Student's Contributions. First Week.

Granular media, colloids & interphases

G. Chamorro, Moises

On granular fluids driven by stochastic and drag forces

Moisés G. Chamorro, Francisco Vega Reyes, Vicente Garzó
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Abstract: The homogeneous state of a granular gas of smooth inelastic hard spheres fluidized by the presence of a random and a drag force described by the Enskog-Boltzmann equation is analyzed. The combined action of both forces tries to mimic the interaction of the set of particles with a surrounding fluid. This state is characterized by a scaled distribution function φ that does not only depend on the dimensionless velocity but also on the dimensionless driving force parameters. The dependence of φ and its first velocity moments a_2 and a_3 on both the coefficient of restitution α and the driven parameters is investigated by means of the DSMC method. In addition, approximate forms for a_2 and a_3 are also derived from an expansion of φ in Sonine polynomials. The theoretical expressions of the above Sonine coefficients agree well with simulation data, even for quite small values of α.

Majka, Maciej

A model for environment induced interaction between colloid particles.

M. Majka, P. F. Góra
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Abstract: The typical model of colloid is a system consisting of two particle species: one which can be observed and the other that acts as environment. The presence of environment results in the additional Effective Interaction (EI) between distinguished particles, which can lead to self-organization in the system. Standard theories can predict EI from various types of particle-environment interactions, but they neglect the influence of intra-environment interactions. We propose a new general model of EI, which includes both particle-environment and environment–environment interactions. The EI is expressed by a single compact-form formula combining the microscopic interactions. This result is not restricted to any specific potential type and can serve as a tool to design systems of desired characteristics. The theory is illustrated by several analytically or numerically solvable examples, including hard-sphere systems and the systems based on 'ion in the solution' interactions.

Rimas, Zilvinas

Title: Condensation of liquid in porous media

Zilvinas Rimas, Sergei Taraskin
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Abstract: Using a lattice constructed on a network representation for real soil samples we analytically and computationally investigate capillary condensation in out-of-equilibrium regime. The expressions for the critical parameters marking the appearance of hysteresis have been derived and tested computationally. By detailed comparison of the dynamics in the real soil network topology and random network, we found that the effects of spatial heterogeneity in soil network for

the most part can be neglected. However the distribution of the vertexes with a particular coordination number and the disorder in structural parameters of the constructed lattice has an immense influence to the dynamics. Therefore we deduce that random network with given distribution in coordination number and structural properties could be used to model real material.

Tyukodi, Botond

Depinning models and amorphous plasticity

B. Tyukodi, D. Vandembroucq

École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris, laboratoire PMMH (ESPCI - PMMH), Paris, France

Abstract: Recently, the study of the mechanical behavior of complex materials (ranging from soft foams, colloidal gels, pastes to the hard granular materials, structural glasses, porous or heterogeneous rocks) has attracted a growing number of physicists. Although very different regarding their typical length- or time scales, all of these materials share a common feature, the disorder of their structure and a common phenomelogy: instead of breaking/sliding/flowing in a smooth way, they exhibit intermittent and heterogeneous dynamics over a wide range of time and length scales. In particular, recent efforts have been focused on the plasticity of dense amorphous solids and we intend to address this question. In this study we focus on developing a mesoscopic depinning-like model inspired by previous closely related models developed to describe the propagation of elastic lines in random media (crack fronts, contact lines, magnetic walls) and known to exhibit a (depinning) dynamic phase transition.

Heinonen, Vili

Bcc crystal-fluid interfacial free energy in Yukawa systems

V. Heinonen(1), A. Mijailovic(2), C. V. Achim(1,2), T. Ala-Nissila(1,3), R. E. Rozas(2), J. Horbach(2) and H. Lowen(2)

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Abstract: We determine the orientation-resolved interfacial free energy between a body-centered-cubic (bcc) crystal and the coexisting fluid for a many-particle system interacting via a Yukawa pair potential. For two different screening strengths, we compare results from molecular dynamics computer simulations, density functional theory, and a phase-field-crystal approach. Simulations predict an almost orientationally isotropic interfacial free energy, which is independent of the screening strength. This value is in reasonable agreement with our Ramakrishnan-Yussouff density functional calculations, while a high-order fitted phase-field-crystal approach gives about 2-3 times higher interfacial free energies for the Yukawa system. Both field theory approaches also give a considerable anisotropy of the interfacial free energy. Our result implies that, in the Yukawa system, bcc crystal-fluid free energies are a factor of about 3 smaller than face-centered-cubic crystal-fluid free energies.

Kallus, Yoav

Pessimal shapes for packing and covering

Yoav Kallus

Princeton University

Abstract: Shapes that tile space provide an obvious optimum for packing fraction and covering fraction among all shapes. The question of which convex shapes leave the most empty space in their densest packing is much less obvious and has been the subject of various mathematical conjectures. I show that the ball is a local pessimum among centrally symmetric 3-dimensional shapes and the regular heptagon is a local pessimum among 2-dimensional shapes. In 2 dimensions and in dimensions above 3 the ball is not a local pessimum, so the situation in 3 dimensions is exceptional despite what might be expected naively. For covering, the ball is a local pessimum in 2 and 3 dimensions, but not in 4 and 5 dimensions.

Work & fluctuations

Kuśmierz, Lukasz

Heat and work distribution for mixed Gauss-Cauchy process

L. Kuśmierz(1), E. Gudowska-Nowak(1), J. M. Rubi(2)

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Abstract: We analyze energetics of a non-Gaussian process described by a linear stochastic differential equation. The process represents a paradigmatic model of a nonequilibrium system. We define thermodynamic quantities for trajectories of the process and analyze contributions to mechanical work and heat. As a working example we consider a particle subjected to a drag force and two independent additive Lévy white noises with stability indices $\alpha=2$ and $\alpha=1$. Distributions of dissipated heat and work performed by the force acting on the system are addressed by examining contributions of Cauchy fluctuations to either bath or external force acting on the system.

Kutvonen, Aki

Dissipated work and fluctuation relations for non-equilibrium single-electron transitions

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(1) COMP CoE at the Department of Applied Physics, Aalto University School of Science, Espoo, Finland (2)Low Temperature Laboratory (OVLL), Aalto University School of Science, Espoo, Finland (3) Department of Physics, Brown University, Providence, USA

Abstract: We discuss a simple but experimentally realistic model system, a single-electron box (SEB), where common uctuation relations can be tested for driven electronic transitions. We show analytically and numerically that Jarzynski equality can be violated even if the system starts from equilibrium, the process in contact with only one heat bath and we perform no feedback. However, an integral uctuation relation based on total entropy production works also in this situation.

Mihelich, Martin

Maximum entropy production and ASEP model

M. Mihelich(1), B. Dubrulle(1) and D. Paillard(2)

(1) Service de Physique de l'Etat Condensé, Direction des Sciences de la Matière, CEA-Saclay, CNRS URA 2464, 91191 Gif-sur-Yvette cedex, France (2) Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS Centre d'Etudes de Saclay, Orme des Merisiers Gif-sur-Yvette, France

Abstract: The Principle of Maximum Entropy Production (MEP) stipulates that an nonequilibrium stationary system selects the state which maximizes the entropy production taking into account contrains. Though many attempts to demonstrate this principle did not lead to convincing evidence, it has been used in many fields such as solid physics, electromagnetism, quantum physics or climate science. MEP is widely used because it permits to obtained well fitted approximation without huge calculation. We will show how, in a simple model close to those used in climate science, the Maximum Thermodynamics Entropy Production Principle (MEP) and the Maximum Kolmogorov-Sinai Entropy Principle are equivalent. This result highlights an existing link between two empirical principles offen used in nonequilibrium physics.

Tizón Escamilla, Nicolás

Fluctuations in the Ising model

P.L. Garrido (1,2), P.I. Hurtado, (1,2) and N. Tizón (2)

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Abstract: Nonequilibrium phenomena characterize the physics of many natural systems. Despite their importance, no general theory exists yet capable of predicting nonequilibrium macroscopic behavior in terms of microscopic physics, in a similar way to equilibrium statistical physics. This is due to the difficulty in combining statistics and dynamics, which plays a major role out of equilibrium. However, during the last years, new advances made in the study of macroscopic fluctuations, with their statistics and associated structures, have improved our understanding of nonequilibrium behavior. The language of the fluctuations is the theory of large deviations, with large-deviation functions (LDFs) measuring the probability of fluctuations and optimal paths sustaining these rare events as central objects. In fact, LDFs play in nonequilibrium systems a role akin to the equilibrium free energy. Our aim is to show how we can study fluctuations in a particular system: the Ising model.

Sartoretti, Guillaume

Self-Organized mixed canonical-dissipative dynamics for Brownian planar agents

G. Sartoretti and M.-O. Hongler

Laboratory of Microengineering for Manufacturing (STI/IMT/LPM), EPFL (Swiss Federal Institute of Technology in Lausanne), Switzerland

Abstract: We consider a collection of N homogeneous interacting Brownian agents evolving on the plane. The time continuous individual dynamics are jointly driven by mixed canonical-dissipative (MCD) type dynamics and White Gaussian noise sources. Each agent is permanently at the center of a finite size observation disk D, and counts the number of its fellows located in this disk to re-actualize control parameters entering into the MCD. Dissipation mechanisms together with the noise sources ultimately drive the dynamics towards a consensual stationary regime characterized by an invariant measure P_s on an appropriate probability space. Assuming propagation of chaos, a mean field approach enables to analytically calculate P_s. The MCD drift is derived from a Hamiltonian function H and incites the agents to follow one consensual orbit coinciding with a level curve of H. When H is the harmonic oscillator, we are able to analytically derive the consensual orbit as a function of the size of D.

Transport & Diffusion

Becker, Thijs

Diffusion of interacting particles in discrete geometries

T. Becker (1), K. Nelissen (1,2), B. Cleuren (1), B. Partoens (2) and C. Van den Broeck (1)

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Abstract: A new model describing the diffusion of interacting particles is introduced. Exact analytical expressions for the self- and transport-diffusion are obtained when correlations are neglected. The effect of correlations is investigated by comparing the analytical expressions with results from simulations. The self-diffusion is found to exceed the transport-diffusion when particles cluster, explaining recent experimental findings published in Phys. Rev. Lett. by Chmelik et al. Finally, quantitative agreement with experiment is obtained.

Ibrahim, Yahaya

Propulsion mechanisms of a phoretic-swimmer

Y Ibrahim (2), R Golestanian (1), T Liverpool (2)

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Abstract: Colloid particles have been shown experimentally to propel themselves in the presence of some gradient (e.g Electric field, chemical gradient) due to phoretic effects. We review the theory for such phoretic mechanisms and hydrodynamics responsible for the particle propulsion. Furthermore, reviewed here is a theoretical framework elucidating generic design paradigm for self-propelled particles capable of generating and sustaining such gradients - consuming the free energy in the ambient.

Laenen, François

Heavy particle dynamics in random smooth flows by probabilistic method.

F. Laenen(1), J. Bec(2), G. Krstulovic(3)

(1) Lagrange, UMR 7293, CNRS, Observatoire de la Côte d'Azur.

Abstract: Heavy particle dynamics plays an important role in nature, including pollutants suspension in water, water droplets formation and aerosols transport in atmosphere, as well as in the industrial world, including chemical reactions, combustion processes and others. By use of numerical simulation using smooth, homogeneous and isotropic flow, preferred concentration with multi-fractal clustering and Lyapunov exponents determination has been shown. The goal here is to prove the reproducibility of these results using a more probabilistic approach inspired from Lattice-Boltzmann modeling.

Straka, Mika

Anomalous heat conduction in the one-dimensional FPU-alpha-beta chain

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Abstract: After more than fifty years, heat conduction in the one-dimensional FPU-alpha-beta chain still poses an open question. Recent studies challenge the generally accepted opinion of diverging thermal conductivity in the thermodynamic limit, suggesting its convergence. In our work we intend to clarify the basic assumptions of a theoretical hydrodynamic approach and to test the possibility of normal heat conduction.

Suñé, Marc

Anomalous transport and diffusion of Brownian particles

M. Suñé and J.M. Sancho

Departament d'Estructura i Constituents de la Matèria (UB), Barcelona, Spain

Abstract: We present a numerical study, through simulation of the Langevin equation, of the anomalies in transport and diffusion of overdamped Brownian particles in totally disordered potential landscapes either in one and two dimensions. In particular, the effects of three different disorder correlations or spectra have been analyzed. The anomalous regimes are characterized by the time exponents of the power law relation carried out both by the mean and the variance. Though the anomaly in transport is always of subtransport type, diffusion exhibits more anomalies: both subdiffusion and superdiffusion are indeed reached. In two dimensions we present a mixed anomaly: subdiffusion in the perpendicular direction to the force and superdiffusion in the parallel one. We have recently observed some novel properties of diffusion of infradamped Brownian particles which are still under discussion.

Student's Contributions. Second Week.

Biological & ecological systems

Barardi, Alessandro

Phase-coherence transitions in the gamma range between delay-coupled neuronal populations

Alessandro Barardi, Belen Sancristobal, Jordi Garcia-Ojalvo
Department of Experimental and Health Sciences, Barcelona Biomedical Research Park, Universitat Pompeu Fabra, Barcelona, Spain Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Terrassa, Spain

Abstract: In neuronal systems, firing synchronization is of great importance in information transmission between brain areas. In the last decades, several studies have reported various examples of synchronization among neurons, such as chaos synchronization in a large ensemble of HH neurons. It is known that synchronized spikes increase their impact to a given target neuron. Analogously, synchronized electrical oscillations emerging from the activity of thousands of neurons can increase the functional connectivity between neural assemblies by coherently coordinating their firing dynamics. We have studied, using conductance-based models, the influence of the synaptic delay on the synchronization of neural populations oscillating in the gamma range. We examined how different ranges of synaptic delays give rise to in-phase/out-of-phase transitions at different frequencies and show this behavior is related to the level of coherence achieved by the two signals.

Camilo Luna, Juan

Study of competition in intercellular signaling in extended dynamical systems

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Abstract: Cell to cell communication involves the binding of a ligand with a receptor anchored in the cell membrane of neighboring cells, such that from this interaction is triggered a signal that regulates gene transcription inducing cell-fate commitment. Lateral induction and lateral inhibition are two main processes mediated by intercellular signaling. In the former the ligand activates the formation of the signal, which in turn activates the transcription of the ligand, while in the later the ligand activates the formation of the signal, but the signal represses the transcription of the ligand. Lateral induction and lateral inhibition have opposite functional responses. In this work we have studied the response of a system when there are two molecular mechanisms acting simultaneously. We have found that the competition between the ligands for the receptor induce change in the topology of the mechanisms and favors transitions between lateral induction and lateral inhibition in a robust manner.

Catalán, Pablo

toyLIFE: a new framework for the study of gene network evolution

Pablo Catalán, Clemente Fernández-Arias and Jose A. Cuesta
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Abstract: Genes affect the expression of other genes, creating a complex network of regulating

interactions that determines the way a cell will function through its life. These networks are called gene regulatory networks (GRNs). Many models have been proposed for the study of GRN evolution, but most of them model mutation as direct changes in the topology of the network. However, real mutational changes occur on the DNA, and there are several levels of redundancy before these mutations get translated into actual changes in the topology of the GRN. These changes can be small or have a large impact on the GRN. We present here toyLIFE, a new framework designed to study the evolution of GRNs. toyLIFE contains analogs of genes, aminoacids and proteins, which interact through well-defined physical laws to produce "toyGRNs". This simple framework allows us to study how the effects of mutation at the "toyDNA" level are carried to higher levels, leading to new insights on the evolution of these systems.

Ebadi, Haleh

Identification of biological control networks from dynamics

H. Ebadi, K. Klemm

Bioinformatics Group, Computer Science Department, Leipzig University, Germany

Abstract: An observation of a state transition provides partial information on the interactions constituting a high-dimensional deterministic system. Here we strive to quantify how the number of observed single state transitions and/or short trajectories reduces the number of interaction matrices consistent with the set of observations. As a test-bed, we use several established Boolean (threshold unit) models of cell cycle control in living organisms. The numerical study also uses ensembles of randomly reshuffled matrices as a null model. We find that the original interaction matrices are easier to reconstruct than the shuffled surrogates.

Martinez Garcia, Ricardo

Optimizing the search for resources by sharing information: Mongolian gazelles as a case study.

R. Martinez-Garcia (1), J.M. Calabrese (2), T. Mueller (2),(3), K.A. Olson (2), C. Lopez (1).

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Abstract: We propose a model of Brownian searchers which are able to perceive the quality of the environment at its location, and with a long-range pairwise interaction that provides information on the habitat in far away regions of the space. First, we study the efficiency of the search depending on the range of the communication from a temporal and a spatial point of view measuring the population mean searching time and the spatial distribution of individuals in the long time limit. Our results point out that the search is optimal at intermediate scales of communication. Finally, we study the foraging in Mongolian gazelles coupling the model with remotely-sensed data on resource quality in the Steppe of Mongolia and show that at intermediate lengths of communication gazelles optimize the search. Finally, the optimal communication range and frequency obtained with our model are in good agreement with experimental results.

Nogueira de Souza Medeiros, Bruno

Title: Use of electronic circuits in the study of collective neuronal phenomena

Bruno N. S. Medeiros, Mauro Copelli

Departamento de Física, Universidade Federal de Pernambuco, Recife, PE, Brazil

Abstract: We make use of electronic devices that mimics the behavior of sensory neurons and chemical synapses to study collective neuronal phenomena. The devices are designed to be as simple as possible while still retaining physiological simmiliraty with their biological counterparts. This allows for scalability, simple mathematical modeling and real-time parameter scanning. With these building blocks, we are able to investigate most types of network configuration and, therefore, phenomena such as Coherence Resonance, optimal dynamical range and short-term synaptic plasticity leading to self-organized criticality.

Social & Economical systems

Ashcroft, Peter

Pattern formation in individual-based systems with time-varying parameters

P. Ashcroft and T. Galla

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Abstract: We investigate pattern formation in discrete systems driven by sweeping the system through a symmetry-breaking bifurcation at a finite rate. It is this rate which determines the typical length- scale of the resulting patterns. This is known as the Kibble-Zurek (KZ) theory of defect formation. The Turing picture of pattern formation has been studied in stochastic systems, but the KZ picture has so far been restricted to continuous systems. We study discrete, individual-based models where pattern formation is driven by intrinsic so-called demographic noise. We display results for a model of opinion dynamics, a model of evolutionary dynamics, and a model of cellular decision making with time-dependent lateral inhibition. Analytical descriptions of patterns formed in these models are derived through the linear-noise approximation. Further numerical work shows similar results in the case where the symmetry breaking bifurcation is triggered by population growth.

Bustos, Ricardo

On the distribution of per capita Gross Domestic Products

R. Bustos-Guajardo, C. F. Moukarzel

CINVESTAV, Departamento de Física Aplicada, Mérida Yucatán, México

Abstract: World per capita Gross Domestic Products have been customarily assumed to have a log-normal distribution in many macroeconomic studies. This is only justified if the most relevant part of the dynamics can be seen as locally-acting random multiplicative noise, for each country independently. This simplification neglects the importance of exchange processes like international commerce, so it is not surprising that the log-normal hypothesis fails to fit the available data for per capita GDP. We have been able to analytically calculate the distribution of per capita GDP for a model that involves both commerce, in the form of Random Multiplicative Exchange, and local Multiplicative Noise for each country. Our analytic expressions provide greatly improved fits to per capita GDP data and allow us to estimate the relative importance of exchange versus local noise. Contrary to the implicit assumptions in some earlier models, we find that commerce cannot be neglected.

Carro, Adrián

Network effects on the local and dynamic properties of an agent-based herding model

A. Carro, R. Toral, M. San Miguel

Instituto de Física Interdisciplinar y Sistemas Complejos (CSIC - UIB), Palma de Mallorca, Spain

Abstract: Some of the stylized facts of financial time series have been addressed as macroscopic patterns, emerging from herding interactions among groups of agents with heterogeneous trading strategies and a bounded rationality. These approaches focus on the processes of social interaction among agents, which can be described within a network framework whose structural effects upon the relevant macroscopic properties become crucial. We analyze the microscopic implementation of a simple stochastic herding formalism introduced by A. Kirman to model decision making among financial agents. By means of suitable approximations, we are able to derive closed-form solutions for the steady state of the order parameter, as well as the variance and the autocorrelation of the global state variable as functions of the degree distribution of the underlying network. We also show that it is possible to infer some characteristics of the underlying communication structure by measuring only global variables.

Nyczka, Piotr

Phase transitions in the q-voter model with two types of stochastic driving

Piotr Nyczka, Katarzyna Sznajd-Weron, Jerzy Cislo

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Abstract: We study a nonlinear q-voter model with stochastic driving on a complete graph. From a social point of view, it is very important to distinguish between two types of nonconformity: anticonformity and independence. A majority of work has suggested that these social differences may be completely irrelevant in terms of microscopic modeling that uses tools of statistical physics. In this paper we clarify the concept of social temperature and show that different types of noise may lead to qualitatively different emergent properties. In particular, we show that in the model with anticonformity the critical value of noise increases with parameter q, whereas in the model with independence the critical value of noise decreases with q. Moreover, in the model with anticonformity the phase transition is continuous for any value of q, whereas in the model with independence the transition is continuous for $q < 6$ and discontinuous for $q >= 6$.

Pace, Bruno

Voter model with surface tension

B. Pace and K. Klemm

Bioinformatics group of Leipzig University

Abstract: Spin systems are very central in the context of statistical physics for their simplicity and generality. But also, any process out of the realm of physics that shares some intrinsic properties and symmetries will inherit some of their characteristics such as the phase transitions or scaling properties. There is a well-known comparison between the Voter Model and the Ising Model at zero temperature. In the latter, however, curvature-driven surface tension orders the system. Here we propose a different microscopic mechanism for the emergence of surface tension with some different macroscopic behaviour and we compare the three models.

Valverde , Pablo

Effect of size of groups in an Optional Public Good Game model.

P. Valverde, S. Gonçalves, J.C. González-Avella, J.R. Iglesias

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Abstract: We study under which conditions cooperation can emerge in a type of social dilemma dynamics known as Optional Public Good Game (OPGG). We consider N agents, which can be in one of three possible states: cooperator (C), defector (D) or loner (L). In order to study the global properties of the OPGG in a mean field and a two-dimensional network, we have used the subset S of players chosen to play OPGG, the r parameter, the multiplication factor of OPGG and the probability p which defines the disorder degree in the network. Through the systematic study of those parameters, the system displays two different dynamics: i) convergence to an absorbing state, and ii) evolution to a state of coexistence in which the three strategies coexists. In the coexistence state and for some values of those parameters, the dynamics of the system exhibits a cyclic behavior among the three states.

Complex Networks

Bianco Martinez, Ezequiel

Determining functional and physical connectivity in complex time-series

E. Bianco-Martinez, C. Antonopoulos and M.S. Baptista

Institute for Complex Systems and Mathematical Biology, University of Aberdeen, King's College, Aberdeen, UK

Abstract: The study of the way information is exchanged between nodes in complex networks is of primordial importance for understanding its functionality. A quantity known as Mutual Information Rate (MIR) can quantify the exchange of information between nodes in a pair-wise fashion and is well defined for systems with memory or that presents non-zero correlation. Its calculation involves probabilities which requires a proper definition of a partition. Here, we show that there is a finite partition with equal-sized cells that optimally approximates a Markov partition, allowing for the accurate estimation of many dynamical invariants (Lyapunov exponents, Expansion rates, MIR, etc).

Ferdinandy, Bence

HIV competition dynamics over sexual networks

B. Ferdinandy(1), E. Mones(1), T. Vicsek(1) and V. Müller(2)

(1) Department of Biological Physics, Eötvös Loránd University, Budapest, Hungary (2) Research Group of Theoretical Biology and Evolutionary Ecology, Eötvös Loránd University and the Hungarian Academy of Sciences, Budapest, Hungary

Abstract: The global phylogeography of HIV is characterized by compartmentalized local epidemics that are typically dominated by one subtype, which indicates strong founder effects. We developed a stochastic modelling framework to simulate HIV epidemics over dynamic contact networks, parameterized based on empirical data. We simulated epidemics in which the second strain was introduced into the population with varying time lags after the first. With strains of equal transmission efficiency, the second strain was unable to invade on a time scale relevant for the history of the HIV pandemic. To become dominant over a time scale of decades, the second strain needed considerable advantage in transmission efficiency over the resident strain. Our simulation confirmed asymmetrical competition dynamics of HIV at the population level, with an advantage of the first successful strain in the population. The modelling framework also allows us to make predictions on the future evolution of the pandemic.

Jiménez Martín, Manuel

The influence of network topology on the existence of spatially asymmetric retrieval states in binary attractor neural networks

Manuel Jimenez-Martin, Elka Koroutcheva

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Abstract: Neocortical neural networks can be understood as autoassociative networks with spatially dependent connectivity and they exhibit localized regions of activity during memory operations. These 'bumps' of activity are called Spatially Asymmetric States (SAS). The SAS have been shown to occur spontaneously in binary attractor Hoppfield neural networks when asymmetry between the retrieval and the learning is imposed. The conexión between the SAS and some topological features of the nework such as modularity is the topic of current research.

Rodríguez Méndez , Victor

Inference in networks embedded in metric spaces

Victor M. Rodriguez, José J. Ramasco, Victor M. Eguíluz

Instituto de Física Interdisciplinar y Sistemas Complejos (CSIC - UIB), Palma de Mallorca, Spain

Abstract: We have introduced a method to infer significant structure in networks based on Expectation Maximization, with the aim of applying it to networks whose nodes are embedded in a metric space. The method is used on different benchmark networks produced with a prior probability of connection between the nodes i and j. This probability is a function of the position coordinates of the nodes. By combining Expectation Maximization and Metric Multidimensional Scaling, we have recovered the given connection probability functions, the position of the nodes and the dimension of the underlying metric space from the benchmark networks. The quality of the inference is measured using the Pearson Correlation to compare the inferred and the original connection probabilities. The results are shown for different number of links in the networks.

Vallès-Català, Toni

Identifying significant node groups in complex networks

Toni Vallès-Català, Marta Sales-Pardo, Roger Guimerà

Departament d'Enginyeria Química, Universitat Rovira i Virgili (DEQ - URV), Tarragona, Catalonia, Spain

Abstract: Complex networks enable an accurate representation of a large amount of information, with which a wide variety of problems can be solved. For instance, the spreading of a disease can be studied with the worldwide air transportation network, and metabolic networks provide methods to

uncover novel drug targets within the every-increasing amount of biological data available. By studying the structure of a network we can extract all the information that can be used in the process of decision making. A good approach to unravel the characteristics of a structure is to group nodes into stochastic block models, where nodes with the same pattern of connections are grouped together. Trying to capture all the characteristics in one stochastic block model will produce a lack of information, since some properties of the structure would not be distinguishable. Our method provides all the characteristics of the structure in separately stochastic block models.

Nonlinear Dynamics

Abolaffio, Milo

Excitable systems in two dimensional flows

G. Boffetta, F. Delillo, M. Abolaffio
Univesità degli studi di Torino

Abstract: Recently was studied, for the first time, an excitable system in bidimensional turbulence, and the result is that the mean scale and the mean velocity of the characteristic patterns are renormalized by the turbulent diffusion. Stimulated by this work, we perform numerical simulations, validating numercally the results of the experiment and reaching region of parameters never joined by the experiment. We found that the crucial parameter for this system is the Damköhler number, the ratio between the correlation time of the velocity field and the time of the reaction, as expected by analogy with turbulent flame combustion theory.

Escalona, Miguel

Complexity, information transfer and collective behavior in chaotic dynamical networks

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Abstract: We investigate the relationship between complexity, information transfer and the emergence of collective behaviors, such as synchronization and nontrivial collective behavior, in a network of globally coupled chaotic maps as a simple model of a complex system. Our results show that the emergence of nontrivial collective behavior is associated to higher values of complexity. Little transference of information from the global to the local level occurs when the system settles into nontrivial collective behavior while no information at all flows between these two scales in a synchronized collective state. As the parameter values for the onset of nontrivial collective behavior or chaos synchronization are approached, the information transfer from the macroscopic level to the local level is higher, in comparison to the situation where those collective states are already established in the system.

Löber, Jakob

Controlling the position of a front

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Abstract: We present a method to control the position as a function of time of traveling front solutions to reaction-diffusion systems according to a pre-specified protocol of movement. Given this protocol, the control function is found as the solution of a perturbatively derived integral equation. Two cases are considered. First, we derive an analytical expression for the space and time dependent control function that is valid for arbitrary protocols and many reaction-diffusion systems. Second, for stationary control of traveling waves, the integral equation reduces to a Fredholm integral equation of the first kind. In both cases, the control can be expressed in terms of the uncontrolled wave profile and its propagation velocity, rendering detailed knowledge of the reaction kinetics unnecessary.

Manzano Paule, Gonzalo
Title: Synchronization and quantum correlations in networks
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Abstract: Synchronization is one of the paradigmatic phenomena in the study of complex systems. Although several mechanisms and conditions for synchronous behavior in spatially extended systems and networks have been identified, the emergence of this phenomenon has been largely unexplored in quantum systems until very recently. Here we discuss synchronization in quantum networks of different harmonic oscillators relaxing towards a stationary state, being essential the form of dissipation. By local tuning of one of the oscillators, we establish the conditions for synchronous dynamics, in the whole network or in a motif. Beyond the classical regime we show that synchronization between (even unlinked) nodes witnesses the presence of quantum correlations and entanglement. Furthermore, synchronization and entanglement can be induced between two different oscillators if properly linked to a random network.

Martínez-Llinàs, Jade
Tuning the period of square-wave oscillations in two delay coupled systems with delay feedback
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Abstract: Time delays are a source of instabilities and complex dynamics. Delays arise in optical and optoelectronic systems with feedback, where the feedback time is usually larger than the intrinsic time scale, and in coupled systems where delay is due to the finite propagation time from one system to another. An example of dynamical regime that can arise through time-delayed feedback is square-wave switching. The generation of tunable pulsating dynamics has been studied during the past few years, motivated by fundamental interest and also towards applications such as optical clocks and other binary logical applications, generation of stable microwave signals or optical sensing. Here we focus on the dynamics of two optoelectronic oscillators, each one with intrinsic delay, which are mutually coupled with delay. Optoelectronic oscillators exhibit a rich variety of dynamical regimes with different potential applications, including chaos generation and production of ultra-pure microwaves.

Sonnenschein, Bernard
Title: Dimensionality reduction for stochastic Kuramoto oscillators
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Abstract: A highly influential model describing the phenomenon of synchronization is due to Kuramoto. It is concerned with the competition between diversity, which hinders synchronization, and couplings, by which the phase oscillators tend to synchronize. Here we consider all-to-all coupled oscillators, where diversity purely comes from noise acting on the frequencies. In the noise-free case the Ott-Antonsen theory provides an exact dimensionality reduction. No such stochastic counterpart has been found yet. However, one can derive an approximate theory within the framework of the so-called "Gaussian approximation". We obtain thereby a solution for the time-dependent order parameter, which measures the synchronization between the oscillators. We show that the analytical results are very accurate below and sufficiently above the exact critical value. We furthermore discuss the asymptotic behavior of the order parameter, which suggests a new tight upper bound for the corresponding scaling.