMATEC e UNEB* ■Since 1930, when the first football world championship was lunched it has increasingly attracted the audience and the teams from different countries made this event a great success of public in additional an important bussiness. Each four years one of the biggest expectations is the choice of selecting the best players of the competition, which it takes into account a set of subjective information, originating from the observation of the games thus such choices become subject to disputes as to the actual performance and contribution of each player to the team's success during the competition. One of the main difficulties to meet these challenges is the ability to consider statistical data of the players in each game, such as right and wrong passes, assists that generated submissions, tackles, crosses and more. In this work, seeking to fill that gap, multivariate statistical analyzes are presented: Cluster Analysis, Faces of Chernoff, K-means, multidimensional scaling, based on data collection matches of the FIFA 2014 World Cup held in Brazil. The results can be useful for analyzing the choices of the best athletes in a competition, identifying players clusters with similar characteristics game, discovery of patterns of play to assist in the decision-making process by the football coach.

[04/11/2015 - P025]
Non-extensivity of the X-ray binary systems, Melina Silva de Lima, Marcelo A. Moret, *SENAI/CIMATEC* ■Systems in stationary states or in quasi-stationary states that cannot be consistently approached by classical Boltzmann and Gibbs Thermostatistics are non-additive. On the other hand, objects whose gravitational forces display a long-range gravitational reach are parts of so-called Self-Gravitating Systems (SGS). For both cases, the Generalized Thermostatistical formalism (GTS) proposed by Tsallis is a possible tool to be applied in replacement of classical Thermostatistics. X-Ray Binary Systems (XRBS) are SGS objects that present quasi-stationary states features. If one knows their emission values of light curves it is possible measuring their probability density distributions. The obtained results presented as the best fitting q-Gaussian distributions. For the present paper the research tasks analyzed 136 curves relating to time series evolution of X-Ray emission values of XRBS. Some nonlinear Fokker-Planck equations present as solution to the steady-states q-Gaussian distributions. We recall that it was in good accordance to the data provided by the X-Ray Rossi satellite. The results showed accuracy with respect to the original data, by means of analysis of variance (ANOVA), with $F_{Value} = 140297$ and $Prob > F = 0$. In all analyzes the q-Gaussian distribution proved better fit to the points regarding the Gaussian distribution, demonstrating the non-extensive character of the behavior of the X-Rays emissions arising from XRBS.

[04/11/2015 - P026]
Complex Features in a Network of Worldwide Seismic Events, Bernardo A. Machado, Paulo S. L. Oliveira Junior, Douglas S. R. Ferreira, *LIS-Comp, IFRJ - Campus Paracambi* ■The understanding of long-distance relations between seismic activities has for long been of interest to seismologists and geologists. Despite all the existing knowledge about the production of seismic waves through slips on faults, much remains to be discovered regarding the dynamics responsible for these slips. A key step in deepening this knowledge is the study, analysis and modeling of the seismic distributions in space and time. In this paper we have used data from the world-wide earthquake catalog for the period between 1972 and 2011, to generate a network of sites around the world for earthquakes with magnitude $m \geq 4.5$ in the Richter scale. After the network construction, we have analyzed the results under two viewpoints. Firstly, in contrast to previous works, which have considered just small areas, we showed that the best fitting for networks of seismic events is not a pure power law, but a power law with exponential cutoff. We also have found that the global network presents small-world properties. Secondly, we have found that the time intervals between successive earthquakes have a cumulative probability distribution well fitted by nontraditional functional forms. Our results reinforce the idea that the Earth is in a critical state and furthermore point towards temporal and spatial correlations between earthquakes in different places. We also sketch some future trends of our work.

NON-EQUILIBRIUM

[04/11/2015 - P028]
Synchronization of a computationally efficient neuron model with memory and synaptic delay, Germano S. Bortolotto, Mateus Kinasz, Marcelo H. R. Tragtenberg, *Departamento de Física, Universidade Federal de Santa Catarina* ■Experiments have recently shown synchronization in pairs of biological neurons. Several models have been studied, from biological plausible ones like the Hodgkin-Huxley model to formal models (Rulkov). We use the modified Kinouchi-Tragtenberg (KTz) model to study the synchronization of two coupled identical neurons with memory and synaptic delay. The KTz is a logistic neuron model with the membrane potential described by the discrete time recursion relation $x(t+1) = f(u(t))$, where f is a sigmoidal function, $u(t) = [x(t) - Ky(t) + z(t) + I(t)]/T$, I(t) is an external current and $z(t)$ is a slow current. We study the

case where $f(u) = u/[1 + |u|]$. This is a computationally efficient neuron model with many dynamical behaviors similar to biological neurons: excitable fixed point, fast and slow regular spiking, bursts and spikes with plateau etc. Using a master-slave configuration we demonstrate that depending on the relationship between memory and synaptic delay times the neurons synchronize either with anticipation or with lag. We use the similarity function $S^2(\phi)$ to characterize anticipation and lag. The difference between memory and synaptic delay times corresponds to the mean delay time. We vary the coupling strength between two neurons in order to show that it controls phase-locking and frequency entrainment of the system.

[04/11/2015 - P029]
Sampling methods for absorbing-state phase transitions on complex networks, Renan S. Sander, Silvio C. Ferreira, *Universidade Federal de Viçosa* ■Phase transitions into absorbing states, configurations from which the system cannot escape, are a current topic on the frontier of the non-equilibrium statistical mechanics. Despite the fact that there are still problems being investigated on regular topologies, phase transitions on complex networks have been subject of increasing interest to the scientific community due to the fact that such networks describe a wide variety of systems, relevant both in the technological and intellectual aspects. Considering the dynamical nature and huge size of real complex networks, the statistical physics approach has proved to be suitable since its association with the graph theory permits a characterization of emergent macroscopic phenomena in terms of the time evolution of basic elements composing the system. Since numerically we deal with finite systems necessarily, and finite-size effects are particularly stronger on power-law complex networks than on its regular lattice counterparts, a finite-size scaling (FSS) analysis is required. In this work, we perform simulations for the susceptible-infected-susceptible (SIS) model and the contact process (CP) on power-law networks with a degree distribution $P(k) \sim k^{-\gamma}$, using three different sampling techniques: the reflecting boundary condition (RB), the coupled vanishing external field (EF) and the quasi-stationary (QS) simulation methods. We show that the three methods are equivalent for the CP, successfully capturing its critical behavior on networks. The SIS on power-law networks presents multiple transitions and for this model the three sampling techniques successfully characterize the transition associated to an endemic phase (diverging lifespan), but provide different results for transitions involving localized states. In this regime, the RB and EF method do not capture, for example, a transition associated with the activation of the most connected vertex of the network, as predicted by the quenched mean-field theory (QMF). Acknowledgement: FAPEMIG

[04/11/2015 - P030]
Epidemic thresholds of the susceptible-infected-removed-susceptible process on networks, Renan S. Sander, Silvio C. Ferreira, *Universidade Federal de Viçosa*, Romualdo Pastor-Satorras, *Universitat Politècnica de Catalunya* ■Heterogeneous topologies, as observed in many natural and artificial complex networks, can fully alter the behavior of dynamical processes mediated by such patterns of contact, when compared to the expectations for regular lattices. With many practical applications, the case of epidemic models on heterogeneous social contact networks is particularly important in this respect. In scale-free networks, with degree distribution exhibiting long tails of the form $P(k) \sim k^{-\gamma}$, the epidemic threshold can vanish in certain models. Therefore, a disease can spread macroscopically, irrespective of its infective rate. There is an ongoing scientific debate regarding the nature of this null threshold, concerning its origin in the simplest susceptible-infected-susceptible (SIS) model. A more realistic epidemic model is the susceptible-infected-removed-susceptible (SIRS), which considers immunization or death for the dynamics. In this process, an infected node turns to a removed state during an averaging time $1/\alpha$, before becoming susceptible again. In this work, we show analytically, and verify numerically (using quasi-stationary simulations on degree-uncorrelated power-law networks) that the dynamics on hubs (basically large star graphs) plays an important role for general epidemic processes on top of networks. Our non-mean-field theoretical analysis is based on the interplay between lifetime of hubs and the reinfection mechanism presented in the SIRS model and leads to different predictions, based on the value of the degree exponent γ. We analyzed numerically the density of infected vertices, the epidemic lifespan and a susceptibility definition that presents a divergence at the transition point to an endemic phase. For networks with $\gamma < 3$, we found a vanishing threshold in the infinite-size limit, as observed in the SIS model. For $\gamma > 3$ our simulation results shows a threshold that converges to a finite value for not large values of α, contrasting with the vanishing threshold of the SIS model. These results are backed up by our theoretical formulation. Acknowledgement: FAPEMIG

[04/11/2015 - P031]
Analysing the reinfection effect for transmitted diseases and social adoptions through stochastical SIRI model, Alessandro de Barros, *Instituto Federal da Bahia*, Lucas Tinti, Roberto Andrade, Suani Pinho, *Universidade Federal da Bahia*, Jesus Gomes-Gardenes, *University of Zaragoza* ■The reinfection effect is relevant for many transmitted diseases such as Tuberculosis and Viral Hepatitis. In such cases, the second infection is less probable than the primary one. On the contrary, in social context, in general, the primary adoption of a product, innovation or idea is less probable than the second one [1]. For both cases, an stochastic version of the SIRI model is able to translate the spreading idea, based on the following compartments: Susceptible (Ignorant), Infected (Spreader) and Recovered (Inactive). The dynamical rules between compartments are given by: $S + I \to 2I$ with infection rate β; $I \to R$ with recovery rate γ; $R + I \to 2I$ with reinfection rate $\sigma\beta$. When $\sigma = 0$, the stochastical SIR model is recovered. We set up the master equation for stochastical SIRI model. According to one-site and pair mean-field approximations of the master equation of SIRI model on a lattice, for $\sigma < 1$, the relevant scenario for transmited diseases, there is a phase transition between the endemic and epidemic states. For $\sigma < 1$, Monte Carlo simulations also exhibit a second-order phase transition between

endemic and epidemic phases, revealing that SIRI model is in the same universality class of directed percolation. However, for $\sigma < 1$, the relevant scenario for social adoptions, the phase transition becomes abrupt in a network. We are studying analitically the stochastical SIRI model in homogeneous and heterogeneous networks in order to investigate the effect of the connectivity distribution on the phase transition as it was previously done for the stochastical SIS model [2].

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[04/11/2015 - P032]
A Stochastic Differential Equation Approach to Spectral Fluctuations in systems with Mixed Dynamics, Iván González, Antônio M S Macêdo, *UNIVERSIDADE FEDERAL DE PERNAMBUCO* ■The distribution of energy level spacing in mixed ballistic cavities (where regular and chaotic dynamics may coexist), can be understood in terms of a Wigner-Dyson distribution with fluctuating variance σ^2. In a recent work [1-4], a detailed analysis of the spacing distribution in mixed cavities was made using the method of statistic superposition (or superstatistics). It was found that σ^2 is well described by a chi square distribution, which in turn is used to obtain the corresponding spacing distribution via Bayes theorem. Another interesting result is the estimation of the time scales in the problem via the time correlation function for the spacing S, yielding two time scales τ_1 and τ_2, and the kurtosis of the spacing distribution, yielding the time scale T. The estimated T turned out to be one order of magnitude larger than τ_i, which was used to justify the superstatistical method for deriving the spacing distribution. However, no model description was given for the time correlation function of S [3]. Furthermore, the time correlation function of σ^2, which could yield additional large time scales [4], was not studied. In this work, we describe the fluctuations of energy spacing levels in ballistic quantum cavities with mixed dynamics using a coupled system of stochastic differential equations (SDE). The main advantage of our method is the possibility to account for all time scales of the problem, thus describing in the same dynamical model both the spacing distribution and its time correlation function. The results of the superstatistical method are recovered in the limit where all time scales ratios go to infinity. Our SDE model is an extension of recent generalization of statistical ensembles to multiscale systems, in which an Ornstein-Uhlenbeck inverse gamma (OUIG) process with M time scales is coupled to a single variable Langevin equation with one time-scale [5]. In our model we couple Dysons random matrix process with N time-scales to an OUIG process with M time-scales. A detailed analysis of some particular cases ($N = 2$, $M = 1$) and ($N = 2$, $M = 2$) is provided and both the spacing distribution and the time correlation functions are calculated from the same model.

[04/11/2015 - P033]
Entropy production for irreversible systems with $C_{3\nu}$ symmetry, Oscar A. Barbosa, Tânia Tomé Martins de Castro, *USP - SP - Brasil* ■Lattice non reversible models characterized by the own symmetry of the imposed dynamics are dealt. The dynamics is considered Markovian and stochastic, ruling the time evolution of the system by means of the master equation, that determines in time the configuration space. The work is focused on the study of the critical behavior of the entropy production, as this physical quantity shows to be susceptible to the irreversibility of the system from its own definition, but also because its construction comes to be coherent with a treatment of the model which takes into account the contributions done by the its basic components, hence, supplying a perspective which explains the global behavior of the system as a consequence of the considerations done on its basis.
Being so, it's proposed a three state Potts model on a square lattice which is ruled by an irreversible dynamics with symmetry properties in the $C_{3\nu}$ group. For the entropy production it's chosen the Schnakenberg prescription, being harmonic with a Markovian stochastic perspective which is supposed to act in a microscopical level, as stated. Using Monte Carlo simulation its critical properties are analyzed, characterizing the expected divergent tendency of its derivative at the critical point. Other quantities as the order parameter are calculated, since these allows a complete description of the system response to the control parameter, and elucidates features as the phase transition, its nature, and also the properties of the states involved in each of the phases. Dynamics and stationary critical exponents are calculated from the numerical results, those being a signature of the universality class of the system, which, in accordance to the Grinstein conjecture, shouldn't depend on the reversible conditions, but just on the symmetries involved in the model, as most of our results confirm.

[04/11/2015 - P034]
From quasi-stationary states to multi-absorbing states growth model., DIEGO ALEJANDRO CARVAJAL JARA, FRANCISCO CASTILHO ALCARAZ, *Instituto de física de São Carlos - USP* ■A one-dimensional growth model with local absorption and nonlocal desorption is studied. Its phase diagram is characterized by two parameters, one controlling the temporal correlation and the other describing the ratio between the absorbing and desorbing rates. Depending on the parameters, the stochastic model exhibits either self-organized criticality, quasi-stationarity, multi-absorbing transitions or massive behaviors. Two boundaries are of special interest: the first separates the region with self-organized criticality from the one of massive behavior, and it corresponds to a conformal invariant growth model. The second divides the regions of quasi-stationarity and of multi-absorption phase and it appears as a critical line in the phase diagram.
In the non-equilibrium regime, we observe quasi-stationary states with an exponential increase in the lifetime as a function of the size system, a behavior typical of activated dynamical scaling. In the no-absorption case, the dynamics of the surface can be derived analytically and exhibits a transient dynamic whose timescale is much larger than the expected lifetime of $1/E_1$, with

E_1 the energy gap. This timescale behaves like a "critical initial slip"and strongly depends on the size of the biggest cluster in the initial condition. This highlights the need of controlling the typical size of the clusters in the initial conditions, otherwise the estimation of dynamical exponents may be erroneous.
Finally, we observe deviations from the conformal tower in the no-absorption case when investigating the critical transition from the absorbing to the multi-absorbing phase, as an additional parameter in the model in tuned.

[04/11/2015 - P035]
Phase Transitions in a Non-equilibrium System with Parity Conservation and Long-range Diffusion, Tainã L. M. Silva, Marcelo Leite Lyra, *UFAL - AL - Brasil*, Carlos Argolo, *IFAL - AL - Brasil* ■The Contact process is the simplest model for phase transitions out-equilibrium and it was originally introduced to describe epidemic spreading models. In the present work, we study the effect of long-range interactions promoted by Levy flights in an out-equilibrium system in which the parity is conserved. This model is of great interest to the scientific community working in phase transitions and critical phenomena, since it is expected to present a universality class that differs from that common Directed Percolation - DP. We investigate the critical properties of this system using computational techniques and finite-size scaling. Through the Monte Carlo simulation method, we analyzed the region of transition on linear finite lattices with an odd number of sites and initially totally occupied. We estimate the critical point p_c through the scale invariance of the particles density cumulant. After finding p_c, it was possible to determine the set of critical exponents that characterize the universal behavior in the neighborhood of the second order phase transition. From such analysis, we found a set of exponents in agreement with the already presented in the literature, besides new critical quantities which have not been studied previously for systems with parity conservation and long range diffusion. Our results confirm that the present model depicts a non-equilibrium phase transition that don't belong to the DP's universality class. Therefore, we can assert that a new set of critical exponents arises from the effects of parity conservation and long-range interactions. Further, we unveil that the critical order parameter distribution evolves from the Gaussian to exponential form as the diffusion process becomes of longer range.

[04/11/2015 - P036]
Nonequilibrium statistical mechanics of electrons in a diode, Samuel Marini, Felipe B. Rizzato, Yan Levin, Renato Pakter, *Instituto de Física - UFRGS* ■Fully kinetic descriptions of long-range self-interacting systems are generally very difficult to obtain because these systems do not relax to the Maxwell-Boltzmann distribution and the tools of equilibrium statistical mechanics cannot be employed. This is the case of electron flows in diodes and in crossed-field devices which are fundamental for the development of several advanced applications in areas ranging from microwave sources to space propulsion, as well as in the semiconductor industry. Here, a statistical theory is presented that allows the calculation of the stationary state achieved by the electron in such systems after a process of collisionless relaxation. The stationary collisionless Boltzmann (Vlasov) equation with appropriate boundary conditions is reduced to an ordinary differential equation, which is then solved numerically. Special attention is given to the space-charge limited transition when the electron density becomes high enough to screen the accelerating electric field at the cathode. It is found that while for unmagnetized diodes this transition is always continuous [1], in the case of crossed-field diodes it becomes discontinuous below a critical temperature [2]. We also investigate how intrinsic space-charge oscillations may drive stationary states unstable in certain parameter regimes [2]. The results are verified with molecular-dynamics simulations.
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[04/11/2015 - P037]
Instability of dewetting fronts in thin solid films, Anna Chame, *UFF-RJ -Brasil*, Olivier Pierre-Louis, *Université Lyon 1-CNRS, France* ■Anisotropy has an important effect in the dewetting dynamics of thin solid films. Instabilities in the dewetting front morphology have been experimentally observed [1, 2], for instance in films of Si and Ge on SiO_2 substrates. When an initial hole is produced in a thin film, its edges can be unstable, and void fingers may develop. In the case of Si films, these fingers grow along diagonal directions with respect to the main axes of the film lattice, whereas in the case of Ge films, the fingers grow along axial directions. To investigate the effect of anisotropy in dewetting, we employ kinetic Monte Carlo simulations to implement the dynamics, using a 2D solid-on-solid model. In this model, epilayer atoms can hop to nearest neighbor sites and an atom needs to break all its bonds to hop, therefore the hopping barrier is given by the binding energy of the atom. The hopping rates also depend if the atom is in contact with the substrate or not. The model parameters are the adsorbate-substrate excess energy E_S,the temperature T and the thickness h of the film.
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[04/11/2015 - P038]
Dynamics of mean spherical model with correlated noise, Masayuki Hase, *Escola de Artes, Ciências e Humanidades da Universidade de São Paulo*, Malte Henkel, *Groupe de Physique Statistique, Institut Jean Lamour (U. Lorraine)* ■The dynamics of the mean spherical model [1, 2, 3] with a dissipative term and a correlated noise is investigated. This noise obeys a fractional brownian motion [4] with Hurst index H, and some mathematical techniques are proposed to obtain asymptotically exact results for large times. The analysis is based on the two-time autocorrelation and response function, and the results are compared to the work of Godrèche-Luck [5], where the noise is uncorrelated (it is worth noting that this problem has been considered before [6]). Comparing the two dynamics (which differ in the nature of the noise only), the present case shows a richer behavior, which is expected due to the presence of an extra parameter H; nevertheless, one can also observe

the realization of some non-trivial interplay between dissipative part and noise term.

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[04/11/2015 - P039]
Width and extremal height distributions of Kardar-Parisi-Zhang interfaces with window boundary conditions., Ismael Segundo da Silva Carrasco, Tiago José de Oliveira, *Universidade Federal de Viçosa* ■We present a detailed numerical study of squared local roughness (SLRDs) and local extremal height distributions (LEHDs), calculated in windows of lateral size l, for KPZ interfaces, in $1+1$ and $2+1$ dimensions. We show that their cumulants follow the Family-Vicsek type scaling, and, at early times (when the correlation length ξ is smaller than l), the nth SLRDs cumulant scale in time as $\langle w_n \rangle_c \sim t^{\gamma_n}$, with $\gamma_n = 2n\beta + (n-1)d_s/z = [2n + (n-1)d_s/\alpha]\,\beta$. This scaling is featured by small corrections, providing exponents (α, β and z) in nice agreement with their respective universality classes. Therefore, it is an useful framework for numerical and experimental investigations, where it is, usually, hard to estimate the dynamic z and the (global) roughness α exponents. At the stationary regime ($\xi \gg l$), we observe that SLRDs and LEHDs for small l's can present strong finite-size corrections, and the best way to prove their universality is through extrapolations (for long times and l's) of their cumulant ratios. This shows that the procedure adopted in recent comparisons of experimental and numerical/theoretical distributions, based on small l data collapse, could lead to misleading conclusions. As final result, we demonstrate that SLRDs and LEHDs are the same for flat interfaces and curved ones. We acknowledge FAPEMIG, CAPES and CNPq by the financial support.

OTHER TOPICS

[04/11/2015 - P040]
High dimension analysis of the symbiotic two-species contact process model, T. B. dos Santos, C. I. N. Sampaio Filho, A. A. Moreira, J. S. Andrade Jr., *Grupo de Sistemas Complexos, Departamento de Física, Universidade Federal do Ceará* ■In the symbiotic contact process model each node in a graph can be vacant, occupied by one or two particles of different species. The symbiotic interaction is represented by the reduced death rate μ ($0 < \mu < 1$) for a pair of particles in the same node. From the analytical analysis of the mean-field theory, we show that the model undergoes a discontinuous phase transition at the critical creation rate $\lambda_c(\mu)$, which is a decreasing function of μ.Moreover, we determine a region of bistability, where the system has two stable states, namely, both populations persist or are extincted depending on the initial state of the system. By performing Monte Carlo simulations, we have analyzed two different methods in order to maintain the system out of the absorbing state. The first method introduces a small perturbation on the absorbing state replacing one particle of each species. In the second method, once the system reaches the absorbing state, this state is replaced by a visited active one. Our results show that the bistable phase can be observed just with the first method. In this case, a hysteresis loop appears either in the Erdös-Rényi graph or in the complete one. Finally, this method can be applied to low-dimensional systems, where it is possible to find a hysteresis loop which has its length depending on the simulation time.

[04/11/2015 - P041]
Transfer-matrix study of a hard-square lattice gas with two kinds of particles and density anomaly, Tiago J. Oliveira, *Departamento de Física, UFV*, Jürgen F. Stilck, *Instituto de Física, UFF and INCT-SC* ■Using transfer matrix and finite-size scaling methods, we study the thermodynamic behavior of a lattice gas with two kinds of particles on the square lattice. Only excluded volume interactions are considered, so that the model is athermal. Large particles exclude the site they occupy and its four first neighbors, while small particles exclude only their site. The correlations length of the model defined on strips with finite widths and periodic boundary conditions is found diagonalizing the transfer matrix and the critical point is estimated using phenomenological renormalization. Two thermodynamic phases are found: a disordered phase where large particles occupy both sublattices with the same probability and an ordered phase where one of the two sublattices is preferentially occupied by them. The transition between these phases is continuous at small concentrations of the small particles and discontinuous at larger concentrations, both transitions are separated by a tricritical point. Estimates of the central charge suggest that the critical line is in the Ising universality class, while the tricritical point has tricritical Ising (Blume-Emery-Griffiths) exponents. The isobaric curves of the total density as functions of the fugacity of small or large particles display a minimum in the disordered phase. It should be mentioned that since two particles are present in the model with distinct sizes, one may say that two length scales are involved in the interaction potential, a feature which has been proposed to lead to density anomalies in models for water.

[04/11/2015 - P042]
Three wave nonlinear interaction: a multimode extension, P. Iorra, S. Marini, E. Peter, A. T. Chávez, F. B. Rizzato, *Instituto de Física, Universidade Federal do Rio Grande do Sul* ■The slow modulational approximation to the dynamics of high-frequency carrier waves has been proved time and time again as a powerful technique to deal with system with virtually infinite degrees-of-freedom. Instead of describing the oscillatory modes at their short space and time scales, the modulational approach allows to obtain approximate governing equations for a smaller and much smoother varying set of dynamical variables: the amplitudes and phases of the involved waves.
Modulational techniques have been applied to a variety of physical settings, ranging from mechanical waves in

solids, to electromagnetic waves in plasma accelerators. In all cases, the needed condition for accuracy is that the wave interaction is weak enough that amplitudes and phases indeed change in a much larger space-time scale than the high-frequency times scale and wavelength spatial scale of the carriers.
The modulational theory has been successfully applied to the study of three waves systems, where energy exchange involving three wave modes is possible if parametric instabilities is present. The wave triplet is a cornerstone in the study of nonlinear wave interaction and more complex interactive system can be frequently understood with basis on three wave partitions.
Considering the importance of the three wave interaction, a recent work investigated the behaviour of the triplet dynamics as the coupling grows beyond the proper validity range for modulational approximations. It has been found that there exists indeed a critical coupling strength separating modulational and chaotic regimes, where in the latter amplitudes execute much larger and much faster oscillations than in the former.
In the present work we shall focus on a multimode extension of the triplet interaction to address the behaviour of this multimode system as the nonlinear coupling between the various modes increase. The question to be examined here is basically whether or not a critical coupling factor is present defining a transition from a smoother to a less regular type of dynamics, similarly to what happens with an isolated triplet.
As we shall see, a transition will be indeed identified and argued to be of relevance to nonlinear wave fields with cubic nonlinearities in the corresponding Lagrangian or Hamiltonian functions.

[04/11/2015 - P043]
Aqueous two-phase systems of polyethylene glycol and inorganic salts: a statistical model, Filipe Leoncio Braga, *Instituto Federal de Educação e Tecnologia do Espírito Santo, Rod. Gov. José Sete, s/n - Itaciba, Cariacica - ES, 29150-410*, Mario Noboru Tamashiro, *Universidade Estadual de Campinas, Instituto de Física "Gleb Wataghin", Departamento de Física Aplicada, Rua Sérgio Buarque de Holanda, 777 - Barão Geraldo, Campinas-SP, 13083-859* ■Thermal-statistical models that try to reproduce the behavior of aqueous polymer solutions have been extensively studied over the years. However, the number of articles related to aqueous systems containing polymers and added salts is still very restricted. We investigate a model based on the Flory-Huggins theory to analyze the formation of aqueous two-phase systems comprising long-polymer chains of polyethylene glycol in mixtures containing monovalent inorganic salts. In the proposed statistical model the competition between the hydrogen-bond formation among water molecules and the monomers of the polymer chain, in addition to the ion-dipole interactions between water and the dissociated salt ions play a key role in shaping the equilibrium configurations. Through numerical fits of experimental data presented in the literature, for each type of salt introduced into the mixture, with model predictions for the phase-separation temperatures, the so-called Cloud-Point Temperatures (CPT), we find a set of four phenomenological interaction parameters that enables proper theoretical representation of the continuous behavior of the CPT's as a function of the concentration of solutes. The observed behavior of the adjusted parameters can be interpreted in terms of the Hofmeister (or lyotropic) series. The reduced number of adjustable parameters needed to reproduce some experimental data is one of the advantages of the proposed model over other theoretical approaches as activity-coefficient chemical models like UNIFAC or UNIQUAC.

[04/11/2015 - P044]
Thermal properties of a solid through of Fibonacci oscillators, André Afonso Araujo Marinho, Francisco de Assis de Brito, *UFCG* ■We treat the study of the thermodynamics of a crystalline solid, applying algebra of Fibonacci oscillators. As is known a solid is formed by a large number of atoms connected by cohesive forces of various types. Each atom moves only in a small neighborhood, vibrating around its point of balance. The impurity states are located, and correspond the movement of electrons inside a space (structure) limited, resulting in some areas or types of electronic interaction, i.e., the network is experiencing a kind of electron rearrangement change in motion of nuclear spins, etc. In our study, we consider models Einstein and Debye. We applied to (q_1, q_2)-algebra and deform the energy spectrum, we obtain a Hamiltonian (q_1, q_2)-deformed and hence thermodynamic quantities. The interpretation of the results allowed the strain acting as parameters factors disorder or impurities which alter the characteristics of a crystal structure, e.g., in the case of semiconductors. The main results indicate that we have more flexibility in adopting values for q_1 and q_2, we can imagine the future, a new element with ideal characteristics, or even occasionally improve an existing element. We need more studies and evidence to substantiate such a complex case. For example, we are trying to establish a connection between this theory and experiences through the growth of thin films, an issue that will be addressed elsewhere.

[04/11/2015 - P045]
Nonlinear Relaxation Time Model, D. S. Oliveira, R. M. O. Galvão, *Instituto de Física, Universidade de São Paulo* ■In the collisional kinetic plasmas theory, the traditional approach lies on the use of an approximative collisional term in order to avoid the issue of the full complicated equation. In this work, we present a new simple nonlinear relaxation model based on two different relaxation times, namely, τ_1 and τ_2. In contrast with many models in kinetic plasmas theory, our model has the striking feature of not being directly linearized when the local thermodynamic equilibrium is assumed. It is also proved that the model satisfies the H-theorem and the conservations laws (particles, momentum and energy conservation during the collisions). The basic theoretical framework is outlined and it is applied for three distinctive relevant applications: 1) The relaxation to equilbrium in the spatially homogeneous case. The expression found for the distribuition function f shows that the nonlinear term can either accelerate or decelerate the relaxation process; 2) Electrons runaways in a cooling plasma. We use the condition of vanish collision term, $C(f) = 0$, to find the distribution function f of the electrons in the runaway phenomena; 3) Negative differential resistance

in GaAs. In this application, the drift velocity and the density of the electrons are calculated. In addition, the threshold electric field and the density of the electrons at the upper conduction band are calculated and the values found show good agreement with other results present in the literature.

[04/11/2015 - P046]
Domain-size heterogeneity in the Ising model: Geometrical and thermal transitions, André R. de la Rocha, Jeferson J. Arenzon, *Instituto de Física, Universidade Federal do Rio Grande do Sul, CP 15051, 91501-970 Porto Alegre, Rio Grande do Sul, Brazil*, Paulo Murilo C. de Oliveira, *IMEA, Universidade Federal da Integração Latino Americana, Foz do Iguaçu, Paraná, Brazil - Instituto de Física, Universidade Federal Fluminense, Niterói, Rio de Janiero, Brazil* ■Cluster or domain size distributions are commonly used in statistical mechanics to unveil geometric properties and characterize both the equilibrium critical behavior and the out of equilibrium dynamics of several models. If the system is finite, not all possible domain sizes are present on a single configuration. These sample-to-sample fluctuations disappear and the distributions become dense in the infinite size limit, or after ensemble averages are taken. In order to characterize these fluctuations, a quantity associated with how heterogeneously sized the equilibrium domains are, H, was recently proposed in the context of explosive percolation and then applied to ordinary random percolation and to domains of parallel spins in the Ising and Potts models. Differently from the cluster size distribution, the heterogeneity H only takes into account whether a given size is present in each configuration and gives the number of such distinct sizes. In addition to geometric domains of parallel spins, for thermal spin models one can consider physical clusters, which take into account the temperature-dependent correlation between neighboring spins and encode the critical properties of phase transitions. In this work we extend the measure of H to these clusters and, moreover, present new results for the geometric domains in the Ising model with $d = 2$ and 3. We show through extensive Monte Carlo simulations that the heterogeneity associated with physical domains for $d = 2$ has a single peak that diverges at the critical temperature, while for the geometric domains it has a previously unnoticed double peak, presenting signatures for both the percolative and thermal transitions [1].
[1] Phys. Rev. E 91, 042113 (2015)

[04/11/2015 - P047]
Flux representation for the vector Potts model, Marcio Woitek, Gastão Krein, *IFT-UNESP* ■One of the models that have been most widely studied for gaining insight on the ferromagnetic phase transitions is the so-called *vector Potts model* (VPM) with N states, a straightforward generalization of the Ising model [1]. It is well known the fact that, except for some very particular values of N and of the dimension d of the corresponding lattice, this model can not be studied in an entirely analytical manner. Therefore, one can say that our understanding about the VPM in the general case is based on results of computer simulations that employ *Monte Carlo methods*. A class of such methods that received considerable attention during the last decade is that of the *worm algorithms* [2]. Devising these algorithms involves changing the original variables of the problem, the "Potts spins", to new ones that are known as *flux variables*. One says that the introduction of these variables corresponds to utilizing a *flux representation* (FR) for the VPM [3,4]. First we discuss how the description of the model can be reformulated in terms of the flux variables. Then we explain how the FR allows us to conceive new Monte Carlo methods for studying the VPM. Moreover, we consider a second application of the FR to the analysis of the VPM within the *mean field approximation*. Preliminary results – valid in this approximation – for observables such as the magnetization are presented.
[1] F. Y. Wu, *Rev. Mod. Phys.* **54**, 235 (1982).
[2] N. Prokof'ev and B. Svistunov, *Phys. Rev. Lett.* **87**, 160601 (2001).
[3] Y. D. Mercado, H. G. Evertz and C. Gattringer, *Phys. Rev. Lett.* **106**, 222001 (2011).
[4] Y. Mercado, H. Evertz and C. Gattringer, *Computer Physics Communications* **183**, 1920 (2012).

[04/11/2015 - P048]
Discrete Fields in Condensed Matter, Breno Rodrigues Segatto, Manoelito Martins de Souza, *UFES* ■Fundamental interactions, according to quantum field theory, are realized through the exchange of interaction quanta-packets of matter-energy with defined quantum numbers, namely momentum-energy, spin, electric charge, etc. They are discrete interactions, in contradistinction to the classical continuous picture. By a classical model of discrete interaction, we mean the replacement of the potential representative of the continuous interaction, by the exchange of, in an evident abuse of language, classical quanta, little bits of well-defined amounts of energy-momentum. This classical quantum is emitted/absorbed in an instantaneous process caused also by the absorption/emission of a previous quantum. We intend to start a discussion about the formalism of discrete interactions in a non-relativistic regime, which is appropriate for dealing within condensed matter, and propose a model of two spin interacting, via Heisenberg Hamiltonian, where the exchange interaction is via a discreet field that will be discuss during the presentation where we will use the statistical physics to analyses the new terms that appear during the formalism.

QUANTUM FLUIDS & CONDENSED MATTER/ DISORDERED AND GLASSY SYSTEMS

[04/11/2015 - P049]
A Lattice-Boltzmann Method for electrons in metals, Rodrigo C. V. Coelho, Mauro M. Doria, *Universidade Federal do Rio de Janeiro*, Anderson Ilha, *Instituto Nacional de Metrologia, Normalização e Qualidade Industrial* ■In the 80's a numerical method was developed to solve the Boltzmann equation with the BGK (Bhatnagar, Gross and Krook) collision term. This method, based on the discretization of the phase space, was very successful in solving various problems of fuid mechanics, including problems with complex geometry, interfacial phenomena and multicomponent fluids. Known as the LBM - Lattice Boltzmann Method - it describes the

evolution of a set of statistical distributions of particles defined on a regular space lattice in which each site has a finite number of velocities directed to neighbouring sites. The advantage over other methods lies in the simplicity of its dynamics and especially the flexibility for implementation in parallel computing. In recent years, there has been a great interest in the construction of an LBM able to describe fluids that are not described by Maxwell-Boltzmann distribution, like semi-classical fluids (described by Fermi-Dirac and Bose-Einstein distribution) and relativistic fluids (described by Maxwell-Juttner distribution).
In this presentation we derive a general mathematical framework that leads to new LBM models associated to generic equilibrium distribution functions. This framework is based on our discovery of a new polynomial basis in Euclidean space which yields the Hermite polynomial basis in the special limit that the weight function becomes the Gaussian function. The equilibrium function is expanded in this new basis and we discuss the order that must be considered to obtain the correct conservation laws. We also obtain the discrete lattices associated to the new polynomial basis. As an application, we construct a LBM capable of describing electrons in the Fermi surface and show some numerical simulations. This particular LBM is a very promising one since it could be used to describe the conduction of electrons in arbitrary geometries, something of interest in condensed matter and also in industrial applications.

[04/11/2015 - P050]
PERCOLATION THEORY IN THE POTTS MODEL, Tiago de Souza Farias, Jonas Maziero, *UNIVERSIDADE FEDERAL DE SANTA MARIA* ■The Potts model may be used to describe several systems, as e.g. the magnetic behaviour of some materials. In this model, the magnetic moment of each atom, known as spin, can assume a range of possible values and orientations which depend on the material under consideration. The Hamiltonian of this model is given by:

$$H = -J \sum_{i,j} cos\theta_{ij}$$

where θ_{ij} is the angle between two nearest neighbours spins and J is the energy exchange. This model may exhibit a magnetic phase transition from ferromagnetism to paramagnetism at a critical temperature Tc. This temperature can be estimated via computational methods like, for example, the Monte Carlo method.
Fractal lattices are scale-free structures, very commonly present in nature, that have interesting topological features, such as lacunarity and fractal dimension. These geometrical properties can give a better perspective of the topological behavior of magnetism in general lattices.
In this work, we have shown that the ferromagnetic phase transition is related to the geometrical phase transition by the percolation theory. This theory studies the connection among clusters within the lattice and, through techniques such as image analysis, provides a mean for obtaining the Tc faster than some other methods. Additionally, we compared the phase transition order for different number of orientations and its relation to the geometry of general structures. These results presents a deep connection between geometry and phase transition theory, opening new possibilities for many models and possible magnetic phases.

[04/11/2015 - P051]
Electronic dynamics under effect of a nonlinear Morse interaction and a static electric field, Adhemar Ranciaro Neto, Francisco Anacleto Barros Fidelis de Moura, *Instituto de Física - UFAL* ■The problem concerning the time-dependent behavior of an initially localized electronic wave-packet under effect of nonlinearity and a static electric field has attracted the interest of scientific community. It is well known that, at the absence of nonlinearity, a static electric field applied parallel to a periodic lattice promotes the dynamic localization of a given initial wave-packet. Furthermore, the presence of static electric field gives rise to an oscillatory behavior of the electron wave packet (also called "Bloch oscillations"). The size of the region over which the electron oscillates and the period of these oscillations are inversely proportional to the magnitude of the static electric field. In this work we will make a contribution by going forward on the understanding of electronic transport in low-dimensional nonlinear systems under effect of uniform electric field. We study numerically the one-electron dynamics in a one-dimension alloy in which that the atoms are coupled by a Morse potential. In addition, we consider a static electric field parallel to chain. Within our model, the electron transport is treated quantum-mechanically over the alloy in tight-binding approximation and the longitudinal vibrations of the lattice are described by using classical formalism. The electron-phonon interaction was introduced by considering the electron hopping as a function of the effective distance between neighboring atoms. By solving numerically dynamic equations for electron and lattice we can compute the spreading of an initially localized electronic wave-packet. We report numerical evidences of the existence of an electron-soliton pair even at the presence of electric field. We offer a detailed analysis of the dependence of this electron-soliton pair with the magnitude of the electric field and the electron-phonon interaction.

[04/11/2015 - P052]
Dynamical class of a two-dimensional plasmonic Dirac system, Érica de Mello Silva, *Universidade Federal de Mato Grosso* ■Since the advent of graphene as a tunable plasmonic material, the dynamics of surface plasmons became a hot research topic in nanophotonics. Graphene plasmons have a high capability of light confinement and have been considered feasible to mediate interactions between externally controlled signals and small quantum systems, e.g. quantum dots. However, in spite of significant progress in the field, graphene plasmons damping is still a hinder for the realization of graphene-based plasmonic devices. In this sense we believe it might be of interest to enlarge the knowledge on the dynamical class of two-dimensional plasmonic Dirac systems. According to the recurrence relations method, the dimensionality d and the shape σ of the realized Hilbert space are the static properties that characterize time correlation functions of a dynamical variable in a system towards relaxation process. Therefore one can state if different systems are dynamically equivalent if they have

the same d and σ, i.e., identical relaxation functions, and such commonality may lead to deep connections between seemingly unrelated physical systems. We employ the recurrence relations approach to obtain relaxation and memory functions of density fluctuations and show that a two-dimensional plasmonic Dirac system at long wavelength and zero temperature belongs to the same dynamical class of standard two-dimensional electron gas and classical harmonic oscillator chain with an impurity mass.

[04/11/2015 - P053]
Influence of disordered porous media in the anomalous properties of a simple water model, Alexandre Penteado Furlan, *Instituto de Física, Univeridade Federal do Rio Grande do Sul,*, Carlos Eduardo Fiore, *Instituto de Física, Univeridade de São Paulo,*, Marcia Cristina Barbosa, *Instituto de Física, Univeridade Federal do Rio Grande do Sul,* ■The phase behavior of systems of particles interacting via the so-called core-softened (CS) potentials has received a lot of attention recently. They show a repulsive core with a softening region when particles are very close These CS can be modeled as continuous potentials or lattice gas models. For the lattice structure the two competing scales arise from two equilibrium configurations: low density and high density. This procedure generates models that are analytically and computationally tractable and that one hopes are capable of retaining the qualitative features of the real complex systems. The physical motivation behind these studies is the assumption that two length scales systems exhibit the same anomalous behaviors present in water. Confirming this hypothesis a number of continuous and lattice gas models show the presence of density, diffusion and structural anomalous behavior as observed in water. Within the other seventy-two anomalies, water has at very low temperatures two coexisting amorphous phases with distinct densities: the low density amorphous (LDA) and high density amorphous phases (HDA). These two amorphous phases led to the hypothesis of the existence at higher temperatures of two liquid phases: a low density liquid and high density liquid phases. Such conjecture establishes that the coexistence between these two liquid phases ends in a second critical point or also called, liquid-liquid critical point (LLCP) [24]. Experiments for testing the existence of this criticality are difficult since the region in the pressure versus temperature phase diagram where the alleged critical point exists is locate beyond the homogeneous nucleation limit. In order to circumvent this difficulty for testing the existence of the liquid-liquid critical point recently confined geometries have been employed. In this sense the thermodynamic, dynamic and structural behavior of a water-like system confined in a matrix is analyzed for increasing confining geometries. The liquid is modeled by a two dimensional associating lattice gas model that exhibits density and diffusion anomalies, in similarity to the anomalies present in liquid water. The matrix is a triangular lattice in which fixed obstacles impose restrictions to the occupation of the particles. We show that obstacules shortens all lines, including the phase coexistence, the critical and the anomalous lines. The inclusion of a very dense matrix not only suppress the anomalies but also the liquid-liquid critical point.

[04/11/2015 - P054]
On the special properties of generalized harmonic systems within the $n \to 0$ replica approach, Everton M. C. Abreu, Edson S. de Pinho, *Universidade Federal Rural do Rio de Janeiro* ■Spin glass models are relevant until today because they provide the simplest models to investigate underlying concepts like disorder and frustration. They are endowed with a kind of phase transition and hence a kind of organization at low temperature. In order to study systems with quenched disorder, a proper treatment involves averaging the free energy, but this task, as well known, is very difficult since we have to deal with the logarithm of the partition function to calculate the free energy which is "self-averaging"in the thermodynamic limit. However, the average cannot be carried out directly because the random variables occur inside the logarithm. Spin glasses are highly random systems, and in many of the standard models, the nonrandom part is zero. This technique is therefore not generally applicable, though even for spin glasses it is valid at high temperatures and can be used to generate high-temperature series expansions. At low temperatures and certainly below a spin glass transition temperature, one needs a non-perturbative way of averaging over disorder. And this is the idea behind the replica approach. In this work we will use the replica approach to analyze the spectral properties of generalized harmonic systems. A replica symmetry breaking analysis is accomplished too.

[04/11/2015 - P055]
Ghatak-Sherrington model with a random field in a random network, Amanda de Azevedo Lopes, Rubem Erichsen Jr, *UFRGS* ■The statistical mechanics of a three-state Ising spin-glass model with a Ghatak-Sherrington crystal-field term and a random field term is studied in the present work. A finite connectivity technique is used, in which each spin is connected to a finite number of other spins. The spins were connected according a Poisson distribution, the random field term followed a bimodal distribution and the bonds between the spins were considered uniform. Thus, there is only a connection disorder. We focused on determining how the nature of the transition changes with the connectivity and if there is a reentrant behavior of the phase boundaries. The replica technique is used to obtain saddle-point equations for the effective local-field distribution. The replica symmetric ansatz for the order function is written in terms of a two-dimensional effective-field distribution, where one of the components is associated with a linear form in the spins and the other with the crystal-field term. This allows us to derive equations for the order function and for the free-energy. A population dynamics procedure is used to solve numerically a self-consistency equation for the distribution of the local field and with it some physical parameters, like magnetization and free-energy. Our results indicate that for the bimodal distribution there is a tricritical point, whose location is strongly dependent on c. The tricritical point is suppressed below a certain minimum value of connectivity.

[04/11/2015 - P056]
PACKING OF DISKS ON A TWO DIMENSIONAL CAVITY WITH DILUTED PINS, Wellington Castro Ferreira, Valdemiro da Paz Brito, José Pimentel de Lima, *UFPI*, Marcelo Andrade de Filgueiras Gomes, *UFPE* ■The physics of two-dimensional systems have fascinating behavior, and can also be surprisingly different from physics in three dimensions. This has stimulated the study of statistical properties of several systems such as monolayer packing configurations of a string of beads [1], as well as, two-dimensional systems involving hard discs on a flat cell. These systems have been subject of continued interest in physics, because they have connections with many problems, as e.g. in the study of elastic and inelastic deformation of polymers, and the study of fundamental properties of condensed matter, including structural phase transitions, among others. In this contribution it is investigated the problem of the packing of hard discs on a two dimensional cell with fixed cylindrical pins which are obstacles with a much smaller diameter than the disks. The cell consists of two rectangular sheets of acrylic separated by a thickness that allows to accommodate only a single layer of discs. More than two hundred configurations of such packing were analyzed and grouped by considering the density of pins and the nature of their distribution (square lattice or random lattice), all them obtained in the limit of maximum packing density. Working with the digitized image of each configuration, the centroid of each disk was determined. The packing of disks was analyzed as a function of the number of obstacles and it was represented as configurations of Wigner-Seitz (WS) cells. We found that the cellular structure of packaged discs follows a statistical description already described by Weaire and Rivier [2], in the partial characterization of random structures in two dimensions in several aspects as, the distributions of angles and the number of sides of the WS cells. The distribution of sides for the WS cells was analyzed and compared with the Shackelford-Masaryk hypothesis, and we also found that the arguments of Buechner et al. [3] do not apply to this study to explain the lognormal distribution proposed in [3]. Additionally we verified a reasonable agreement with the Aboav's law [4]. The pair correlation function was calculated for the centroid of the discs and the results suggest the characterization of the properties of the system in periodic, hexatic and random regimes, which depend of the density of pins.
[1] Brito,V.P., Castro,W.S., Coelho,A.S.O., Gomes,M.A.F., Physica A, 342(2004)419. [2] Weaire,D.; Rivier,N. Soap, Contemporary Physics, 25(1984)59. [3] Buechner,C., Schlexer,P, Lichtenstein,L, Stuckenholz,S, Heyde, and Freund,H-J, Z. Phys. Chem, 228(2014)587. [4] Hilhorst,H.J. Journal Physics A, 39(2006)7227.

Oral sessions (11:00-12:30)

NONLINEARITY AND CHAOS

[04/11/2015 - 11:00 - Room Tubarão]
Dynamics and indirect finite-time synchronization of chaotic systems, Hilda A. Cerdeira, *Instituto de Física Teórica - UNESP, Universidade Estadual Paulista, Rua Dr. Bento Teobaldo Ferraz 271, Bloco II, Barra Funda, 01140-070 Sao Paulo, Brazil* ■We addresses the problem of finite-time synchronization of tunnel diode based chaotic oscillators. After a brief investigation of its chaotic dynamics, we propose an active adaptive feedback coupling which accomplishes the synchronization of tunnel-diode-based chaotic systems with and without the presence of delay(s), basing ourselves on Lyapunov and on Krasovskii-Lyapunov stability theories. This feedback coupling could be applied to many other chaotic systems. A finite horizon can be arbitrarily established by ensuring that chaos synchronization is achieved at a pre-established time. An advantage of the proposed feedback coupling is that it is simple and easy to implement. The case of relay-coupled oscillators in a small network of three chaotic oscillators will be discussed in detail

[04/11/2015 - 11:20 - Room Tubarão]
Chaos in MEMs/NEMs resonators, Wellington G. Dantas, André Gusso, *Universidade Federal Fluminense* ■The Galerkin's method is used to derive a consistent one degree of freedom (1DOF) model for a suspended fixed-fixed beam micro/nanoelectromechanical (MEM/NEM) resonator including the contributions of geometric non-linearity and the Casimir force. This model goes beyond the parallel plate approximation by including the main correction to the electrostaic and Casimir forces due to the beam curvature. The chaotic regime found in a small region of the parameter space close to the dynamic pull-in is fully characterized by means of the calculation of the Lyapunov exponent and bifurcation diagrams. The comparison with results presented in the literature, obtained using much more computationally demanding approaches, evidences the reliability of the proposed 1DOF model, and the relevance of incorporating the effects of beam curvature in simplified models of beam dynamics when large displacements are involved. We go further on that analysis studying similar systems and trying to stablish the sources to the appearing of this chaotic regime in such devices. A systematic analysis has been carried out in order to understand all possible regimes to the vibration of those resonators using as control parameters three typical quantities in those devices. Some modifications in its architecture or in the dissipation mechanism modelling are made, trying to stablish the robustness of each dynamical regime.

[04/11/2015 - 11:35 - Room Tubarão]
Finite-time generalized high-order Lyapunov exponents for kicked double rotor, Rodrigo Frehse Pereira, *Federal University of Technology - Paraná* ■The ordinary Lyapunov exponents spectrum describes the average exponential expansion/shrinkage rates of the axis of an infinitesimal ball around a trajectory under the temporal evolution

of a dynamical system. These exponents are given by the linearization of the ruling equations. Due to intrinsic nonlinearities present in models that present chaotic dynamics, nonlinear effects, swept off by the linearization, can be crucial in elucidating details of the temporal evolution of such systems. Moreover, since Lyapunov exponents are dynamic invariants computed as an average over an ergodic trajectory, they are "blind"about local/finite-time fluctuations present in typical chaotic dynamical systems. We present a detailed analysis of the finite-time fluctuations of the generalized high-order Lyapunov exponents for a physical system composed of a periodically kicked double rotor. We focus in its chaotic regime and in the transition from chaos to hyper-chaos as the intensity of the kicks is increased. Generalized high-order Lyapunov exponents are given by the analysis of high-order derivatives of the dynamical equations, which define linear mappings and their effects over the Lyapunov vectors are studied in a similar manner done for ordinary Lyapunov exponents. We study the temporal fluctuations of these high-order Lyapunov exponents for finite-time trajectories and relate their properties with those observed in the chaos / hiper-chaos transition.

[04/11/2015 - 11:50 - Room Tubarão]
Defining universality classes for three different local bifurcations, Edson Denis Leonel, *UNESP - Departamento de Física* ■The convergence to the fixed point at a bifurcation and near it is characterized via scaling formalism for three different types of local bifurcations of fixed points in differential equations, namely: (i) saddle-node; (ii) transcritical; and (iii) supercritical pitchfork. At the bifurcation, the convergence is described by a homogeneous function with three critical exponents α, β and z. A scaling law is derived hence relating the three exponents. Near the bifurcation the evolution towards the fixed point is given by an exponential function whose relaxation time is marked by a power law of the distance of the bifurcation point with an exponent δ. The four exponents α, β, z and δ can be used to defined classes of universality for the local bifurcations of fixed points in differential equations. The formalism is proved to be valid and can be used in either mappings and nonlinear differential equations. In a family of logistic-like mapping of the type $x_{n+1} = Rx_n(1 - x_n^\gamma)$, the exponent α is independent on the nonlinearity of the mapping while both β and z do indeed depend on γ for both transcritical and saddle-node bifurcation. The critical exponents for the period doubling bifurcation however do not depend on γ and seem to be universal. Because of the so called normal forms, the three main bifurcations above mentioned can be observed in a set of three distinct differential equations. The present approach can be an alternative to define classes of universality in local bifurcations both in mappings and in differential equations.

[04/11/2015 - 12:05 - Room Tubarão]
Crises in a non-conservative bouncer model, André L. P. Livorati, Carl P. Dettmann, Iberê L. Caldas, Edson D. Leonel, *Departamento de Física - UNESP - campus de Rio Claro* ■The dynamics of a bouncing ball model under the influence of dissipation is investigated by using a two dimensional nonlinear mapping. The dynamics can be basically described as a free particle that collides with a vibrating plate under the influence of a constant gravitational field. The dissipation is introduced via a restitution coefficient between the vibration platform and the free particle. The perturbation parameter is set as a ratio between accelerations of the particle and the moving platform. For low dissipation regime, the root mean square velocity of the particle grows for short times, pass through a crossover and then bend towards a stationary state. This behaviour is characterized by scaling laws. When high dissipation is considered, the dynamics evolves to different attractors. The evolution of the basins of the attracting fixed points is characterized, as we vary the control parameters. Crises between the attractors and their boundaries are observed. We found that the multiple attractors are intertwined, and when the boundary crisis between their stable and unstable manifolds occur, it creates a successive mechanism of destruction for all attractors originated by the sinks. Also, a physical impact crises is described, an important mechanism in the reduction of the number of attractors.

q-STATISTICS

[04/11/2015 - 11:00 - Room Vitória]
Thermodynamic Framework for a Nonextensive System, Fernando D. Nobre, Evaldo M.F. Curado, *Centro Brasileiro de Pesquisas Físicas*, Andre M.C. Souza, *Departamento de Física, Universidade Federal de Sergipe*, Roberto F.S. Andrade, *Instituto de Física, Universidade Federal da Bahia* ■Recently, an effective temperature θ was introduced within the context of interacting vortices in type II superconductors. The quantity θ was shown to represent an appropriate definition of effective temperature for this system, exhibiting properties very similar to those of the usual thermodynamic temperature T, being: (a) A positive quantity by definition; (b) Thermodynamically conjugated to a generalized entropy per particle, s_q with $q = 2$, characteristic of nonextensive statistical mechanics. In this way, a heat contribution was defined, $\delta Q = \theta ds_2$; (c) Proportional to the density of vortices n. This property yields the desirable possibility for varying θ, since recent experimental researches in type II superconductors led to considerable advances in the ability of controlling many properties of these vortices, including their density; (d) Characterized by values that are much higher than typical room temperatures ($\theta \gg T$), so that the thermal noise can be neglected as a good approximation ($T/\theta \simeq 0$); (e) Physically interpreted in terms of the variance of the vortex positions, $\theta \propto \langle x^2 \rangle^{3/2}$; (f) Consistent with the definition of a Carnot cycle, whose efficiency was shown to be $\eta = 1 - (\theta_2/\theta_1)$, where θ_1 and θ_2 represent the effective temperatures associated with the isothermal transformations of the cycle, with $\theta_1 > \theta_2$. In order to achieve this later result, an infinitesimal-work term δW was introduced, leading to a proposal for the first law of thermodynamics. In the present work we explore the heat contribution, $\delta Q = \theta ds_2$, by considering systems in thermal contact in such a way to exchange heat among themselves. Important concepts like thermal equilibrium and heat reservoir are introduced, and particularly, the zeroth principle is established.

Moreover, we consolidate the first-law proposal by following the usual procedure for obtaining different potentials, i.e., applying Legendre transformations for distinct pairs of independent variables. From these potentials we derive the equation of state, Maxwell relations, and define response functions. All results presented are shown to be consistent with those of standard thermodynamics for $T > 0$.

[04/11/2015 - 11:20 - Room Vitória]
The standard map as an example of crossing from Boltzmann-Gibbs statistics to Tsallis statistics., Ugur Tirnakli, *Ege University, Izmir, Turkey*, Ernesto P. Borges, *Universidade Federal da Bahia*
■As well known, Boltzmann-Gibbs statistics is the correct way of thermostatistically approaching ergodic systems. On the other hand, nontrivial ergodicity breakdown and strong correlations typically drag the system into out-of-equilibrium states where Boltzmann-Gibbs statistics fails. For a wide class of such systems, it has been shown in recent years that the correct approach is to use Tsallis statistics instead. Here we show how the dynamics of the paradigmatic conservative (area-preserving) standard map, exhibits, in an exceptionally clear manner, the crossover between both statistics. Our results unambiguously illustrate the domains of validity of both Boltzmann-Gibbs and Tsallis statistics. The standard map is defined as $p_{i+1} = p_i - K \sin x_i,\ x_{i+1} = x_i + p_{i+1}$, where p and x are taken as modulo 2π. This map has very rich properties depending on the map parameter K. The phase space of the standard map presents regions of positive Lyapunov exponents coexisting with regions of zero Lyapunov exponents. The positive Lyapunov regions present mixing and thus the system is ergodic in those regions. For sufficiently low values of the control parameter K, the phase space is almost entirely dominated by zero Lyapunov behavior and the distributions (obtained through time averaging, along the lines of central limit theorems) are q-Gaussians. As the value of K increases the measure of the zero Lyapunov regions decreases, and we see a continuous crossing between q-Gaussians distributions (Tsallis statistics) and Gaussian ones (Boltzmann-Gibbs statistics). Remarkably enough, the distributions originated from initial conditions taken inside the region of islands, instead of over the entire phase space, yield one and the same value $q = 1.935$, independently on whether we consider one or many of these regions, and independently from K. Initial conditions taken within the chaotic sea always yield Gaussians. Since various important physical systems from particle confinement in magnetic traps to autoionization of molecular Rydberg states, through particle dynamics in accelerators and comet dynamics, can be reduced to the standard map, our results are expected to enlighten and enable an improved interpretation of diverse experimental and observational results.

[04/11/2015 - 11:35 - Room Vitória]
A NEW INSIGHT ABOUT THE STELLAR VARIABILITY USING NONEXTENSIVE ENTROPY: FROM ASTROPHYSICAL NOISE TO EXOPLANETS, Daniel B. de Freitas, *DFTE/UFRN*
■Time series analysis is an enormous field of study in mathematical statistics, econometrics, signal processing, and other fields, among them, astronomy. Using a wide array of statistical tools including entropy concepts and complex systems theory, the present work proposes to investigate time series that exhibit variabilities in a very broad spectrum of research interests, ranging from astrophysical noise, rotational modulation and pulsation to planetary transit and explosive events. Thus, we intent have been to develop a powerful statistical environment for study of nonstationary, nonlinear, quasi-periodic, unevenly spaced, and non-equilibrium time series in astrophysics. For that, our research will point toward the stochastic processes associated to dynamical complexity in time series from Kepler spacecraft telescope. No doubt, dynamical complexity is a phenomenon expected to be observed in astrophysical time series when normal and abnormal states (e.g. pre-storm activity and magnetic storms) are detected. In this context, distinct physical effects in the stellar photosphere associated to large and short variabilities and multifractal structure can be discriminated using diagnostic tools for forthcoming extreme events. In our case, these phenomena are characterized by an entropic index q which leads to a nonextensive statistics. In several scenarios, time-dependent q-entropy effectively detects with a high precision small and crucial details in dynamics of the signal, where the vast majority of statistical techniques fails. The results show that Tsallis entropy can effectively detect the dissimilarity of complexity between the different variabilities present in our sample.

[04/11/2015 - 11:50 - Room Vitória]
Non-additivity and Complex Systems, Marcelo A. Moret, *UNEB e SENAI-CIMATEC*
■Many complex physical, chemical, economical, and biological systems manifest non-additivity characterized by long-tail distributions. Recently, we studied different time series that presented non-additive behavior in astrophysical sources, neuronal responses, dengue fever epidemics, proteins, sunspots, vehicle demand on the ferry-boat system, among others. That said, we studied light curves coming from astrophysical systems. We observe that astrophysical objects obey q-Gaussian distribution as probability density and the q-value increases for systems when the Tsallis entropy decreases. The classical concepts establish that the magnitude of spontaneous miniature end-plate potentials of mammals recorded at neuromuscular junctions is characterized by Gaussian statistics and that their intervals are randomly displayed, but it is not true. Power laws of protein mass, volume and solvent-accessible surface area are observed and q-Gaussian distributions fit well for this class of systems. When we analyzed the time series of vehicle demand on the ferry-boat system we note that stationary states of this dynamics process can be obtained by a nonlinear Fokker-Planck equation. On the other hand, the distribution of the sunspots obeys a q-exponential decay that suggests a non-extensive behavior. This observed characteristic seems to take an alternative interpretation of the sunspots dynamics. The present findings suggest us to propose a dynamic model of sunspots formation based on a nonlinear Fokker-Planck equation. The number of epidemiological dengue cases for each city follows a Self-Organized Criticality behavior (SOC). However, the analysis of

the number of cases in Bahia exhibits a q-exponential distribution. To understand this different behavior, we analyzed the distribution of the power law of SOC (γ) for all biomes of Bahia. Finally, we show in this paper that nature often behaves as non-additive object and, sometimes, non-extensively.

[04/11/2015 - 12:05 - Room Vitória]

Time reversibility for stochastic dynamics with multiplicative noise, Zochil González Arenas, *Departamento de Matemática Aplicada, IME, Universidade do Estado do Rio de Janeiro*, Daniel G. Barci, Miguel Vera Moreno, *Departamento de Física Teórica, Universidade do Estado do Rio de Janeiro*

■Stochastic differential equations and its applications is a subject of great interest for scientific research. In this area, Langevin and Fokker-Planck formalisms are extensively used. Systems modeled by differential stochastic equations with additive noise have been largely studied and are the most popular models. However, the understanding of the stochastic dynamics and the evolution to equilibrium for systems dealing with multiplicative noise is difficult and there is a lack of general tools for its characterization. In particular, for the multiplicative noise case, the Fokker-Planck equation does depend on the chosen prescription for the stochastic integration of the associated Langevin equation. In such case, it is possible for time evolutions to reach non-Boltzmann equilibrium states.

To deal with these systems, we use a general prescription α for considering the stochastic integration. α is defined as a continuous parameter, $0 \leq \alpha \leq 1$, and each of its values corresponds with a different discretization rule for the stochastic differential equation. $\alpha = 0$ corresponds with Itô prescription at the time that $\alpha = 1/2$ corresponds with Stratonovich one. We also represent the stochastic process in a functional Grassman formalism [1], which turns out to be very convenient for handling stochastic trajectories.

In this work [2-4], we study equilibrium properties of Markovian multiplicative white-noise processes. For this, we carefully define the time reversal transformation for this kind of processes, taking into account that the asymptotic stationary probability distribution depends on the prescription. In white noise multiplicative processes, stochastic trajectories evolve with different prescriptions in one direction and in the reverse direction. We show that, using a careful definition of equilibrium distribution and taken into account the appropriate time reversal transformation, usual equilibrium properties, such as detailed balance, are satisfied for any prescription.

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Oral sessions (14:30-16:05)

COARSENING AND INTERFACES

[04/11/2015 - 14:30 - Room Tubarão]
Coarsening in inhomogeneous systems, Federico Corberi, *Salerno University - Italy* ■I will review the topic of coarsening phenomena occurring in ferromagnetic systems where quenched features - such as random field, varying coupling constants or lattice vacancies - spoil homogeneity. I will discuss the current understanding of the problem in systems with a non-conserved scalar order parameter by focusing primarily on the form of the growth-law of the ordered domains and on the scaling properties. A general picture emerges characterized by two possible growth-laws, either logarithmic or algebraic, connected by a crossover phenomenon. In systems where lack of homogeneity is due to dilution an interpretation of these two growth-forms can be given in terms of the topology of the underlying diluted network hosting the magnetic system. In particular, a conjecture is proposed where a logarithmic or a power-law growth are associated to the presence/absence of an equilibrium phase-transition. I will discuss how such a conjecture is supported by the results of numerical simulations of paradigmatic model systems such as the Ising model with either site or bond diluted, both in the case of a stochastic dilution and in that of deterministic fractal graphs. The relevance of this to the case of different systems with other sources of inhomogeneities will be also discussed.

[04/11/2015 - 14:50 - Room Tubarão]
Transition from compact to porous films in deposition with temperature activated diffusion, D. di Caprio, *CNRS (France)*, Fábio D. A. Aarão Reis, *Universidade Federal Fluminense* ■We study a thin film growth model with temperature activated diffusion of adsorbed particles, allowing for the formation of overhangs and pores, but without detachment of adatoms or clusters from the deposit. Simulations in one-dimensional substrates are performed for several values of the diffusion-to-deposition ratio R of adatoms with a single bond and of the detachment probability ϵ per additional nearest neighbor (NN), respectively with activation energies are E_s and E_b. If R and ϵ independently vary, regimes of low and high porosity are separated at $0.075 \leq \epsilon_c \leq 0.09$, with vanishingly small porosity below that point and finite porosity for larger ϵ. Alternatively, for fixed values of E_s and E_b and varying temperature, the porosity has a minimum at T_c, and a nontrivial regime in which it increases with temperature is observed above that point. This is related to the large mobility of adatoms, resembling features of equilibrium surface roughening. In this high-temperature region, the deposit has the structure of a critical percolation cluster due to the non-desorption. The pores are regions enclosed by blobs of the corresponding percolating backbone, thus the distribution of pore size s is expected to scale as $s^{-\tilde{\tau}}$ with $\tilde{\tau} \approx 1.45$, in reasonable agreement with numerical estimates. Roughening of the outer interface of the deposits suggests Villain-Lai-Das Sarma scaling below the transition. Above the transition, the roughness exponent $\alpha \approx 0.35$ is consistent with the percolation backbone structure via the relation $\alpha = 2 - d_B$, where d_B is the backbone fractal dimension.

[04/11/2015 - 15:05 - Room Tubarão]
Experimental Realization of Interfacial Fluctuations in the Kardar-Parisi-Zhang Universality Class: A Non-Orthodox Approach & Its Consequences for Kinetic-Roughening Status, R. A. L. Almeida, S. O. Ferreira, *Universidade Federal de Viçosa, Minas Gerais, Brazil*, T. J. Oliveira, *Iowa State University, Ames, United States*, F. D. A. A. Reis, *Universidade Federal Fluminense, Rio de Janeiro, Brazil* ■The Kardar-Parisi-Zhang (KPZ) Universality Class has been helding a central, cornerstone position in the realm of non-equilibrium Physics since the seminal work of KPZ in 1986 [1]. Inspired by Landau-Ginzburg Theory from Equilibrium Statistics, KPZ proposed the simplest, local, continuum and non-linear equation to describe the dynamic of growing surfaces. Unexpectedly, since then, the KPZ class has been showing to underlie the behaviour of a rich family of equilibrium and out-of-equilibrium phenomena beyond its initial purpose. Examples touch models for protein traffic flow, global paths of random walks in random landscapes, lines in superconductors, coffe-rings' effect, besides a striking, wonderful connection to random matrices theory. While most advances have been done in $d = 1 + 1$ dimensions, tying theory, simulations and an increasing number of experiments in a KPZ triumvirate, much less attention has been paid to $2 + 1$ due to the inexorable difficulties to handle mathematically, numerically and experimentally such systems. As consequence, 2D-KPZ experiments, for instance, were not convincingly demonstrated until last year [2,3]. In this talk, we show an unprecedented experimental realization of 2D-KPZ by keeping track on fluctuations at interface of CdTe thin-films grown on Si. Critical exponents are unearthed and demonstrated to agree with numerical results for 2D-KPZ models. Going further the orthodox analysis, we experimentally demonstrate that: i) An universal, rescaled Height Distribution (HD), upper dimensional counterpart of the Tracy-Widom distribution, emerge in the system. Interestingly, a non-integer Gumbel distribution seems to fit well HD data. ii) Squared Local Roughness Distributions exhibit striking agreement with numerical simulations of lattice models, revealing a new universal signature of KPZ, highlighted by its stretched exponential decay. iii) Connection with statistics of extremes provide other universal distribution for 2D-KPZ systems. In the last part, we show how to use i-iii) to uncover the possible KPZ universality in fluctuating surfaces when poor statistics and strong finite-time effects are unavoidable, a common experimental situation. We use this scheme to analyse the temperature effect on our experimental KPZ system. Finally, consequences of i-iii) into the current Kinetic-Roughening Status are addressed.

The authors acknowledge support from FAPEMIG and CAPES.

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[04/11/2015 - 15:20 - Room Tubarão]
Interface fluctuations for deposition on enlarging flat substrates., Ismael Segundo da Silva Carrasco, Tiago José de Oliveira, Sílvio da Costa Ferreira Júnior, *Universidade Federal de Viçosa*, Kazumasa A. Takeuchi, *The University of Tokyo* ■We investigate solid-on-solid models that belong to the Kardar-Parisi-Zhang (KPZ) universality class on substrates that expand laterally at a constant rate by duplication of columns. Despite the null global curvature, we show that all investigated models have asymptotic height distributions and spatial covariances in agreement with those expected for the KPZ subclass for curved surfaces. In 1 + 1 dimensions, the height distribution and covariance are given by the GUE Tracy-Widom distribution and the Airy_2 process instead of the GOE and Airy_1 foreseen for flat interfaces. These results imply that when the KPZ class splits into curved and flat subclasses, as conventionally considered, the expanding substrate may play a role equivalent to, or perhaps more important than, the global curvature. Moreover, the translational invariance of the interfaces evolving on growing domains allowed us to accurately determine, in 2 + 1 dimensions, the analog of the GUE Tracy-Widom distribution for height distribution and that of the Airy_2 process for spatial covariance. Temporal covariance is also calculated and shown to be universal in each dimension and in each of the two subclasses. A logarithmic correction associated with the duplication of columns is observed and theoretically elucidated. Finally, crossover between regimes with fixed-size and enlarging substrates is also investigated. We acknowledge FAPEMIG, CAPES and CNPq by the financial support.

[04/11/2015 - 15:35 - Room Tubarão]
Diffusion, fluctuations and coarsening in an active dumbbell system, Giuseppe Gonnella, Leticia Cugliandolo, Antonio Suma, *Dipartimento di Fisica dell'Università di Bari* ■Active matter refers to systems driven out of equilibrium by energy sources continuously transformed into movement or work on the enviroment. These systems exhibit many peculiar properties not present in their passive counterparts, like clustering, anomalous diffusion and fluctuations, unexpected rheological properties.
Here, we will review the results obtained from the study of a two-dimensional system of active dumbbells, introduced as a paradigmatic example of a system of non symmetrical brownian particles with self-propulsion. Each dumbbell is composed by two colloids kept together by a rigid spring, with an excluded volume interaction modeled through a Weeks-Chandler-Anderson (WCA) potential. They are immersed in an implicit solvent modeled by the Langevin equation. The activity or self-propulsion is modeled by a constant force acting on the principal direction of the dumbbell.
We find that activity triggers a nonequilibrium phase separation if the density exceeds a critical threshold and if the Peclet number is high enough. We study the kinetics of the aggregates of dumbbells in the phase separated region. The clusters spontaneously break chiral symmetry and rotate; they also display a nematic ordering with spiral patterns. We can also determine the growth law for the size of these clusters.
On the other hand, for the phase without aggregation, we determine the translational and rotational diffusion properties. Different regimes can be observed, depending on the combination of the random noise, the activity and the density of the system. These results can be compared with experimental results found in bacterial suspensions. Unusual increase with density of the rotational diffusion is also found and explained as due to particle clustering. Large deviation functions for dumbell velocities have been finally determined showing the appearance of non-singular behaviour.

SOCIAL DYNAMICS

[04/11/2015 - 14:30 - Room Vitória]
Society Collapse through erroneous Annual Tax rates: Piketty Recipe, Paulo Murilo Castro de Oliveira, *UFF/UNILA* ■A simple N-agents dynamic model is introduced with two ingredients:
I) During the year, agents are randomly tossed to increase their wealth. Tossed agent i doubles its wealth W_i towards $2W_i$. The tossing is repeated N times, one agent could be tossed more than once. Then, the wealth distribution is kept normalized $\sum_i W_i = 1$.
II) At the year end, all agents pay their annual taxes with rates pW_i (net tax pW_i^2), where p is a control parameter. Then, the wealth distribution is again kept normalized, $\sum_i W_i = 1$.
(As a matter of technicality, the normalization is performed because we are not interested in the economy growing as a whole, only in the distribution of wealths and its inequalities. For those interested in it, we can inform that the factor 2 warrants an forever-growing economy.)
For $p = 0$, all agents pay the same tax rate. After many years, the whole society collapses, i.e. a single agent owns the whole wealth. This situation is an absorbing state. For $p > 0$, rich agents pay larger taxes than poor agents. For p larger than a critical value $p_c \approx 0.3$ the collapse is avoided, the distribution of wealths survives forever and the absorbing state is never reached. So, there is a transition at p_c. An order parameter for this transition is constructed by ordering the wealth distribution in decreasing order (Zipf plot), and calculating its first moment. The result is obviously null for $p < p_c$ (collapse), but positive in the surviving phase $p > p_c$. We are now calculating the precise value of p_c, as well as the critical indices of this transition.
We tested also the Tea Party ideology, rich agents paying smaller tax rates than poor agents. This corresponds to $p < 0$. The result is simply a predictable collapse acceleration, according to Piketty.

[04/11/2015 - 14:50 - Room Vitória]
Forecasting collective trends in human opinion, M. Ramos, J. Shao, S. D. S. Reis, C. Anteneodo, J. S. Andrade, S. Havlin, H. A. Makse, *PUC-Rio* ■We investigate how extreme opinion trends arise in society by analyzing polls that inquire about a wide range

of issues such as religion, economics, politics, abortion, extramarital sex, books, movies, and electoral vote. The surveys lay out a sharp statistical predictor for the rise of extreme views in society. The precursor is a nonlinear relation between the fraction of individuals holding a certain extreme view and the fraction of individuals that includes also the moderates, e.g., in politics, those who are "very conservative" versus "moderate to very conservative". By means of statistical physics modeling, we show that the onset of the nonlinearity allows to forecast the transition from moderate to extreme opinion before it actually occurs. The tipping point is the result of an abrupt bootstrap-percolation transition with cascades of extreme views caused by the "stubbornness" of individuals, as suggested by modeling. By means of a phase diagram given in terms of critical fractions of extremists and number of peoples ties, we classify societies from moderate to extreme. The nonlinearity is ubiquitous across a diversity of polls and countries and may reflect a remarkable "generic" feature of human collective behavior at large.

Ref.: Ramos, M., Shao, J., Reis, S. D. S., Anteneodo, C., Andrade, J. S., Havlin, S., & Makse, H. A. *How does public opinion become extreme?* Scientific Reports 5, 10032 (2015).

[04/11/2015 - 15:05 - Room Vitória]

Analytical expression for the exit probability of the q-voter model in one dimension., André M. Timpanaro, *Instituto de Física da Universidade de São Paulo, Brazil*, Serge Galam, *CEVIPOF - SciencesPo, France* ■We present in this paper an approximation that is able to give an analytical expression for the exit probability of the q-voter model in one dimension. This expression gives a better fit for the more recent data about simulations in large networks [A. M. Timpanaro and C. P. C. do Prado, Phys. Rev. E 89, 052808 (2014)] and as such departs from the expression $\frac{\rho^q}{\rho^q+(1-\rho)^q}$ found in papers that investigated small networks only [R. Lambiotte and S. Redner, Europhys. Lett. 82, 18007 (2008); P. Przybyla et al., Phys. Rev. E 84, 031117 (2011); F. Slanina et al., Europhys. Lett. 82, 18006 (2008)]. The approximation consists in assuming a large separation on the time scales at which active groups of agents convince inactive ones and the time taken in the competition between active groups. Some interesting findings are that for $q = 2$ we still have $\frac{\rho^2}{\rho^2+(1-\rho)^2}$ as the exit probability and for $q > 2$ we can obtain a lower-order approximation of the form $\frac{\rho^s}{\rho^s+(1-\rho)^s}$ with s varying from q for low values of q to $q-\frac{1}{2}$ for large values of q. As such, this work can also be seen as a deduction for why the exit probability $\frac{\rho^q}{\rho^q+(1-\rho)^q}$ gives a good fit, without relying on mean-field arguments or on the assumption that only the first step is nondeterministic, as q and $q-\frac{1}{2}$ will give very similar results when $q \to \infty$.

[04/11/2015 - 15:20 - Room Vitória]

Unraveling people interactivity by means of electoral vote, A. Mondaini, N. Crokidakis, C. Anteneodo, *Department of Physics, PUC-Rio, Rio de Janeiro, RJ, Brazil* ■Elections embody valuable information on the dynamics through which individuals influence each other and make choices. We analyze proportional elections in Brazil, a country with a diversified and huge electorate of around 100 million people, covering the period 1970-2012, which encompasses two distinct political regimes: a military regime followed by a democratic one. Through the distribution $P(v)$ of the number of candidates receiving v votes, we perform a comparative analysis of different elections in the same calendar and as a function of time. We also show the impact of the different political regimes on the vote distributions. Inspired in multi-species population dynamics, we propose a model, consisting in a system of nonlinear differential equations with stochastic parameters, that allows to predict and interpret the observed features. We show that the distribution of votes among candidates reveals patterns that reflect the evolution of people interactions. In particular, a statistical property of vote distributions, that appears to be predominantly associated to the electorate, can be used as a measure of its degree of feed-back. Such measure of a population, which is hard to be accessed otherwise, may be useful to know the extent to which people interact and can be influenced, even beyond the context of political elections.

[04/11/2015 - 15:35 - Room Vitória]

REPUTATION IN MAJORITY RULE MODEL LEADING TO DEMOCRATIC STATES, Fabricio L. Forgerini, *Federal University of Amazonas* ■In this work we introduce a mechanism, Reputation, that limits the persuasion capacity of the agents in the Majority Rule model. It is realistic to believe that the individuals will change their opinions under the influence of highly respected persons. To include this characteristic, we introduce the Reputation, which is a score for each agent and it is compared with other agents before each opinion's flip. In traditional consensus models one can find, for an initial opinion greater than certain threshold, two absorbent states in the long run, all agents with opinions $+1$ or -1. This situation, with fixed points with all spins parallel, describe the opinion in a dictatorship, and do not represent a common situation in public debates and real opinion dynamics. In this work we select **g** agents as part of the discussion group and interact among each other to follow the most popular opinion in the group. The average Reputation of the majority opinion, $\langle r \rangle$ is calculated. However, only the agents with Reputations smaller than $\langle r \rangle$ will flip to follow the dominant opinion. We show that the inclusion of the Reputation change this behavior in Majority Rule models, reaching a consensus with a majority spins parallel (but not all agents on network), which corresponds to a democracy-like situation. We believe that the inclusion of agents reputation makes the consensus models more realistic.

[04/11/2015 - 15:50 - Room Vitória]

Statistical patterns in movie ratings, Marlon F. Ramos, Angelo M. Calvão, Celia Anteneodo, *Depto. de Física, PUC-Rio* ■In recent decades, statistical physics has contributed to the study of social dynamics through theoretical models, providing insights and uncovering the crucial laws that govern phenomena such as the spread of information, rumors and opinions. While there has been notable progress in developing theoretical models, their validation by direct confrontation with real data has yet to be achieved. Nowadays, thanks to websites for ratings and recommendations, new possibi-

lities have arisen to explore this field. In fact, users and consumers can review and rate products through online services, which provide huge databases that can be used to explore people's preferences and unveil behavioral patterns. In this work, we aim to explore patterns in movie rating behavior. As a source of information on the distribution of people's preferences, we consider IMDb (Internet Movie Database), a highly visited site worldwide. The number of votes (where a vote consists of assigning a star rating) rather than, for example, the total number of movie admissions, is a suitable way to measure the popularity of a given movie. We find that the distribution of votes presents scale-free behavior over several orders of magnitude, with an exponent very close to 3/2, with exponential cutoff. It is remarkable that this pattern emerges independently of movie attributes such as average rating, age and genre, with the exception of a few genres and of high-budget films. These results point to a very general underlying mechanism for the propagation of adoptions across potential audiences that is independent of the intrinsic features of a movie and that can be understood through a simple spreading model of avalanche dynamics.

Oral sessions (17:05-18:15)

NETWORKS

[04/11/2015 - 17:05 - Room Vitória]
Collective versus hub activation of endemic states on networks, Silvio C. Ferreira, *Universidade Federal de Viçosa - Mina Gerais - Brazil* ■Heterogeneous topological patterns of contacts, such as those exhibited by many natural and artificial complex networks, can utterly alter the behavior of dynamical processes mediated by them, as compared with the classical expectations in regular lattices. One of most remarkable results is that the epidemic threshold of the susceptible-infected-susceptible (SIS) model on scale-free (SF) networks with a degree distribution $P(k) \sim k^{-\gamma}$, where γ is the degree exponent, is zero in the infinite size limit. Theoretical approaches showing that hubs in a network (identified as star graphs) can have an exceedingly large lifetime of activity in SIS model and that stars can reinfect each other through connected paths imply in an active endemic state for any infection rate $\lambda > 0$. These results highlight the role the the large survival infection time of hubs in the SIS model have on the sustaining of the endemic active state. Here we will discuss the extension of these concepts to more generic epidemic processes. Particularly, we considered temporary immunization conferred after the infective period in simple susceptible-infected-removed-susceptible (SIRS) epidemic model, which is equivalent to SIS in the basic theoretical approaches for epidemic processes. However, our theoretical analysis predicts that the interplay between lifetime of hubs and th reinfection mechanism in SIRS model leads to different outcomes depending on the degree exponent γ. For $\gamma < 3$, a SIS-like behavior having a null threshold in the infinite size limit is predicted. For $\gamma > 3$ a finite threshold, where endemic state is possible only through a collective activation of the whole network, is obtained for any finite immunization period, drastically contrasting with the SIS model. Extensive numerical simulations support our predictions.
Financial support: FAPEMIG, CAPES and CNPq

[04/11/2015 - 17:25 - Room Vitória]
Fast Fragmentation of Networks using Module-Based Attacks, Bruno Requião da Cunha, *Departamento de Polícia Federal, Porto Alegre, RS*, Juan Carlos González-Avella, *Departamento de Física, Pontificia Universidade Católica do Rio, RJ*, Sebastián Gonçalves, *Instituto de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS* ■In the multidisciplinary field of Network Science, optimization of procedures for efficiently breaking complex networks is attracting much attention from two practical points of view: attacking and preventing attacks or failures. In this contribution we present a novel procedure to break complex networks guided by the identification of modular structures. Our module-based method first identifies communities in which the network can be represented, then it deletes the nodes or edges that connect different modules by decreasing order in the betweenness centrality ranking list. We illustrate the method by applying it to various well known examples of social (Facebook, Google+, and Twitter), infrastructure (US power

grid, Euro road, Open flights, and US airports), and biological (Yeast protein, C elegans, and H pylori) networks. We show that the proposed method always outperforms vertex attacks which are based on the ranking of node degree or centrality, with a huge gain in efficiency for some examples. Remarkably, for the US power grid, the present method breaks the original network of 4941 nodes to many fragments smaller than 210 nodes ($\approx 4\%$ of the original size) by removing mere 142 nodes (less than 3%) identified by the procedure. By comparison, any degree or centrality based procedure, deleting the same amount of nodes, removes only 18% of the original network, i.e. more than 4000 nodes continue to be connected after that.

[04/11/2015 - 17:40 - Room Vitória]
Emergence and persistence of communities in co-evolutionary networks, Juan C G Avella, M. G. Cosenza, J. L. Herrera, K. Tucci, *Pontifícia Universidade Católica PUC-RJ, Universidad de Los Andes, Universidad de Los Andes, Univerisdad de Los Andes* ■We investigate the emergence and persistence of communities through a recently proposed mechanism of adaptive rewiring in co-evolutionary networks. We characterize the topological structures arising in a co-evolutionary network subject to an adaptive rewiring process and a node dynamics given by a simple voter-like rule. We find that, for some values of the parameters describing the adaptive rewiring process, a community structure emerges on a connected network. We show that the emergence of communities is associated to a decrease in the number of active links in the system, i.e. links that connect two nodes in different states. The lifetime of the community structure state scales exponentially with the size of the system. Additionally, we find that a small noise in the node dynamics can sustain a diversity of states and a community structure in time in a finite size system. Thus, large system size and/or local noise can explain the persistence of communities and diversity in many real systems.

[04/11/2015 - 17:55 - Room Vitória]
Avoiding cascading failures in correlated networks of networks, Saulo D. S. Reis, Y. Hu, A. Babino, S. Canals, J. S. Andrade, M. Sigman, H. A. Makse, *Universidade Federal do Ceará* ■Networks in nature do not act in isolation, but instead exchange information and depend on one another to function properly. Theory has shown that connecting random networks may very easily result in abrupt failures. Many organisms and biological systems in nature often interact with each other, exchanging information in a very efficient way. However, networks built by humans are more prone to cascading failures due to small perturbations, as in blackouts in power grids. Here we provide a solution to this conundrum, showing that the stability of a system of networks relies on the relation between the internal structure of a network and its pattern of connections to other networks. Specifically, we demonstrate that if interconnections are provided by network hubs, and the connections between networks are moderately convergent, the system of networks is stable and robust to failure. We test this theoretical prediction on two independent experiments of functional brain networks (in task and resting states), which show that brain networks are connected with a topology that maximizes stability according to the theory. Our results provide not only an answer to the question of why natural networks are more stable than artificial ones, but they also provide a prediction of how structured networks, whether natural or man-made, should be organized in order to acquire stability.

SOFT MATTER

[04/11/2015 - 17:05 - Room Tubarão]
Thermodynamic and dynamic anomalous behavior in the TIP4P/ε water model, Raul Fuentes-Azcatl, Marcia C. Barbosa, *Universidade Federal do Rio Grande do Sul* ■Water is a fascinating molecule. Even though present in our everyday life, it shows a number of properties that are still not well described. For example, most liquids contract upon cooling. This is not the case of water, a liquid where the specific volume at ambient pressure starts to increase when cooled below 4^C at atmospheric pressure. A number of models have attempted to describe the anomalous behavior of water. While polarizable models are time consuming and exhibit a large number of parameters, the non polarizable models fail in reproducing some anomalous behaviors of water. This is the case of the dielectric constant. In order to produce a nonpolarizable model capable of reproducing the dielectric constant and the solubility of the salt, a new model was developed. We introduce the Tip4p/ε model for water and this model is tested for the presence of thermodynamic and dynamic anomalies. Molecular dynamic simulations for this system were performed and we show that for the bulk the density versus temperature at constant pressure exhibits a maximum. In addition we also show that the diffusion coefficient versus density at constant temperature has a maximum and a minimum. The anomalous behavior of the density and of the diffusion coefficient obey the water hierarchy. The results for the Tip4p-ϵ are consistent with experiments and when compared with the Tip4p-2005 model show similar results a variety of physical properties and better performance for the value of the dielectric constant.

[04/11/2015 - 17:25 - Room Tubarão]
Self-Assembly and Waterlike Anomalies in Janus Nanoparticles, José Rafael Bordin, *Campus Caçapava do Sul, Universidade Federal do Pampa*, Leandro B. Krott, *Campus Araranguá, Universidade Federal de Santa Catarina*, Marcia C. B. Barbosa, *Instituto de Física, Universidade Federal do Rio Grande do Sul* ■We explore the pressure versus temperature phase diagram of dimeric Janus nanoparticles using Molecular Dynamics simulations in the NVT ensemble. The nanoparticles was modeled as a dumbbells particle, with two monomers connect by a rigid bond. The dimetic particle have one monomer that interacts by a standard Lennard Jones potential and a anomalous monomer that is modeled using a two-length scale shoulder potential. Monomeric and dimeric systems modeled by this shoulder potential show waterlike anomalies in bulk and in confinement. In this work, we investigate if a Janus nanoparticle composed by one anomalous monomer and a monomer without anomalous features will exhibit anomalous behavior and self-assembly structures. The influence of the non-anomalous monomer in the dimeric system properties was explored

changing the interaction potential from a attractive Lennard-Jones to a purelly repulsive WCA potential. We show that the diffusion anomaly is maintained, while the density anomaly can disappear depending on the non-anomalous monomer characteristics . As well, the self-assembled structures are affected. A lamellar structure was observed, as well different kinds of micelles, as spherical and elongated micelles. Our results are discussed in the basis of the distinct monomer-monomer interactions and on the two-length scale fluid characteristics. The paper was accepted for publication at Langmuir (http://pubs.acs.org/doi/abs/10.1021/acs.langmuir.5b01555).

[04/11/2015 - 17:40 - Room Tubarão]

New Structural Anomaly Induced by Nanoconfinement, Leandro B. Krott, *Universidade Federal de Santa Catarina*, José R. Bordin, *Universidade Federal do Pampa*, Marcia C. Barbosa, *Universidade Federal do Rio Grande do Sul* ■

In this work we explore the structural properties of anomalous fluids confined in nanopores using molecular dynamic simulations. The fluids are modeled by spherical particles that interact through core-softened potentials given by a repulsive shoulder and an attractive well at a further distance. The different potentials of the fluids are obtained changing the attractive well depth. The confining nanopores are given by two fixed hydrophobic and parallel plates. All the systems present the formation of two or three layers of particles. We studied the translational order parameter t and the excess entropy s_2 of the particles near to the nanopore walls (contact layer). In normal fluids, for fixed temperatures, t increases monotonically with the density and s_2 decreases monotonically with the density. Meanwhile, in anomalous fluids, like in water and silica, the parameter t presents a region of decreasing with density and s_2 presents a region of increasing with density. Under hydrophobic confinement, we found another unusual behavior. When the attractive well of the core-softened potential is shallow, the systems present a transition between two and three layers and the parameters t and s_2 present a second region of anomalous behavior. For attractive well deep enough, the systems do not present the structural transition neither the second region of structural anomaly. Our results indicate that the confinement induces the fluid to exhibit a new behavior, not observed in bulk systems [1].

[1] Leandro B. Krott, José R. Bordin and Marcia C. Barbosa. *New Structural Anomaly Induced by Nanoconfinement.* J. Phys. Chem. B, v. 119, p. 291-300, 2015.

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